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MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

Figure 6. Top: *Calyptraphorus stamineus* (Conrad, 1856) from the Moodys Branch Formation (38 million years old) in pile borings at the construction site of the Museum of Mississippi History in Jackson, Mississippi. Web images: Bottom left: Living relative from the Japan and South China Sea, *Tibia martinii* Marrat, 1877. Bottom right: Living relative from the North Indian Ocean and Red Sea, *Tibia insulaechorab* Roding, 1798.

Environmental News, February 2014, volume 11, issue 2, pages 17-21

FOSSIL FISH OF MISSISSIPPI

David T. Dockery III, Office of Geology

Fish fossils in Mississippi are rarely preserved as body fossils in sedimentary rocks known by the German name Lagerstätten, as is shown in the Glendon Limestone in Figure 1. They are primarily known from their teeth (shark and ray teeth being the most common), isolated vertebrae and spines, bills, and ear bones called otoliths. Otoliths are located in the inner ear and provide the fish with sensitivity to gravity and linear acceleration. They are composed of calcium carbonate (usually aragonite) and grow with the fish, forming growth lines that can determine a fish's age in years (less growth in winter and more in summer) and even days. Linda Ivany (Ivany et al., 2000 and 2003) of Syracuse University used the oxygen isotope of winter and summer growth rings from otoliths of the Jackson and Vicksburg groups in Mississippi to study climatic cooling across the Eocene-Oligocene boundary some 33.7 million years ago. Otoliths are also diagnostic for fish families, genera, and species, allowing the reconstruction of ancient fish ecologies. As they are relatively common in formations where aragonitic shells are preserved, otoliths give the best fossil record of Mississippi's ancient fish species.

World otolith expert Dirk Nolf of the Royal Belgian Institute of Natural Sciences in Brussels, Belgium, came to Mississippi to collect otoliths from the Gulf Coastal Plain with his wife Dora and daughter Sylvia in June and July of 1987. While Dora and Sylvia were sightseeing, Dirk and I spent three weeks (June 19-July 10) collecting otoliths from formations in Mississippi and Alabama, using the Office of Geology jon boat to reach the river localities (Figure 2). In 1990, Dirk and I published the otoliths of the Cretaceous Coffee Sand (Campanian) of Lee County, Mississippi (before this publication less than 20 valid otolith species were known for the whole Cretaceous), and in 1993 published the otoliths of the Paleocene Matthews Landing Member of the Porter's Creek Formation in Alabama. Dirk collaborated with Gary Stringer of the University of Louisiana at Monroe to publish a synthesis of North American Cretaceous fish otoliths in 1996 and the otoliths of the Yazoo Clay at Copenhagen, Louisiana, in 2003.

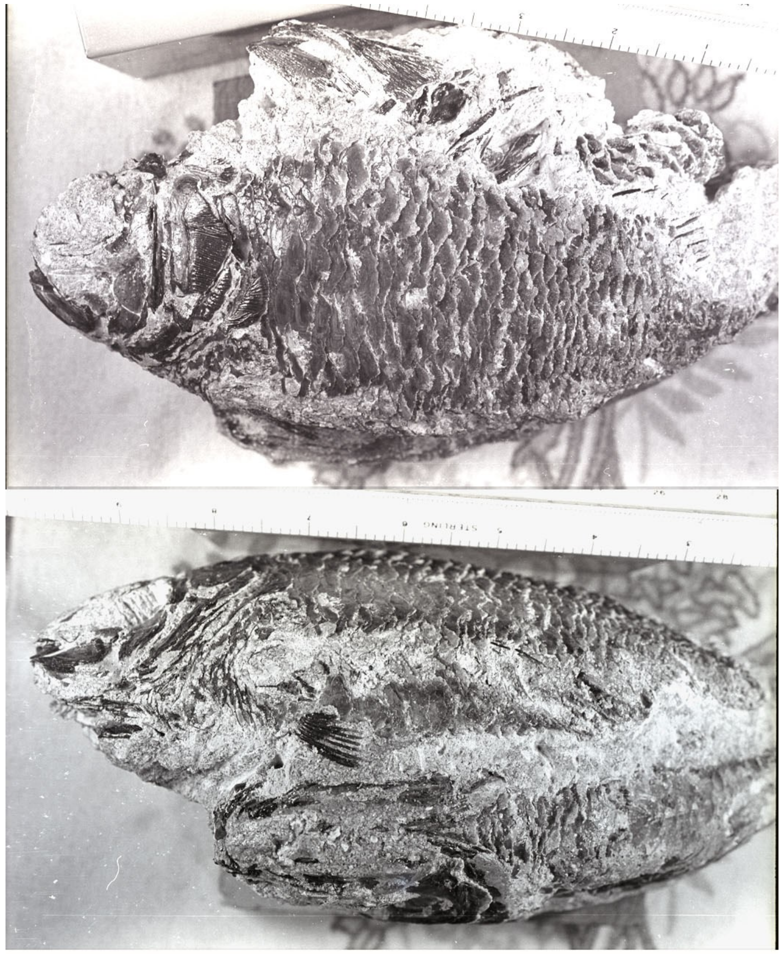

Figure 1. A pair of the fossil squirrel fish *Holocentrites ovalis* from the Glendon Limestone near Florence in Rankin County, Mississippi (private collection). Picture (negative composite 86-41 at top and 86-42 at bottom; Image 1711) taken around March of 1981; scale in inches.

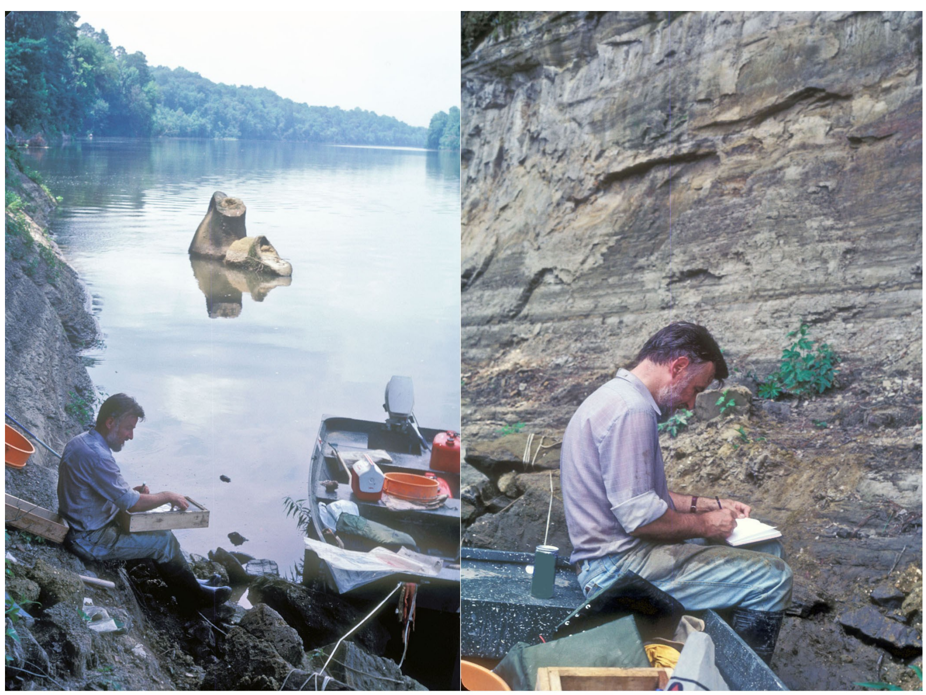

Figure 2. Dirk Nolf collecting fossil otoliths at the type Bells Landing Member of the Tuscahoma Formation at Bells Landing on the Alabama River in Monroe County, Alabama. Pictures (Kodachrome slides 185-5 and 185-8) were taken on June 26, 1987.

Dirk Nolf (with Dora) made additional trips to Mississippi in May of 2001 to collect Cretaceous otoliths from the Owl Creek Formation in Tippah County and the Coon Creek Tongue of the Ripley Formation at Blue Springs in Union County and in September of 2003 to collect Oligocene otoliths from the Red Bluff and Byram formations of the Vicksburg Group (figures 3-4). After a long career of traveling the world to collect fossil otoliths and otoliths dissected from preserved fish specimens in museums, Dirk Nolf has published an impressive monograph (Figure 5) entitled *The Diversity of Fish Otoliths, Past and Present* (222 pages plus 359 full-page plates). In the publication, 2666 nominal species of fossil otoliths are recorded, of which 1391 are believed to be valid. There are also 406 Recent fish species known as fossils, bringing the total number of otolith-documented fossil fish species to 1797. Fossil otoliths from an amazing number of localities worldwide are illustrated, including some 29 species from Mississippi.

Figure 3. Dirk Nolf at Archusa Water Park campground site in Clarke County, Mississippi, breaking up samples to be sun-dried (left) and standing beside drying samples on plastic sheets (right). Pictures (slides 370-1 and 370-3) were taken on September 9, 2003.

Figure 4. Top: Dirk Nolf at the contact of the Shubuta Clay Member of the Yazoo Formation and the overlying Red Bluff Formation as marked by the rock hammer (=Eocene-Oligocene boundary) at the Red Bluff type locality on the Chickasawhay River in Wayne County. Bottom: Dirk Nolf taking a sample of the Red Bluff Formation on the Chickasawhay River bluff at Hiwannee in Wayne County. Pictures (slides 371-6 and 370-4) were taken on September 9, 2003.

Dirk's work with Mississippi otoliths provided: (1) information about the state's ancient fish populations, (2) a way to identify and give meaning to otolith fossils found in the state, and (3) another fossil element that might prove useful in distinguishing, correlating, and mapping geological formations in Mississippi. On the other hand, Mississippi played an important role in Dirk's global monograph of the world's ancient fishes. When the Cretaceous (Campanian) otoliths from the Coffee Sand of Mississippi were published, people took notice and began finding and publishing pre-Tertiary otoliths in other formations of Cretaceous age and even older.

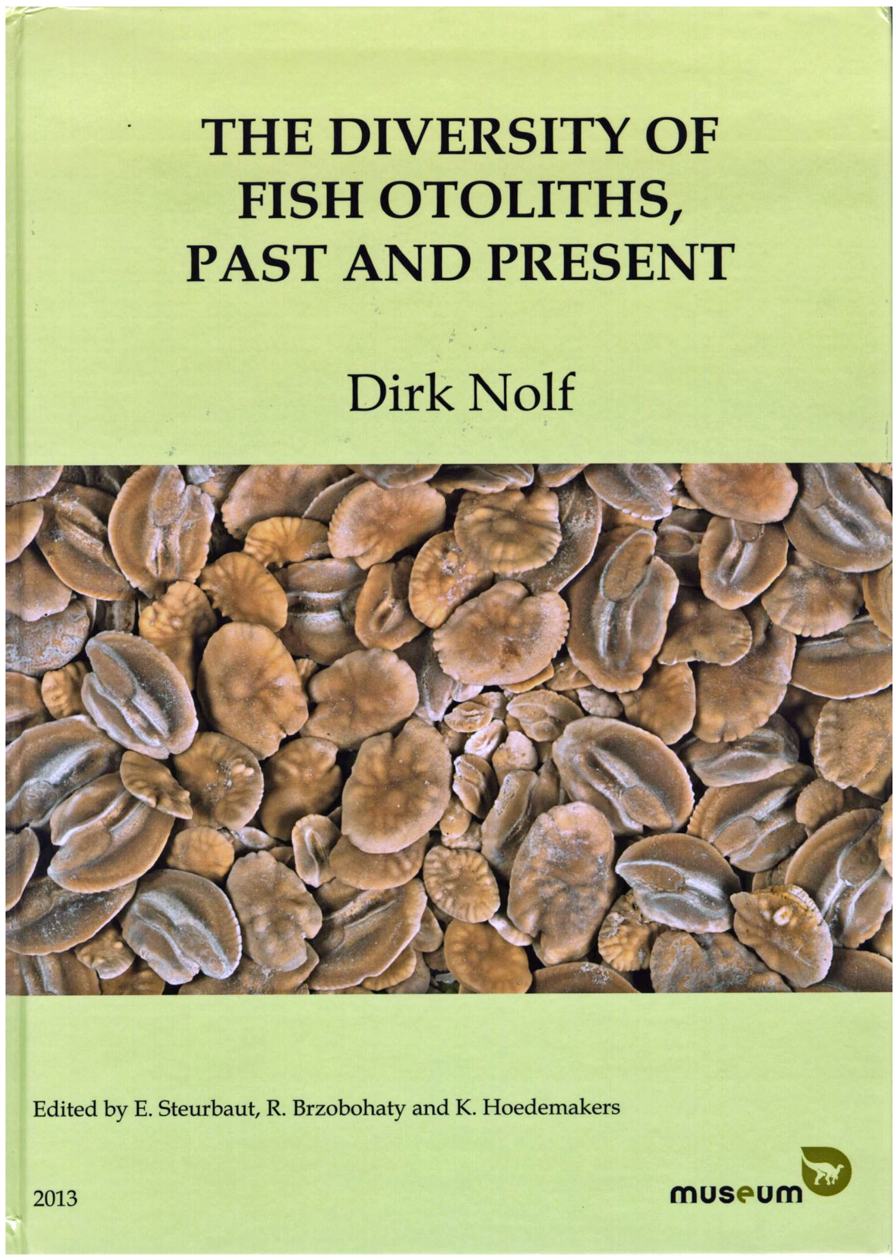

Figure 5. *The Diversity of Fish Otoliths, Past and Present*, by Dirk Nolf, 2013. Otoliths on cover are from the Middle Eocene of Belgium.

FAMILY TIME AT THE 2014 MISSISSIPPI GEM AND MINERAL SOCIETY ROCK SHOW AND THE FOSSIL ROAD SHOW

David T. Dockery III, Office of Geology

The Mississippi Gem and Mineral Society's (MGMS) 55th Annual Gem, Mineral, Fossil, and Jewelry Show at the Trade Mart Building on February 22 to 23 and the 11th Annual Fossil Road Show at the Mississippi Museum of Natural Science on March 1, 2014, were opportunities for families to bring their rocks and fossils for us to examine (or just see) and for the Office of Geology to connect with the rock-and-fossil-happy public. U.S. Senator Thad Cochran was in the Saturday morning crowd at the rock show wearing a "wire wrapping" (a jewelry-making technique) badge. With a Gem and Mineral Society-like badge, I thought that he must be a Thad Cochran look-alike. I went for a closer look, and he held out his hand and said, "I'm Thad Cochran." Senator Cochran was nice enough to stop by our booth for a picture (Figure 1, left) and chat for a while. Of interest to me was that Senator Cochran worked on oil and gas cases as an attorney, knew former State Geologist Fred Mellen, and used him as an expert witness. In Figure 1 (at right) at the Office of Geology booth, is Ann Parker, who worked for longtime MGMS member Dr. Brookes, and her grandson Noah Derrick, a record holder on the Sunkist Swim Team.

Figure 1. Left, Senator Thad Cochran at the Office of Geology booth. Right, Ann Parker and grandson Noah Derrick; Ann worked for the late Dr. Brookes, a dentist and longtime member of the Mississippi Gem and Mineral Society, who did lapidary work faceting gemstones; Noah is a record holder on the Sunkist Swim Team, the team that placed #1 in the 2014 state meet at Tupelo, Mississippi..

$1,800 aquamarine crystals from Gilgit, Pakistan, at the MGMS rock show.

We also enjoyed seeing past Office of Geology (OG) employees such as Jack Moody with his granddaughter Savannah Stevens and Don Bates with his wife Greta, son Jack, and daughters Madison, Amelia, and Meredith. From MDEQ's Office of Land and Water Resources Paul Parrish attended with his wife Julie and daughter Laken, and OLWR Director Kay Whittington was at the Rock Show with her son Charlie (Figure 3).

Figure 2. Former Office of Geology employees. Left, Jack Moody and granddaughter Savannah Stevens. Right, Don Bates with wife Greta, son Jack, oldest daughter Madison, and twins Amelia with headband at left and Meredith at right.

Figure 3. Office of Land and Water Resources families. Left, Paul Parrish with wife Julie and daughter Laken. Right, Kay Whittington and son Charlie.

The ammonite specimen has its original shell preserved as the gemstone ammolite.

James Starnes (OG) brought his daughters Abby and Gracie (Figure 4, left). Abby and Gracie, along with team members Nicholas and Noah Derrick (Figure 4, right), swam for the Sunkist Swim Team at the Short Course Mississippi Swimming State Championship on February 27 to March 2, in Tupelo. Figure 5 shows a mother and daughter with their prized fossil from chert gravel, the extinct Paleozoic marine snail genus *Bellerophon* (the first one reported from Mississippi gravel). The Rock Show is an opportunity for university geology departments to recruit new students. Figure 6 shows the Mississippi State University booth (at top), the University of Southern Mississippi (middle), and the University of Mississippi (bottom). The big fellow standing at left in the Mississippi State University booth is Luke Thompson, a graduate student and son of David Thompson (OG).

Figure 4. Swim team champions. Left, James Starnes with daughters Abby (left) and Gracie (right). Right, Sunkist state swim team champions, from left to right, Abby and Gracie Starnes and Nicholas and Noah Derrick.

Figure 5. Left, Mother and daughter with a fossil from driveway gravel. Right, first record of a fossil *Bellerophon*, an extinct marine snail shell, from Mississippi chert gravel; the slitband or selenizone can be seen down the median line of the shell.

Figure 6. University geology departments. Top to bottom, Mississippi State University, University of Southern Mississippi, and the University of Mississippi.

Natural cross in petrified wood brought to the Fossil Road Show.

The Mississippi Museum of Natural Science's (MMNS) Fossil Road Show was a second opportunity to see rocks and fossils brought in by the public, such as the Devonian trilobite tail (pygidium) found in driveway gravel as shown in Figure 7.

Figure 7. Left, family showing a fossil from Mississippi chert gravel. Right, an eroded Devonian trilobite tail or pygidium similar to that of *Huntonia*.

In Figure 8, a mother and son donate the largest mosasaur tooth known from Mississippi. Robin Persons, director of the Historic Jefferson College Museum at Washington, Mississippi, brought some of the museum's specimens. Of particular interest was a chert block with large trilobite fossils of the genus *Huntonia* from the Devonian Ross Formation in Tishomingo County, Mississippi (Figure 9).

Figure 8. Mother donates one of the largest known mosasaur teeth from the Cretaceous of Mississippi to the Mississippi Museum of Natural Science.

Dinosaur toe bone donated to the MMNS at the Fossil Road Show.

Figure 9. Left, Robin Persons, director of the Historic Jefferson College museum at Washington, Mississippi. Right, a specimen from the museum's historical collections consisting of a chert block from the Devonian Ross Formation in Tishomingo County with trilobite fossils of the genus *Huntonia*.

Finally, in Figure 10 (at left), representing naturalist families at the Fossil Road Show are MMNS director Libby Hartfield, married to biologist Paul Hartfield with the U.S. Fish and Wildlife Service's Mississippi Ecological Services Field Office in Jackson, and MMNS special events coordinator Nicole Phillips, married to MMNS paleontologist George Phillips. In Figure 10 (at right) is a budding naturalist showing her chert gravel fossils with the help of her grandfather.

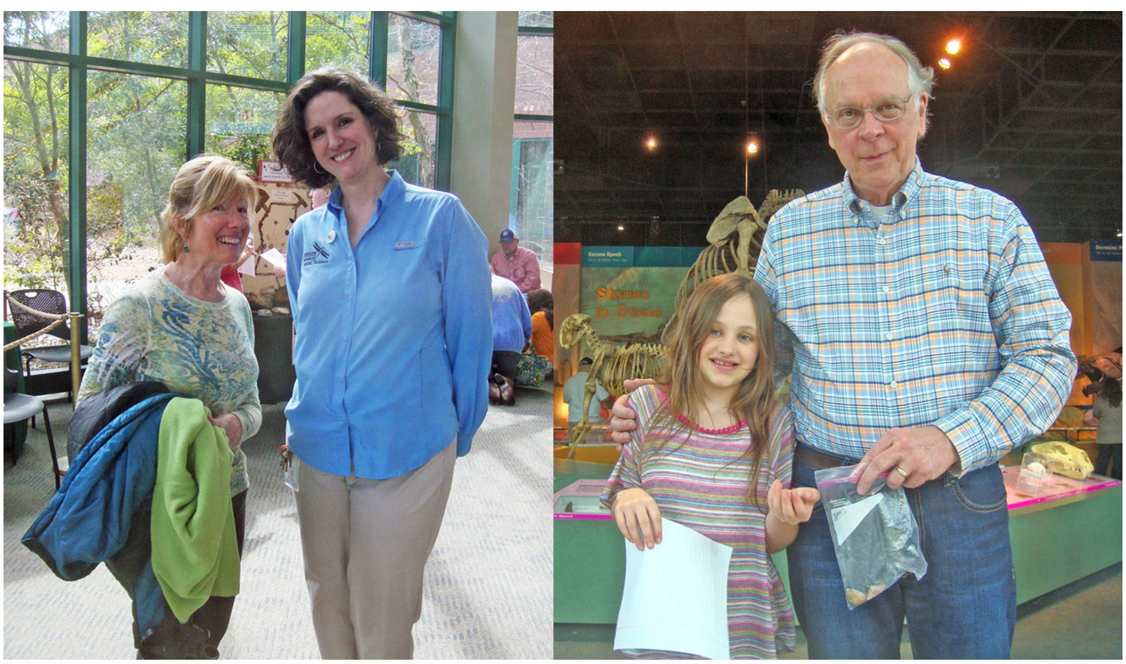

Figure 10. Left, two ladies married to malacologists: Mississippi Museum of Natural Science director Libby Hartfield (left) married to Paul, an expert in recent freshwater mussels, and museum special events coordinator Nicole Phillips (right) married to George, who is an expert in all things fossil, including fossil mollusks. Right, grandfather and granddaughter show their chert fossils.

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FORENSIC GEOLOGY

David T. Dockery III, Office of Geology

The modern science of geology traces its origin to Scotland with the presentation of James Hutton's *Theory of the Earth* to the Royal Society of Edinburgh in 1785 and to England in 1799, where William Smith produced the first large-scale geologic map of the geology around Bath in Somerset County. In 1801, Smith drew a rough-sketch geologic map of England and Wales with part of Scotland, which became known as "The Map that Changed the World." The map was published in color in 1815 (Figure 1). With Britain's rich history in geology, it is no surprise that, when Sir Arthur Conan Doyle created the Sherlock Holmes series, Detective Holmes would be the first to use forensic geology in solving crimes. Holmes memorized the exposed geology of London to the extent that he could identify where a person had been by examining the clay on their shoe (Figure 2).

Figure 1. William Smith's 1815 geologic map of the Strata of England, Wales, and southern Scotland (top) and a cross section of strata from the Thames River Valley in the London area to the hills of central Wales (bottom).

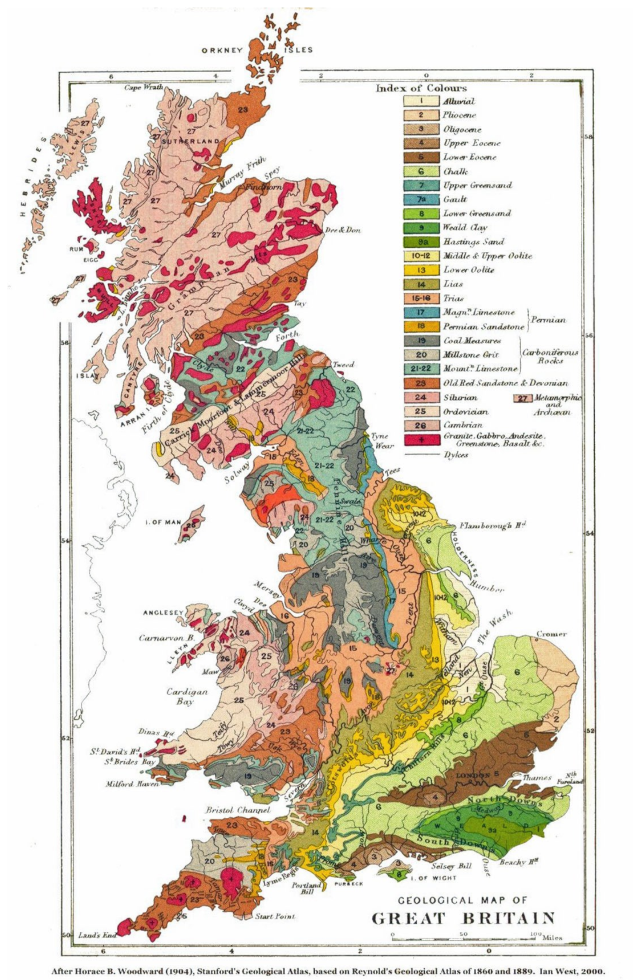


Figure 2. This Geological Map of Great Britain is based on Reynold's Geological Atlas of 1889, and shows the geologic knowledge at the time of the Sherlock Holmes series.

In the story, *The Five Orange Pips*, published in 1891, we have this conversation:

Holmes: “You have come from the Southwest, I see.”

Visitor: “Yes, from Horsham.”

Holmes: “That clay-and-chalk mixture which I see on your toe caps is quite distinctive.”

Forensic geology is the use of geology, including evidence relating to minerals, oil, petroleum, and other materials found on Earth, to answer questions raised by the legal system in both criminal and civil cases. Forensic geology is also used by paleontologists studying fossil deposits to answer the question: “What happened to all these animals and/or plants.” Fossil deposits are of two general types: (1) Biocoenosis contains the remains of organisms buried together in the habitat in which they lived (Figure 3), and (2) thanatocoenosis contains a death assemblage of fossils that were not associated in life and have been removed from their habitat and deposited elsewhere (Figure 4).

Figure 3. Biocoenosis of a community of mollusk shells, that lived in the same habitat, excavated in place from the Coon Creek Tongue of the Ripley Formation at the type Coon Creek locality in McNairy County, Tennessee, and displayed at the Pink Palace Museum in Memphis. Picture from the Pink Palace Museum website.

Figure 4. This one meter square slab was excavated by the staff of the Pink Palace Museum in Memphis, Tennessee, from the road bed of the Highway 45 bypass around Frankstown, Mississippi, and is now exhibited at the museum. The slab shows the original road bed and the excavated sections on each side to expose the many fossils, which are a thanatocoenosis of shark teeth, rare dinosaur teeth, and petrified wood. Picture is from the Pink Palace Museum website.

The detective work for the forensic paleontologist is to distinguish a biocoenosis from a thanatocoenosis. Indications of a biocoenosis are animal remains preserved in their burrows, intact remains of fragile echinoderms such as sanddollars and sea urchins, and clams with both valves (shells) closed together. Clams have abductor muscles that keep the shells closed and an organic hinge that opens the shells when the muscles relax. So when a clam dies in its burrow, its shells remain closed together. This is especially true for deep burrowing clams such as the geoduck, an edible saltwater elongate clam in the genus *Panopea* (Figure 5). When a clam dies and is transported to another place by ocean currents, its shells butterfly and separate. So a bed containing disarticulated shells of clams from different habitats would indicate a thanatocoenosis, while a natural mix of disarticulated shells and articulated shells from a common habitat would indicate a biocoenosis. These forensic observations are not just of academic concern but have legal applications.

Figure 5. Fossil shells of the geoduck *Panopea* in life position in the Owl Creek Formation at a construction site on Highway 15 north of New Albany, Mississippi. Pictures were taken by George Phillips on February 19, 2012.

Forensic geology and differentiating a biocoenosis from a thanatocoenosis became an important issue 1998 when the Office of Geology was called upon by the Secretary of State's office to drill core-holes on property owned by Biloxi Grand Casino in Biloxi and determine if the land was reclaimed from tidal waters by fill or if the land was natural. The state laid claim to that portion of the property reclaimed from the sea, as the tidal waters belonged to the state, and the state could require a lease on that property. The land was seaward of the shoreline as indicated on old maps dating to 1851 (Figure 6). However, the argument could be made that these old maps were incorrectly drawn. To prove that the land was reclaimed from the Mississippi Sound required drilling core holes on the site to determine if the land portion above sea level was fill, as indicated by a human-induced (i.e. oyster shells used as fill) thanatocoenosis and other evidence, or was ground underlain by natural sediments as indicated by a biocoenosis. Cores were obtained from the site using MDEQ's Failing 1500 drilling rig. Examination of the cores found five stratigraphic units. The upper two units comprised all the land above sea level and contained a thanatocoenosis of disarticulated and even ground-up (for chicken grit) oyster shells .

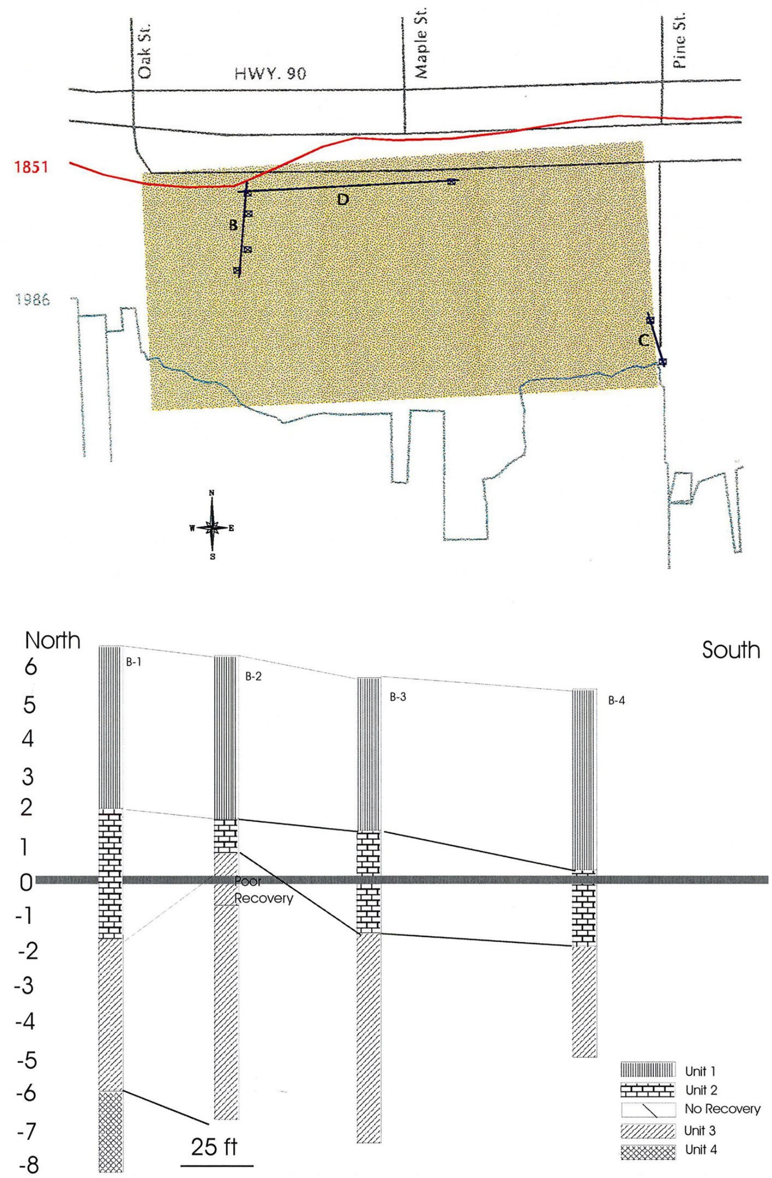


Figure 6. Top: The Grand Casino Property Base Map, Biloxi, Mississippi, as prepared in October 1998. The red line is the 1851 coastline as digitized by the Office of Geology from the U.S. Coast and Geodetic Survey shoreline (1851). The 1986 shoreline is drawn from aerial photography. Bottom: Core holes for the north-south Cross Section B-B' are in the northwest quarter of the property; units 1 and 2 are fill.

Core evidence from the Biloxi Grand Casino site was so convincing that MDEQ was asked to drill another casino site in 2002, the Imperial Palace Casino on Back Bay Biloxi (figures 7-8). As given in the site report's Executive Summary, "it was recognized that a significant portion of the site had at one time been a natural water bottom that was subsequently filled with a variety of materials." Biloxi Grand Casino and Imperial Palace Casino now lease their reclaimed property from the State.

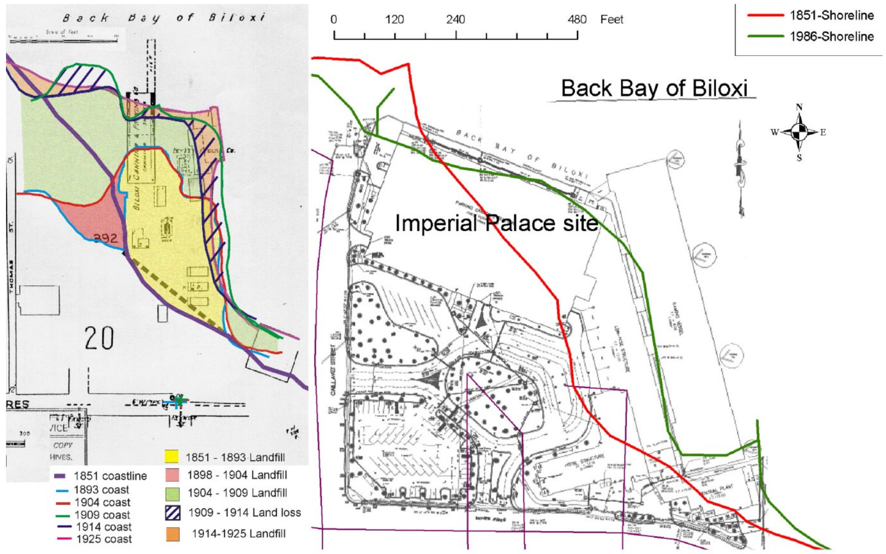
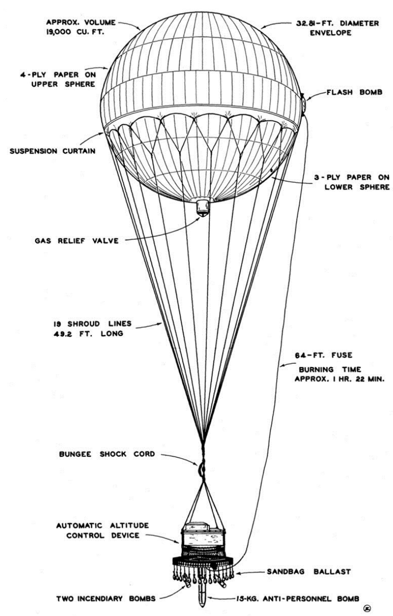


Figure 7. Left: Historical shoreline progression from Sanborn maps in a portion of Back Bay of Biloxi; background image is 1925 Sandborn map; fill is colored by age. Right: 1851 shoreline in red and 1986 shoreline in green; between these lines is a portion of the bay reclaimed by fill.

Figure 8. Core of the Imperial Palace property on Back Bay of Biloxi, showing the contact (at 3-foot mark) of fill (at left) and natural seafloor sediment (right).

During the war years of the 1940s, the Mississippi Geological Survey (now Office of Geology) worked in cooperation with the U.S. Geological Survey to explore for strategic minerals and to create the Geologic Map of Mississippi published in 1945 at a scale of 1:500,000. At the time, MGS employed Dr. Virginia Kline as a paleontologist. Dr. Kline left Mississippi in May of 1943 to become assistant petroleum analyst in the Chicago office of the Petroleum Administration for War. The U.S. Government picked some of the best paleontologists and geologists for the war effort. The following account from John McPhee's (1997) *Irons in the Fire* shows how some of the government's "best and brightest" used forensic geology to solve a pressing military problem.

In the fall of 1944, Technical Major Teiji Takada, of Japan's Ninth Army Technical Research Laboratory, took a walk on the Ninety-nine League Beach at Ichinomiya, which faced east against the great expanse of the Pacific Ocean. Tests had proven satisfactory, and now Takada pondered matters of sand supply, ballast, lift, altitude, wind speed, U.S. War Department defenses, but not a thought of the U.S. Geological Survey. Takada's task would produce the war's only sustained attack against the U.S. mainland (Figure 9). Hydrogen-filled balloons with explosive and incendiary payloads would be launched by the thousands into the winter Jet Stream at an altitude above 30,000 feet, where wind speeds would take them across the Pacific Ocean and to the West Coast in just three days. Once over the target area, the balloons would release their explosive charges and self-destruct. To compensate for the loss of hydrogen along the route, the balloons carried a ballast of sand bags that were released two at a time when the balloons descended to 30,000 feet.



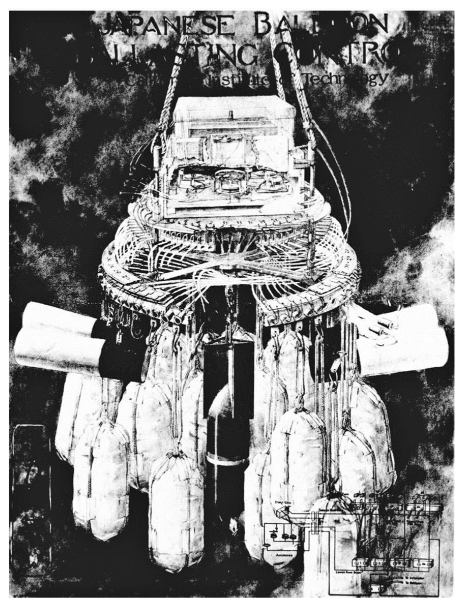


Figure 9. Left: Japanese balloon design as used in World War II. Right: Carrousel-like attachment for sandbag ballast, incendiary bombs, and a central anti-personnel bomb.

The first balloons were launched on November 3, 1944; a few days later, balloons and explosions were sighted from California to Alaska; some 9,000 balloons would follow (Figure 10).

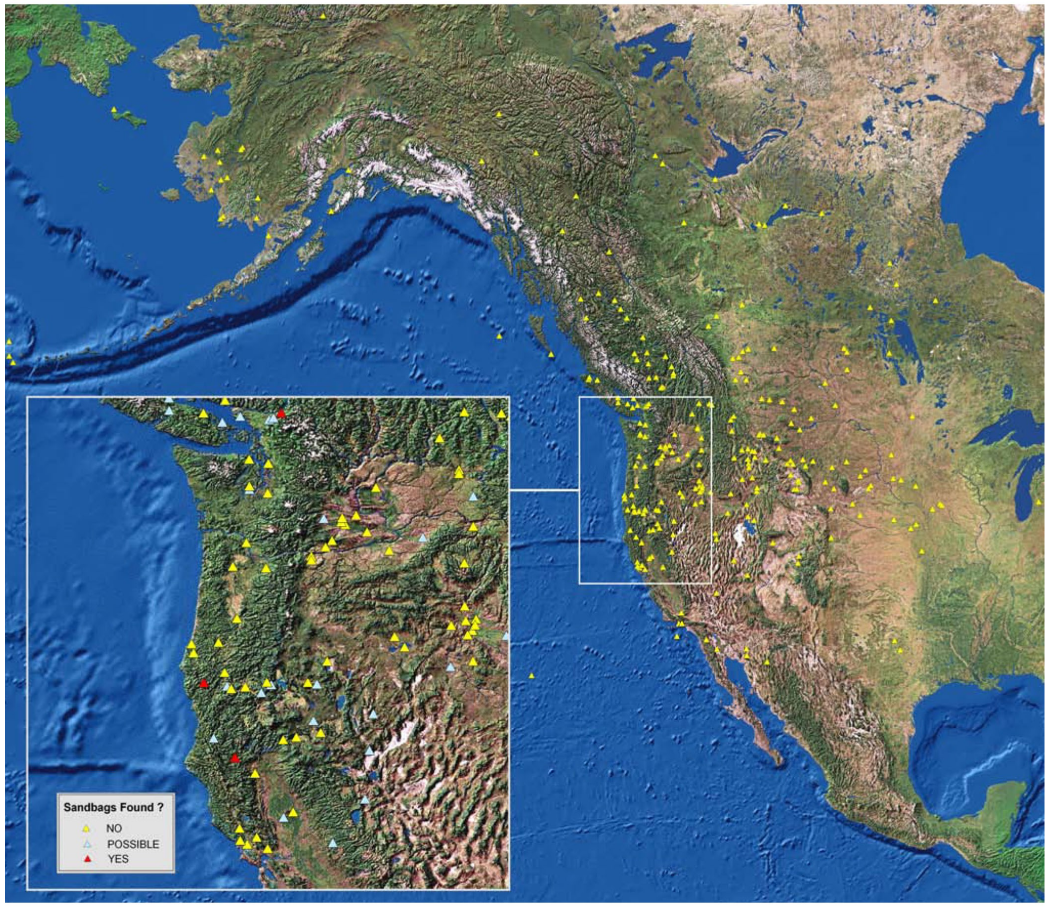


Figure 10. Balloon bomb incidents in North America marked by triangles; red triangles indicate that sandbags were found, from poster by Dave Tewksbury, Department of Geosciences, Hamilton College, Clinton, New York .

While damage created by the balloon strikes was low, authorities worried that some might get "lucky" and also worried that balloons carrying biowarfare agents could be a real threat. Colonel Sidman Poole, U.S. Army Intelligence and military liaison to the U.S. Geological Survey's Military Geology Unit, came to the Survey from the War Department with a bag of sand and asked where the sand came from. At the time, it was inconceivable that balloons could have travelled 5,000 miles from Japan. It was thought that the balloons must be coming from North American beaches, launched by submarine parties. Wild theories speculated secret launches from U.S. German prisoner of war camps or even Japanese-American internment centers.

Fortunately, during the war years, the U.S.G.S. was staffed with paleontologists and mineralogists who were preeminent in their fields. These included paleontologists Ken Lohman, a diatoms specialist, Ken's wife Kathryn Lohman, a Foraminifera specialist, Julia Gardner, a mollusks specialist, and mineralogist Clarence Ross. Clarence Ross found the sand to be unlike any in North America or the Pacific islands. It contained igneous and metamorphic minerals such as hypersthene, augite, hornblende, garnet, high-titanium magnetite, and high-temperature quartz; hypersthene, a mineral common in the andesitic and basaltic volcanic rocks of northeastern Japan, comprised fifty-two percent of the total.

Ken Lohman examined the sand and found it to contain a hundred different species of recent and fossil diatoms; it was obviously beach sand. Julia Gardner searched the samples for reef coral fragments; such corals did not grow in the cold waters north of the 35th parallel, the latitude of Tokyo. The sand did not contain corals. The Foraminifera examined by Kathryn Lohman contained species known only from the east coast of Japan north of Tokyo. Further study by Ken Lohman found the fossil diatoms to be Pliocene in age and with the same species as found in the sands of the beach at Shiogama close to Sendai and the Ninety-nine League Beach at Ichinomiya, some one hundred miles to the south. Armed with this information, photoreconnaissance found the balloon plant and, according to Ken Lohman's quote as published by McPhee, "Jimmy Doolittle went over and bombed the … out of the place." B-29s then destroyed two of the three hydrogen plants that supplied the balloon project. This destruction, coupled with the U.S. press blackout on balloon incidents (the Japanese learned of only one), ended the balloon launches and averted a feared balloon-borne bacteriological attack.

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SAVING EARTH HISTORY AT THE MUSEUM OF MISSISSIPPI HISTORY

David T. Dockery III, Office of Geology

Zachary Musselman, Geology Department, Millsaps College

I (Dockery) received a request on March 26, 2014, to look at fossil shells at the excavation site of the Museum of Mississippi History to see if they should be salvaged. Meeting me at the site were Richard Horton (Thrash Commercial Contractors), Rick Snowden (Deputy Executive Director of the Department of Finance and Administration), Sherri Hilton (Director of Communications, Department of Finance and Administration), and John Sprayberry (Bureau of Buildings) (Figure 1).

Figure 1. Fossiliferous Yazoo Clay at the construction site of the Museum of Mississippi History. The gray clay at bottom is unweathered and contains chalky fossil shells; above this is brown weathered clay with a potential to swell and shrink. From left to right are Richard Horton (Thrash Commercial Contractors), John Sprayberry (Bureau of Buildings), Sherri Hilton (Director of Communications, Department of Finance and Administration), and Rick Snowden (Deputy Executive Director, Department of Finance and Administration). Picture was taken on March 26, 2014.

The fossils were chalky ghosts of former sea shells in the unweathered (gray) part of the Yazoo Clay (Figure 2). I explained that the chalky Yazoo Clay shells were not of interest, but that those below in the Moodys Branch Formation, a nearshore marine sandy interval, were of interest. I requested that Richard Horton notify me when they began drilling the holes for the foundation piles. On April 23, 2014, Richard sent me an email stating: "I wanted to let you know that we have started drilling in the parking garage area. Just give me a call when you want to come out." I came out the next day and showed Richard, and the operator of the front end loader, the drill interval with the fossiliferous sand. They loaded my pickup truck to the limit with about 1,500 pounds of sand (Figure 3) and loaded it full again the next day. These loads were placed under a shade tree near a water connection to be wet sieved for fossil shells (Figure 4).

Figure 2. Yazoo Clay with a fossil pen shell in upper right of the species *Atrina jacksoniana* Dall, 1898. Picture was taken on March 26, 2014.

Figure 3. Left: Auger drill hole for pile is bringing up the fossiliferous sands of the Moodys Branch Formation. Right: Front end loader delivers a 1,500-pound load of Moodys Branch Formation sand to a pickup truck. Picture was taken on April 24, 2014.

Figure 4. Left: Sieving operation and 3,000-pound pile of Moodys Branch Formation on tarps beneath shade tree. Right: Close-up view of sieve, vegetable washer, and washtub below to collect the fine fraction for re-sieving. Pictures were taken on April 26, 2014.

Even though the auger bit destroyed most of the large shells, many small shells remained intact. Two fossils that were immediately seen at the site were the marine snail *Calyptraphorus stamineus* and the coral *Flabellum cuneiforme wailesi*. The subspecies of the latter was named in honor of B. L. C. Wailes, who drew four plates of fossil shells from the Moodys Branch Formation (Figure 5) for his book on the *Agriculture and Geology of Mississippi* published in 1854. These fossils lived at a time some 38 million years ago before there was a land isthmus connecting North and South America and when the Gulf of Mexico and Caribbean Sea were connected to the Pacific Ocean. The closest living relative to *Calyptraphorus* is the genus *Tibia*, which lives in the western Pacific Ocean, Indian Ocean, and Red Sea (Figure 6).

Figure 5. Fossils collected from the Moodys Branch Formation at Jackson, Mississippi, as illustrated by B. L. C. Wailes in his book on *The Agriculture and Geology of Mississippi* (1854, plates 14-17).

Figure 6. Top: *Calyptraphorus stamineus* (Conrad, 1856) from the Moodys Branch Formation (38 million years old) in pile borings at the construction site of the Museum of Mississippi History in Jackson, Mississippi. Web images: Bottom left: Living relative from the Japan and South China Sea, *Tibia martinii* Marrat, 1877. Bottom right: Living relative from the North Indian Ocean and Red Sea, *Tibia insulaechorab* Roding, 1798.

When former Mississippi Governor William Winter took an interest in salvaging fossils from the site, Richard Horton arranged to deliver two 5-yard-dump-truck loads to the grounds of the Mississippi Museum of Natural Science (Figure 7). The grain-size analysis of the Moodys Branch Formation sediments shown in the histogram in Figure 8 was done at the Millsaps College Geology Department laboratory. Here a sample of approximately 115 grams was dried in an oven for 24 hours at 100°C, cooled, disaggregated using a mortar and pestle, and mechanically sieved with a Ro-Tap for 10 minutes. Each size fraction was weighed, washed in an acid bath of 20% hydrochloric acid until no further reaction was detected, and weighed again. The percentage of soluble residue in blue represents the mass of dissolved fossil shells. The insoluble residue in yellow in the very-coarse and coarse sand fractions consists largely of grains composed of consolidated clay and silt. The medium sand fraction is a mix of quartz sand and consolidated clay and silt grains. The fine and very-fine sand fraction is almost exclusively quartz sand and reflects the true grain size of the Moodys Branch seafloor's quartz sand. This sand was winnowed from eroded deltaic deposits of the underlying Cockfield Formation as the "Moodys Branch Sea" transgressed northward across Mississippi and into southeastern Arkansas and southwestern Tennessee.

Figure 7. Left: William Winter and Richard Horton in front of the 5-yard dump truck designated to transport the Moodys Branch fossiliferous sand. Right: George Phillips and the truck driver after the first load was dumped on the grounds of the Mississippi Museum of Natural Science on May 1, 2014.

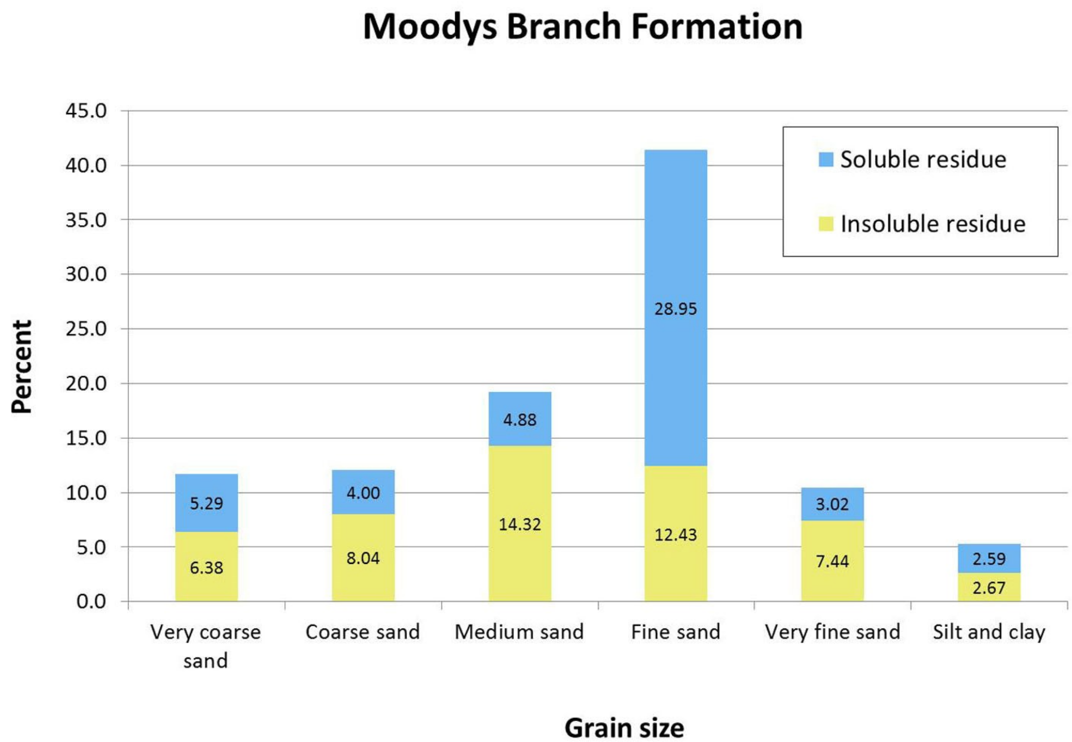


Figure 8. Grain-size analysis of the Moodys Branch Formation from pile borings at the Museum of Mississippi History. This analysis was done at the Millsaps College Geology Department laboratory. The blue soluble residue is from fossil shells.

Information on Earth history obtained from foundation borings at the Museum of Mississippi History construction site adds to the understanding of marine life some 38 million years ago at a time before global cooling, the formation of ice sheets in Antarctica, and associated drop in global sea level. Fossils sieved from salvaged Moodys Branch Formation sediments would make an ideal exhibit on some of Mississippi's really old inhabitants.

MDEQ Outreach

James Starnes from the Office of Geology recently provided a lecture on the wonders of geology and science to the Children's Summer Reading Program at the Eudora Welty Library in Jackson.

Environmental News, July 2014, volume 11, issue 6, pages 18-24

GLOBAL WARMING AND HIGH SEA LEVEL (125,000 YEARS AGO)

David T. Dockery III, David E. Thompson, & Barbara Yassin, Office of Geology

The Eemian Stage of the Pleistocene was first recognized by Harting (1875) from boreholes in the area of Amersfoort, Netherlands, which contained a warm water marine molluscan assemblage that was different from the modern cold-water fauna of the North Sea. In North America, this stage is known as the Sangamonian Stage, or Sangamon Interglacial Stage, the last interglacial warm period before the present. The Sangamon Soil, a paleosol, underlies Wisconsinan loesses or tills in the water wells in northwestern Sangamon County, Illinois. At the Eemian's warmest peak about 125,000 years ago, the hippopotamus was distributed as far north as the Rhine and Thames rivers; trees grew as far north as Baffin Island in the Canadian Arctic Archipelago, and sea level peaked at 5.5 to 9 meters (18 to 29.5 feet) higher than today. This warm period is recorded in Antarctic ice cores (figures 1-2). Evidence for the Eemian sea-level highstand can be found in exposed fossil coral reefs worldwide throughout the tropics, including those of the Bahamas (Figure 3) and Florida Keys. Evidence can also be found in marine terraces along stable continental coastal areas such as that of the Mississippi coast. This sea-level highstand occurred long before the advent of anthropogenic carbon dioxide and indicates that such a sea-level rise could occur in the future for reasons unrelated to carbon dioxide levels.

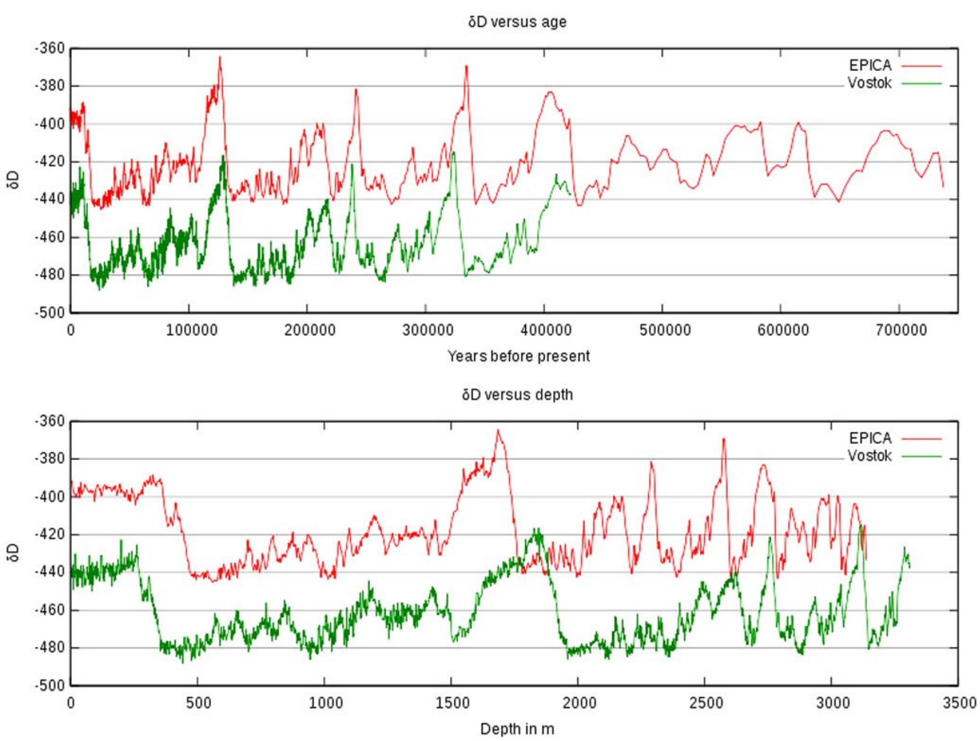


Figure 1. The Eemian Stage is between 1500 and 2000 meters in depth in the EPICA and Vostok ice cores, though a little offset due to problems in correlating depths to ages in the cores. The curves plot delta-deuterium against age and depth; the lower the negative delta-deuterium number, the higher the temperature (toward the top of the graph). In the EPICA curve (in red) the Eemian Stage was significantly warmer that the present interglacial period (from Wikipedia).

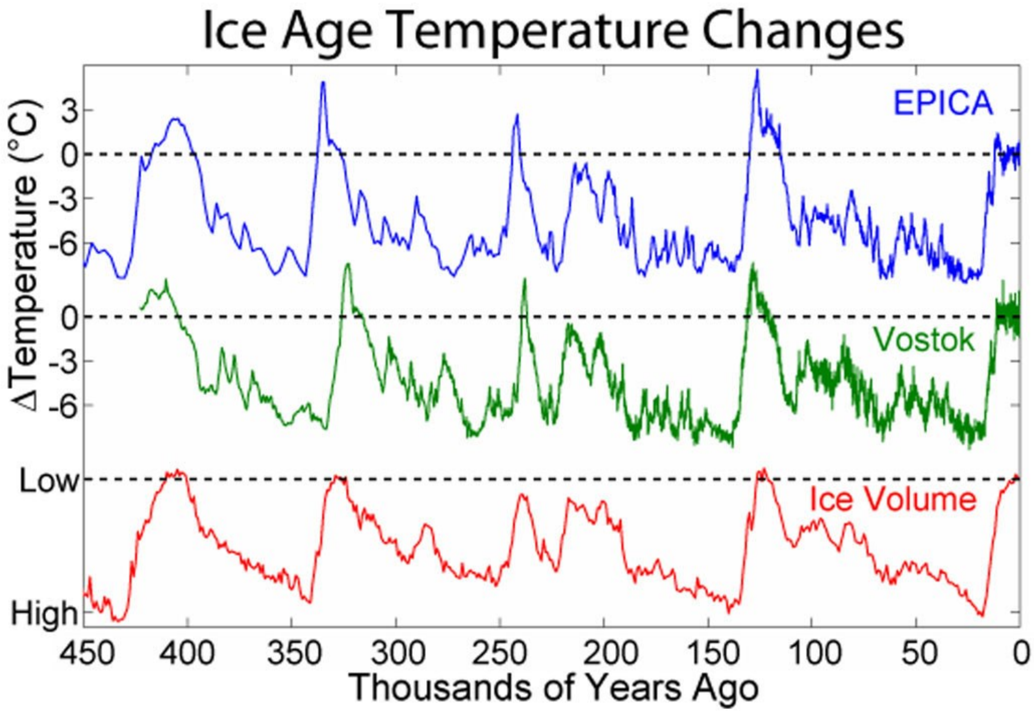


Figure 2. Antarctic temperature changes during the last several glacial/interglacial cycles of the present ice age and a comparison of temperature and ice volume. The upper two curves show local changes in temperature at two sites in Antarctica as derived from deuterium isotopic measurements on ice cores. The warm peak of the Eemian Stage is at 125,000 years (Wikipedia).

Figure 3. An Eemian (Late Pleistocene) fossil coral reef, now above sea level, on Great Inagua, The Bahamas. The foreground shows coral truncated by erosion during Eemian sea level fluctuations; behind the geologist is a post-erosion pillar which grew after sea level rose again (from Wikimedia).

In an article published in the July 13, 2012, issue of *Science* entitled "Ice volume and sea level during the last interglacial," Dutton and Lambeck stated that "During the last interglacial period, ~125,000 years ago, sea level was at least several meters higher than at present, with substantial variability observed for peak sea level at geographically diverse sites." To account for such a rise in sea level would require both the collapse of the West Antarctic ice sheet and the Greenland ice sheet due to small changes in radiative forcing.

Figure 4 is a 1942 aerial photo-mosaic of the Mississippi Gulf Coast in portions of Harrison and Jackson counties. This early photo-mosaic predates much of the recent development and clearly shows beach ridges of Eemian/Sangamonian age, extending from Gulfport to Belle Fontaine. The fluctuating sea level of this period created first the Gulfport beach ridges, which trended southwest to northeast, and then the Biloxi beach ridges, which cut across the Gulfport beach ridges with more of a west-to-east trend. Stewart, Everett, and Marble, in an unpublished map (limited prints made in 2004), recognized 14 coast-parallel terraces in central and southern Mississippi. Figure 5 is a portion of that map, showing the lower 4 terraces: Pamlico 1 at 1-10 feet above msl, Pamlico 2 at 11-30 feet above msl, Wade at 31-50 feet above msl, and Big Point at 51-90 feet above msl.

An island informally named here as the Sandhill Crane Island (an island pointed out to us by Lindsey Stewart) rests on the Wade Terrace; Big Ridge is a westward extension of that terrace with some beach-ridge highlands on its western end. Figure 6 is a lidar-data-derived relief map of the Mississippi coast in parts of Harrison and Jackson counties. This image shows the Gulfport and Biloxi beach ridges in great detail and Big Ridge and the Wade Terrace highlands associated with Sandhill Crane Island, which diverges from Big Ridge in a westerly direction. Dr. Ervin Otvos (1975) recognized the Gulfport and Biloxi beach ridges to be of Sangamon age and named these structures the "Gulfport Formation." Underlying this formation, Otvos described a fossiliferous marine unit of Sangamon age, which he named the "Biloxi Formation."

Figure 4. A 1942 aerial photo-mosaic of the Mississippi Gulf Coast in portions of Harrison and Jackson counties. Beach ridges from Eemian/Sangamonian Stage can be seen at Belle Fontaine on the east and along the Biloxi coast where they cut across older southwest-northeast-trending ridges at Gulfport on the west. The Biloxi beach ridges deflect the Biloxi River from a north-south, to a west-to-east course (image from the Mississippi Department of Marine Resources).

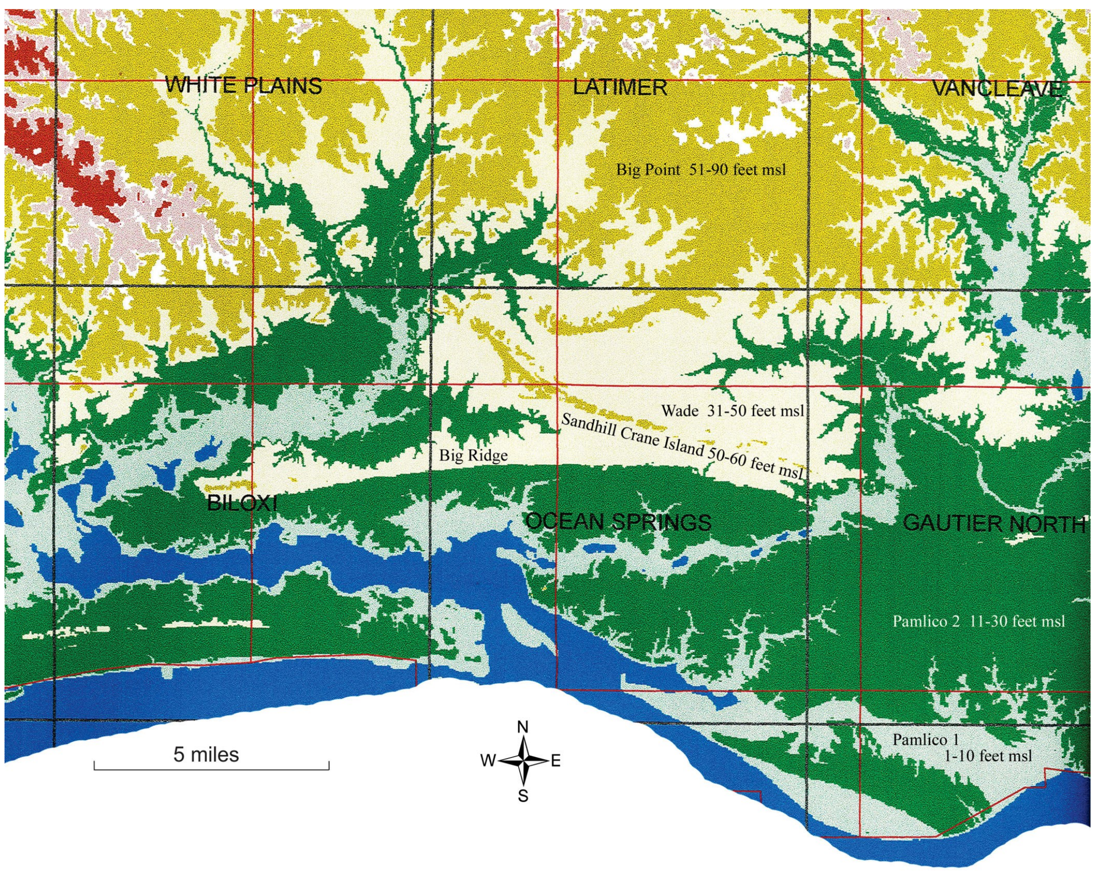


Figure 5. Coastal marine terraces as mapped by elevation data, unpublished map by Stewart, Everett, and Marble (limited prints made in 2004). From lowest to highest elevation, these include Pamlico 1 from 1-10 feet above msl, Pamlico 2 from 11-30 feet, Wade from 31-50 feet, and Big Point from 51-90 feet. Extending westward from the Wade Terrace is Big Ridge with a wave-cut southern margin; perched on the Wade Terrace is the Sandhill Crane Island from 50-60 feet.

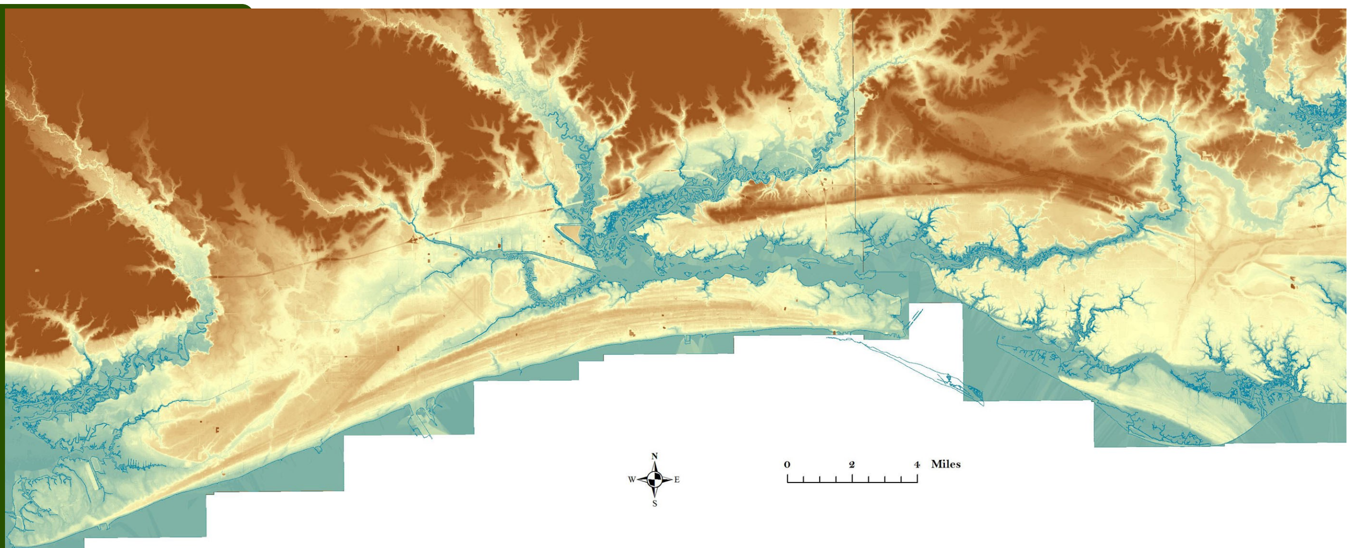


Figure 6. Lidar-data-derived relief map of the Mississippi coast in parts of Harrison and Jackson counties, showing the Gulfport and Biloxi beach ridges and Big Ridge and the Sandhill Crane islands, which converge to the east near their common source. Sequence of events: (1) an old course of the Pascagoula River provided sand to east-to-west longshore currents, creating Sandhill Crane Island and then (2) Big Ridge, (3) the Biloxi River provided sand for the Gulfport beach ridges and then (4) the Biloxi beach ridges, and (5) a later course of the Pascagoula River, visible in high-standing levee deposits, created the Belle Fontaine delta, which was reworked into the Belle Fontaine beach ridges.

Figure 7 is a series of 3 images, which, from top to bottom, gives the coastline after sea-level rises of 16 feet, 25 feet, and 47 feet. At a sea-level rise of 16 feet, the crests of beach ridges at Belle Fontaine appear as barrier islands. At a sea-level rise of 25 feet, the crests of the Gulfport and Biloxi beach ridges appear as barrier islands, and the western end of Big Ridge appears as a spit along a wave-cut shoreline. Islands to the east are levee deposits of an old course of the Pascagoula River, which fed the Belle Fontaine delta. At a sea-level rise of 47 feet, Sandhill Crane Island is visible along with a spit behind the island, extending westward from the mainland, and a barrier island is visible on the western end of Big Ridge. Also at this highstand, irregularities in the coastline between embayed river and stream valleys smooth out to form a linear shoreline.

Figure 8 shows the Point Clear delta of the Pearl River, where truncation of levee deposits associated with an abandoned course of the Pearl River in Hancock County formed barrier spits east and west. Lower on the delta plain are other southeast-northwest trending islands.

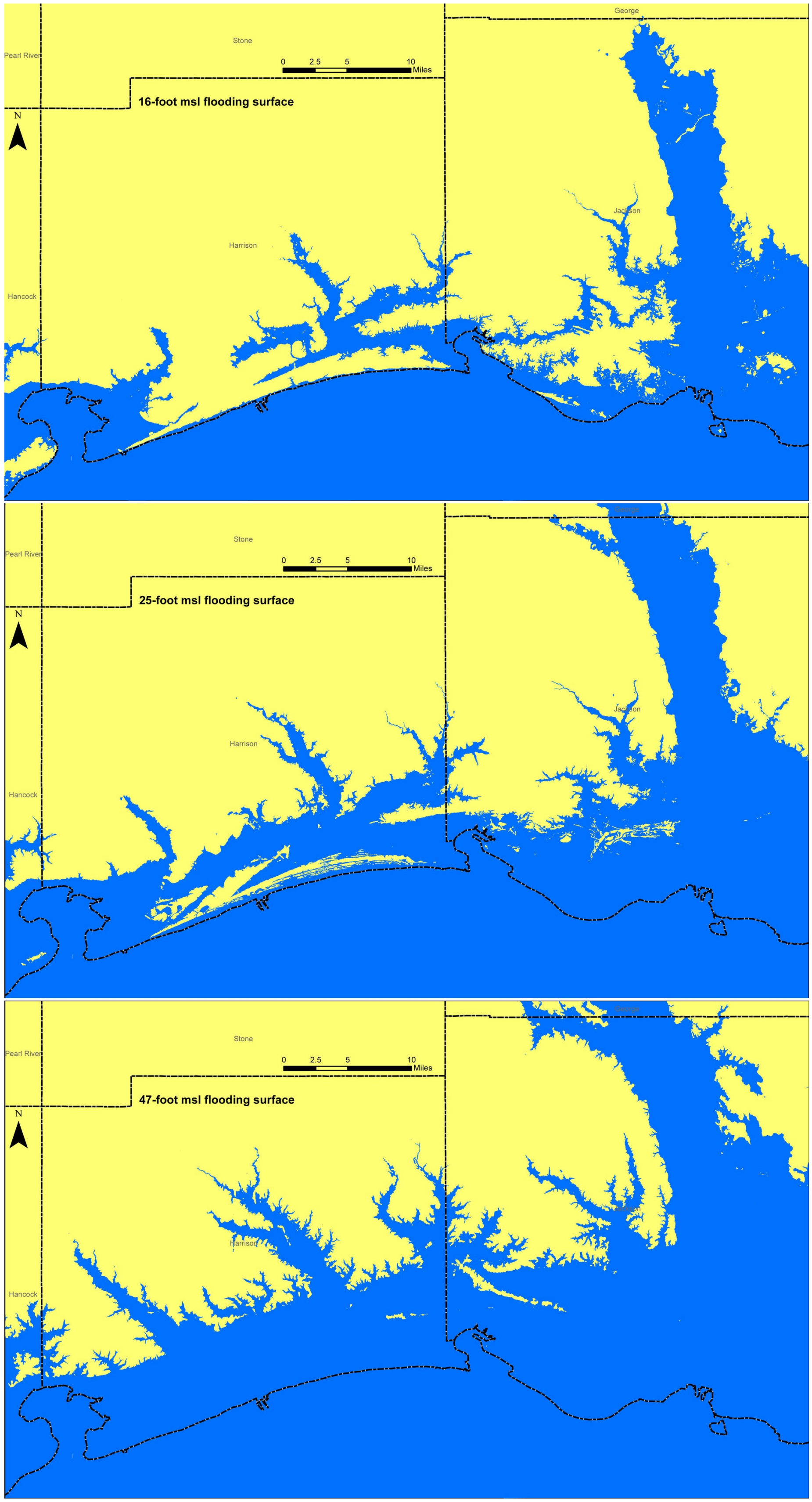


Figure 7. From top to bottom, sea-level rises of 16, 25, and 47 feet show, repectively, the island crests of the (1) Belle Fontaine and (2) Gulfport-Biloxi beach ridges, and (3) Sandhill Crane Island.

The morphology of Mississippi Gulf Coast landforms, created during the Eemian/Sangamon Interglacial period, gives evidence of sea-level rises of: (1) a few feet for the beach ridges on Belle Fontaine in Jackson County and the islands on the Clear Point delta of the Pearl River in Hancock County, (2) over 20 feet for the Gulfport and Biloxi beach ridges in Harrison and Jackson counties, and (3) as high as 47 feet for Big Ridge and Sandhill Crane Island in Harrison and Jackson counties. Yet this "run-away" event in global warming did not prevent the subsequent 100,000-year-long ice age known as the Wisconsin Glacial Episode, which reached its maximum extent only 18,000 years ago and dropped sea level as much as 115 meters, or 377 feet, below present sea level.

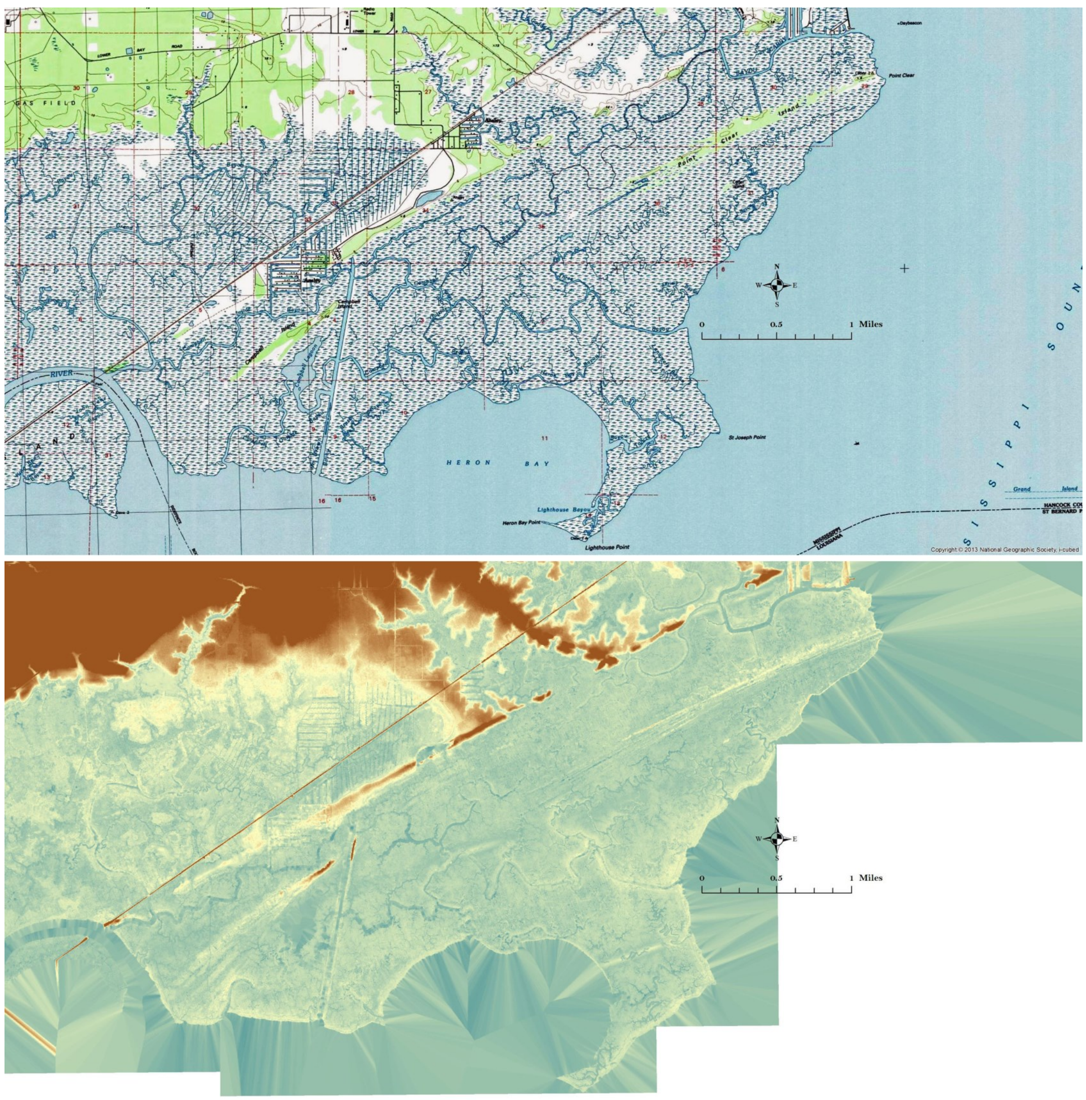


Figure 8. Shoreline prominence in Hancock County at the Point Clear delta of the Pearl River; high ground in brown on the lidar image (bottom) shows the southeastern course of the river's levee deposits, truncated to form southwest-northeast trending barrier islands. Lower on the delta plain are Campbell Island to the west and Point Clear Island to the east (Point Clear Topographic map at top).

JUST GEOLOGY 2012-2013

Just Geology 2012-2013 is a collection of the geology articles from the MDEQ newsletter for the years given. It is available on the MDEQ web site under the Surface Geology Division and then under Downloadable Publications:

http://www.deq.state.ms.us/MDEQ.nsf/pdf/Geology_JustGeology2012_2013/$File/JustGeology2012_2013.pdf?OpenElement


VOLUMES 9-10
2012-2013
JUST GEOLOGY
FROM THE PAGES OF
ENVIRONMENTAL NEWS
MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

Figure 1. Left: Exposure of Glendon Limestone on the east bank of the Mississippi River beneath the Interstate 20 bridge at Vicksburg. Right: An island of Glendon Limestone in a laterally displaced and down-thrown block, rising out of the river on the south (left) end and plunging beneath the water on the north end in front of Pier E-1 of the I-20 bridge. Here the top ledge of limestone in the adjacent river bank reappears as a doubly plunging anticline. Picture on left was taken on October 15, 2012, and the picture on the right was taken on August 14, 2012.

Figure 2. Drilling rig drilling on an island capped by Glendon Limestone in the Mississippi River at Pier E-1 of the Interstate 20 bridge at Vicksburg. At left, the Glendon Limestone plunges below the river level on the south end of an anticline. At right, the vertical pipe behind the rig contains a tiltmeter that measures lateral movement below ground. Pictures were taken on October 15, 2012.

Environmental News, August 2014, volume 11, issue 7, pages 15-18

SAND DUNE SINKHOLES

David T. Dockery III, RPG, Office of Geology

Mount Baldy at Indiana Dunes National Lakeshore remained off-limits indefinitely after the popular attraction swallowed up six-year-old Nathan Woessner in a sinkhole on July 12, 2013. Firefighters rescued the boy after he was trapped for three and a half hours under 11 feet of sand (Figure 1). Two additional sinkholes have appeared on the sand dune since that time (Figure 2). Research by the Environmental Protection Agency identified a large number of anomalies below the dune's surface using ground-penetrating radar. Scientists report that the narrow sinkholes last less than 24 hours before they collapse and fill with the surrounding sand (National Park Traveler, April 26, 2014).

Figure 1. July 12, 2013, photo shows rescue workers with heavy equipment working to free 6-year-old Nathan Woessner from a sinkhole in massive sand (AP Photo/The News Dispatch, Julie McClure).

Figure 2. Left: Depression on the surface of Mount Baldy leading to a hole below. Right: A narrow deep "sinkhole" on Mount Baldy. Pictures from web images.

The sand dunes at Indiana Dunes National Lakeshore were formed some 14,000 years ago. Most are now covered in forest, with the exception of one 124-foot-high dune named Mount Baldy that is a big pile of sand with no grass and a few scruffy trees. Around 200,000 people visit this park every year, mostly to climb on Mount Baldy. Professor of Geosciences Erin Argyilan (Indiana University Northwest) was doing a wind study on Mount Baldy when Nathan Woessner went into an area blocked off for restoration to inspect a small depression. The depression suddenly gave way. Argyilan thought Nathan's parents were mistaken when she heard them screaming and pointing to the place their son disappeared. Narrow deep holes contradicted everything she knew about sand dunes. Based on discussions with other geologists, the best answer is that the holes are caused by decomposing trees buried under the dune for nearly a century. The wet conditions during the spring of 2013 may have caused the decomposed trees to become unstable to the point of collapse, creating holes at the surface. Oregon residents claimed to have seen the same thing happen in sand dunes on the Pacific Coast (Baffling, Boy-Swallowing Holes Close an Indiana Dune, Lindsey Smith, NPR, May 8, 2014). Figure 3 shows sand dunes encroaching on dead trees along Shackleford Banks, North Carolina.

Figure 3. Sand dunes encroaching on dead trees, killed when their roots became buried, on Shackleford Banks, North Carolina. Picture was taken in 1977.

Recent events concerning "sand dune sinkholes" in Indiana may explain the sand-filled molds that preserve 300-million-year old *Lepidodendron* logs in Mississippi (Figure 4) and elsewhere. Figure 5 shows the sandstone-filled trunk and root of a related Pennsylvanian tree *Sigillaria* from the Joggins Formation in the Joggins Cliffs on the Bay of Fundy in Nova Scotia. Stumps of some of the Joggins trees contain the bones of amphibians and early reptiles. One possibility is that these animals were living in hollow stumps and were buried by sediment-laden flood waters. Another is that they were walking across a depression on an ancient sand dune and fell down a rotten-tree sinkhole.

Figure 4. I. E. Gresham and grandson beside a recently-quarried sand-filled *Lepidodendron* log in the Hartselle Sandstone at the Gresham Quarry in Tishomingo County, Mississippi. Picture (black-and-white negative; Image 849) taken by Ed Blake on June 3, 1966.

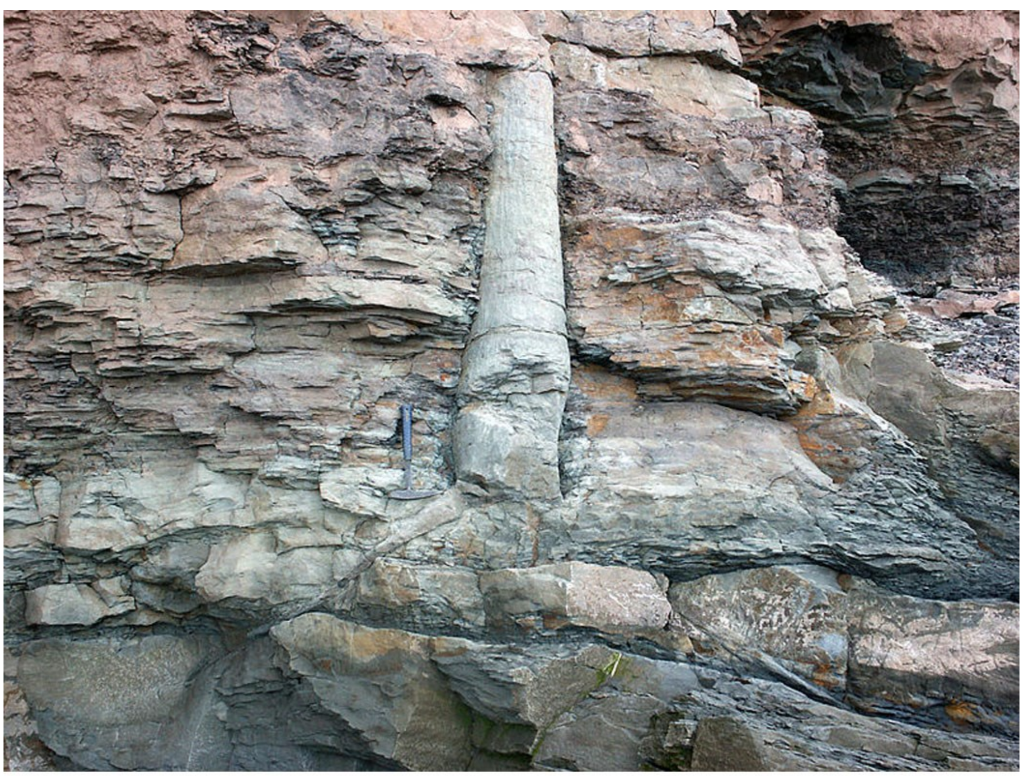
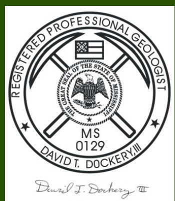


Figure 5. Trunk and roots of the Pennsylvanian tree *Sigillaria* in the Joggins Formation at Joggins Cliffs on the Bay of Fundy in Nova Scotia. Image from Wikimedia Commons.

Environmental News, October/November 2014, volume 11, issue 8, pages 9-12



GEOLOGIC MAPPING AND ENERGY RESOURCES

David E. Thompson, RPG and David T. Dockery III, RPG, Office of Geology

Ken Burns' recent series on PBS, *The Roosevelts*, showed the accomplishments of the Works Progress Administration (WPA) in building roads, bridges, and airports across the country and even creating art projects for out-of-work artists. What is less well known is that in the late 1930s the WPA provided $106,193 to the Mississippi Geological Survey to do geological surveys of 10 counties. To obtain these funds, the State Geological Survey, as sponsor, pledged to contribute $12,768 of that amount. The State Legislature appropriated less than $4,000 to cover the state's share; consequently, it was necessary for the counties to act as cosponsors and provide the balance of $9,000. The counties responded, and the State Geological Survey's pledge was paid in full. Yazoo County was the second county in the survey. Financial support for this work was provided by Yazoo County, Yazoo City, and the Chamber of Commerce under the leadership of Secretary K. S. Foster. In February of 1939, State Geological Survey geologist Fred Mellen discovered an outcrop of the Moodys Branch Formation on Perry Creek in Yazoo County at an elevation 250 feet above its normal position. Recognizing that this structure might have oil and gas potential, it was reported in a press release dated April 12, 1939. Union Producing Company leased the area over the structure and completed the G. C. Woodruff No. 1 well, the first commercial oil well in Mississippi, just four and a half months after the press release. Tinsley Field in Yazoo County would prove to be the largest oil field in Mississippi with a cumulative production of over 200 million barrels of oil and the potential for another 46 million barrels with tertiary recovery (carbon dioxide injection).

Tinsley Field was a huge return on Yazoo County's financial investment in geology and set off an oil exploration boom that benefited the state as well. Tinsley proved the value of geologic mapping in the discovery of new oil-bearing structures, something already known by major oil companies who had their own field-mapping geologists working in Mississippi. Cooperation between the State Geological Survey, the oil and gas exploration industry, the U.S. Geological Survey, and the Mississippi Geological Society resulted in the production of Mississippi's first statewide geologic map at a scale of 1:500,000 in 1945.

Currently, the U.S. Geological Survey contributes around $5.5 million per year in matching funds through the STATEMAP program to state geological surveys for geologic mapping. Mississippi has received $1,752,468 in matching federal funds (from 1994-2014) for geologic mapping through STATEMAP grants.

Dudley Hughes in *Oil in the Deep South* (University Press of Mississippi, 1993) gave an account of Gulf Refining Company's geologic mapping work in Mississippi in 1929 and 1930, some nine years before Mellen discovered Tinsley Field. Bud Norman was on one of Gulf's two-man teams mapping the Yazoo Clay outcrop belt though southeastern Mississippi. According to Hughes, "Bud's team discovered a wide arc in the Yazoo Clay outcrop circling the town of Heidelberg. This later proved to be the result of a large buried structure that formed the trap for the Heidelberg Field, to be discovered 14 years later." Gulf checked with geophysical work to confirm the structure, but it was Bud's surface mapping work that brought it to the company's attention originally. The "wide arc" in the Yazoo Clay outcrop discovered by Bud Norman's mapping team can be seen in a new color version of DeVries' 1963 *Geologic Map of Jasper County Mississippi* in Mississippi Geological Survey Bulletin 95 entitled *Jasper County Mineral Resources*.

The map in Figure 1 adds to Hughes' account; while Bud's surface mapping may have focused on the Yazoo Clay outcrop belt, the actual arc that defined the Heidelberg structure was the outcrop belt of the overlying Forest Hill Formation depicted in yellow. Figure 2 is a close up view of the map with an overlay of the Heidelberg East and West fields. Interstate 59 crosses the midsection of both fields and splits the middle of the Yazoo Clay outcrop belt's "wide arc." Figure 3 is an overlay of the Heidelberg fields, associated faults, and contours on the top of the uplifted Cretaceous section (Selma Chalk) underlying the "wide arc" (contour and fault overlay from Puckett, Bearden, Mancini and Panetta, 2000, Topical Report 3—Petroleum Plays and Underdeveloped Reservoirs in the Mississippi Interior Salt Basin).

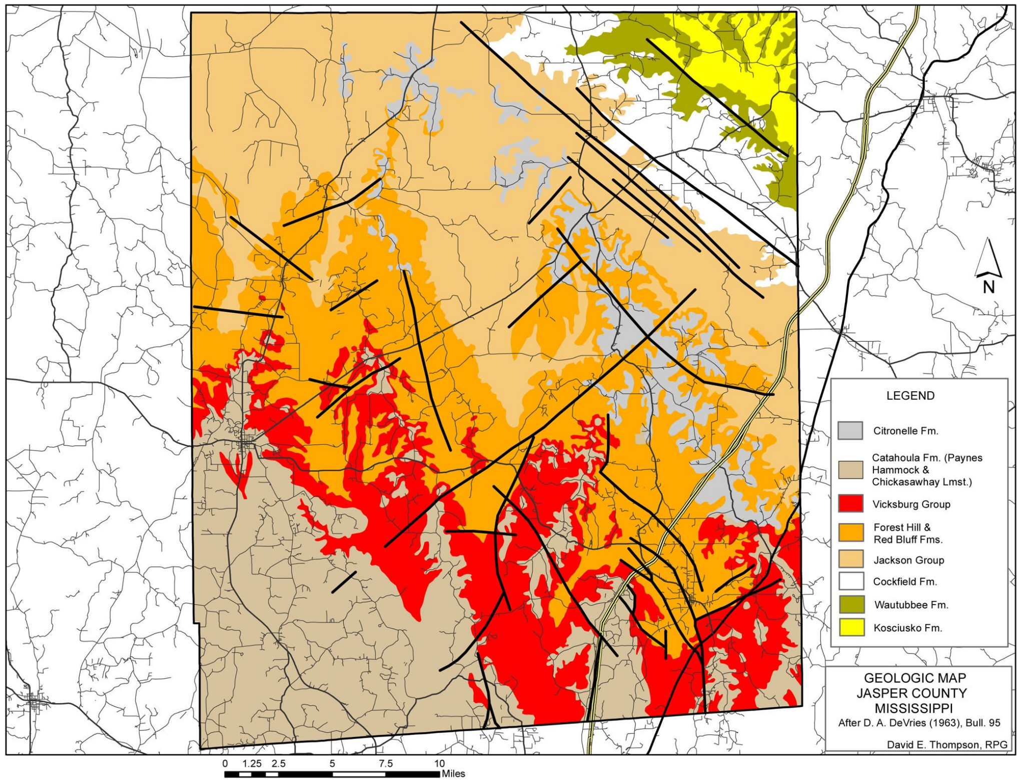


Figure 1. Color version of DeVries 1963 black and white *Geologic Map of Jasper County Mississippi*, showing the "wide arc" in the Yazoo Clay outcrop belt around Heidelberg, Mississippi.

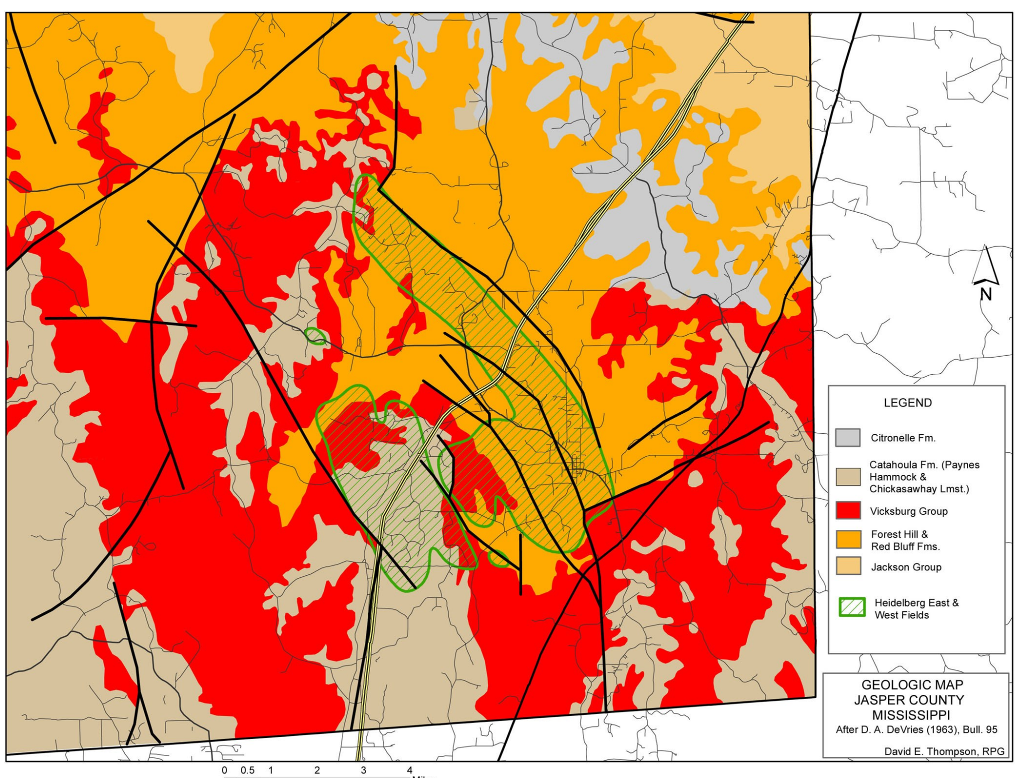


Figure 2. Enlargement of the southeast corner of the *Geologic Map of Jasper County Mississippi*, with Heidelberg East and West fields overlain on the "wide arc" in the Yazoo Clay outcrop belt. Interstate 59 splits the middle of the fields and the arc.

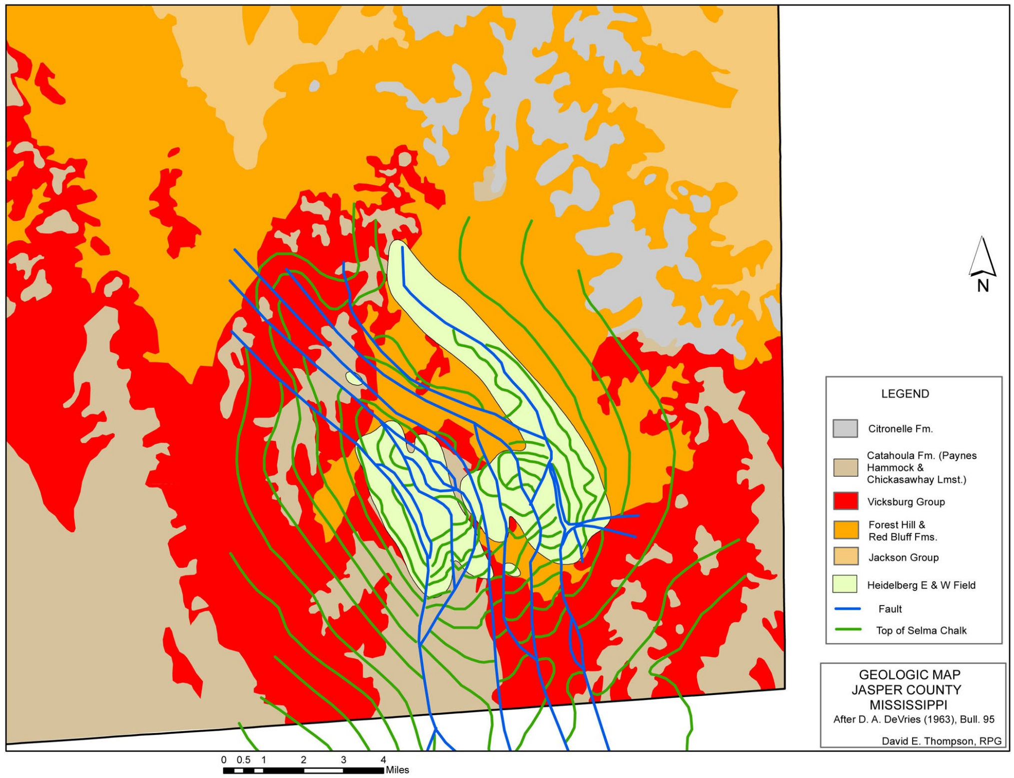


Figure 3. Heidelberg East and West fields, associated faults, and contours of the uplifted Cretaceous section overlain on the “wide arc” in the Yazoo Clay outcrop belt.

Geologic mapping and the discovery of the Heidelberg East and West fields have resulted in the production of over 140 million barrels of oil. Denbury Resources has contracted with the Kemper County (Mississippi) Power Plant under construction to purchase the plant’s “anthropogenic” carbon dioxide for use in tertiary oil recovery from Heidelberg and expects to produce another 44 million barrels of oil.

Environmental News, January 2015, volume 12, issue 1, pages 14-18

GEOLOGIC MAPPING AND LIGNITE RESOURCES

David T. Dockery III, RPG, and David E. Thompson, RPG, Office of Geology

Mississippi lignite deposits were recognized as an important resource early in the state's history. Lignite seams were mentioned in the earliest books on the state's geology, including Wailes (1854), Harper (1857), Hilgard (1860), and Crider (1906). It was also the subject matter of Bulletin 3 of the Mississippi Geological Survey by Calvin S. Brown in 1907 entitled *The Lignite of Mississippi*. In 1973, the Mississippi Geological Survey (MGS) was supported in part by a grant from the Mississippi Research and Development Center to investigate Mississippi's lignite resources. MGS geologist David Williamson vacated his work on the geology of Clarke County to lead the lignite investigation. The results of this work, which included many core-hole records of lignite occurrence, were published as Information Series MGS-74-1 (Williamson, 1976) under the title *An Investigation of the Tertiary Lignites of Mississippi*. Demand for this publication was high, and the book quickly sold out. Figure 1 is a map of statewide lignite prospect regions, which was developed through a combination of state and private industry drilling activity.

In 1989, a revision of geologic mapping was underway in the early Tertiary Midway and Wilcox Groups of Mississippi, a geologic section that is notable for its lignite occurrences. In fact, Wilcox Group was named the Lignitic Stage by Harris (1903) for the common occurrence of lignite seams. The stratigraphic revisions utilized for this geologic section discontinued the antiquated provincial stratigraphic formations used in Mississippi in favor of the classic Alabama stratigraphy of the type Midway and Wilcox sections. Figure 2 illustrates how geologic formations in the Midway-Wilcox section had differing naming schemes along either side of the Alabama-Mississippi state line. An open-file report in 1982 by U.S. Geological Survey geologists reported that a lignite seam in the Naheola Formation of the Midway Group in Alabama was the same lignite seam that was found in the Fearn Springs Formation of the Wilcox Group in Mississippi. This miscorrelation created an artificial state-line fault, and clouded proper stratigraphic correlations across the region (Figure 2).

Major Lignite Prospects of Mississippi

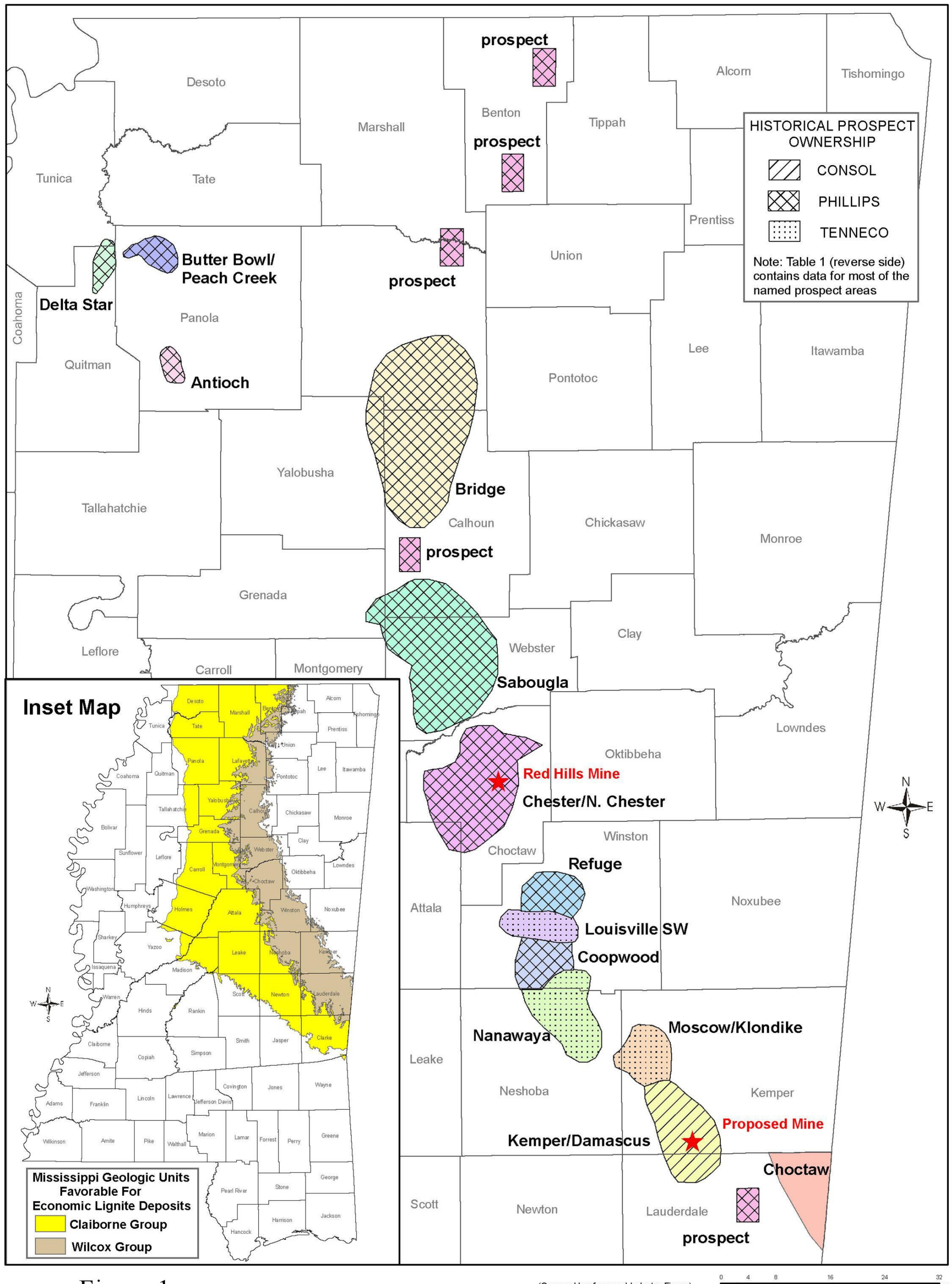


Figure 1.

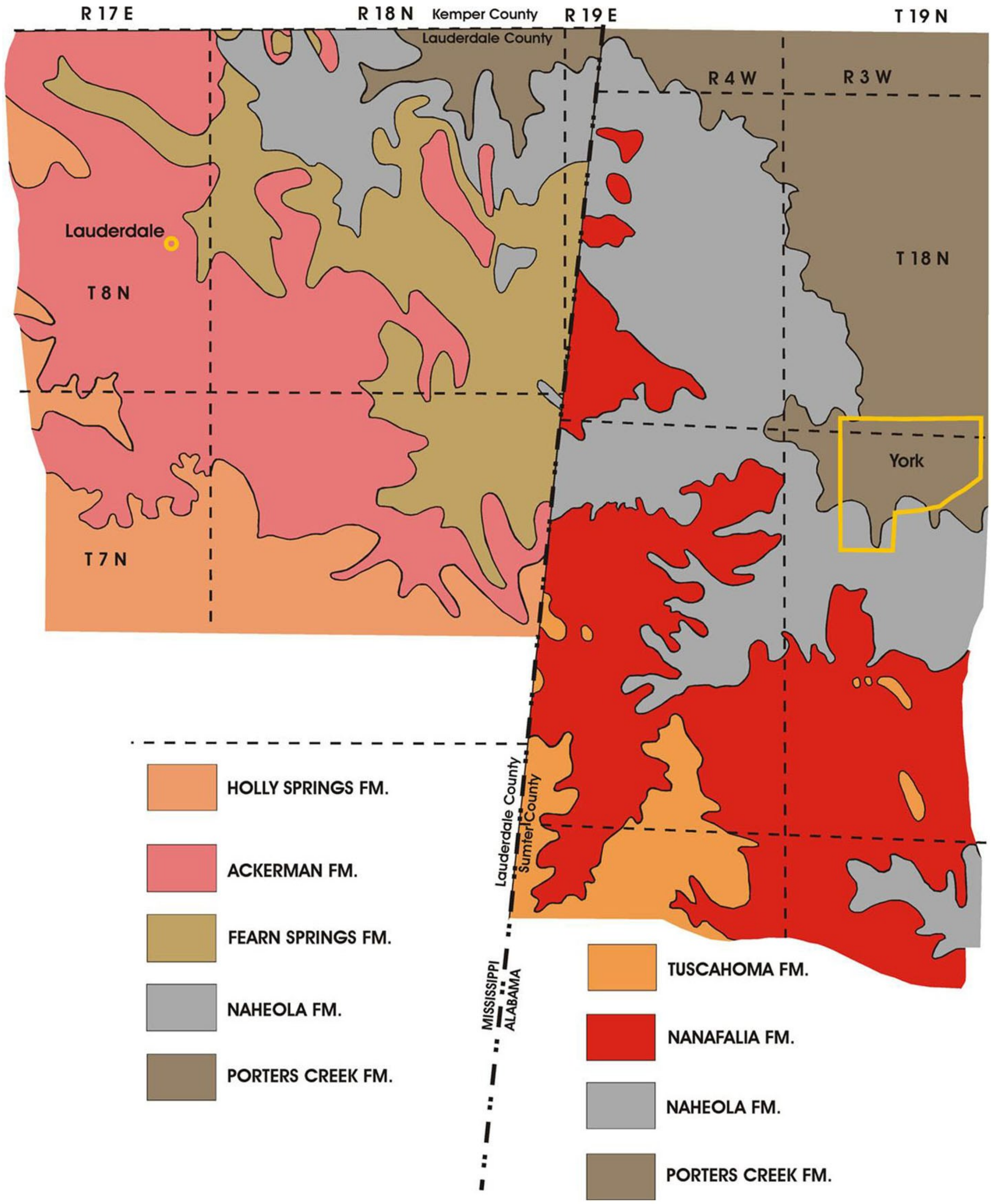


Figure 2. Right, geologic map of Sumter County, Alabama. Left, geologic map of Lauderdale County, Mississippi, published in 1940.

The first state and federal cooperative geologic mapping agreement under the U.S. Geological Survey COGEOMAP grant was to remap the Naheola Formation (of the Midway Group) in Mississippi. This formation was selected for detailed mapping based on its mineral resources (lignite, iron ore, bauxite, ceramic clay, heavy minerals, and groundwater recharge implications) and the premise that it was incorrectly mapped on the state geologic map. Phillip Weathersby and Wayne Stover (both still employed by MDEQ) were given the difficult task of mapping this formation in the field. Dr. Ernie Russell of Mississippi State University's Geology Department made many trips to the field to assist with this mapping effort. Phillip and Wayne would later find themselves coring commercial clay deposits in the Midway-Wilcox groups with funding from the Millsaps College Geology Department.

Figure 3. From left to right, Bill Gilliland, David Dockery, Wayne Stover, and Phillip Weathersby at coring site to sample commercial ceramic clay in the Naheola Formation. Picture was taken in April of 1990.

In 1996 under the U.S. Geological Survey STATEMAP grant, David Thompson and George Puckett mapped the Midway and Wilcox groups in the DeKalb Quadrangle in Kemper County. David Thompson continued this effort, quadrangle by quadrangle, across northeastern Mississippi from the Alabama to the Tennessee state line.

Several hundred lignite test-hole geophysical logs were provided by North American Coal Corporation and were important aids in maintaining stratigraphic control. Equivalent lignite seams were correlated over substantial distances, and the base of the J seam of the lower Tuscahoma Formation was included on certain geologic quadrangle maps as a dashed line. Early quadrangle mapping in the STATEMAP 1996 grant included the Tomnolen (Open-File Report OF-54) and Reform (OF-55) quadrangles, quadrangles important to Mississippi's energy development in the Chester Lignite Prospect.

Several years ago former MDEQ director Charles Chisolm gave department supervisors a memorable talk on Stephen Covey's (author of the bestseller *The 7 Habits of Highly Effective People*) quadrant matrix, which exhibited how people typically spent time at work. Chisolm suggested that we spent too much time in Quadrant I, reacting to crises, pressing problems, and deadlines. Quadrants III and IV were filled with unnecessary reports, trivial busywork, and irrelevant phone calls and emails. Rather, Chisolm said that we should be working in Quadrant II, a quadrant of preparation, prevention, and planning. Those who worked in Quadrant II spent less time in Quadrant I because they were prepared for crisis moments. While MDEQ's Office of Geology was mapping the most difficult geology in the state because it had important resources and needed revision, we were also fortuitously mapping Mississippi's energy future. After a hundred and fifty years of lignite research by the Mississippi Geological Survey/MDEQ Office of Geology, the development of the initial box-cut of the Red Hills Lignite Mine began in April of 1999. The mine's footprint was within the Tomnolen and Reform quadrangles. The geology section of the mine's permit adopted David Thompson's stratigraphic correlation of lignite seams and recently-completed surface geology (Figure 4).

Figure 4. Lignite seams in the Red Hills Lignite Mine as pointed to by James Starnes. Picture was taken on September 29, 2014.

When the Liberty Lignite Mine in Kemper County began operation, we were prepared for that as well. Figure 5 shows the location of the Red Hills and Liberty lignite mines on a composite of geological quadrangle maps. Figure 6 shows the stratigraphy of the lignite seams associated with both lignite mining operations. Today lignite from the ten-foot-thick J seam of the Liberty Lignite Mine is being mined and stockpiled (Figure 7) at the Kemper County Power Generation Plant, near completion. The 5.6-billion-dollar plant includes new clean-coal technology that will transform lignite into synthesis gas as a cleaner fuel for power generation. Sulfur in the lignite will be converted into marketable sulfuric acid. Nitrates in the coal will be converted into marketable nitrate fertilizer, and the carbon dioxide will be sold to Denbury Resources in the company's tertiary oil recovery efforts at Heidelberg Field, a recovery projected to produce 44 million barrels of oil.

Old geologic mapping located lignite mining regions on a thick, undifferentiated sequence of sediments.

New detailed mapping places lignite mining regions in discrete geologic units and allows for recognition of additional deposits.

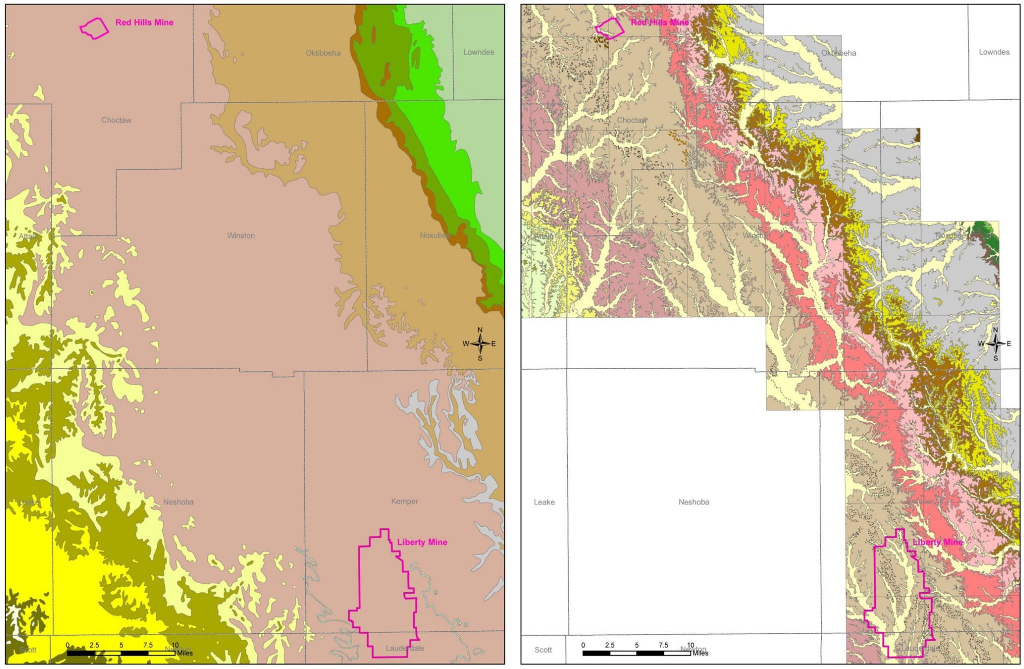


Figure 5. Left, the 1969 Geologic Map of Mississippi at a scale of 1:500,000, with mine sites shown. Right, recent detailed 7.5-minute quadrangle geologic maps at a scale of 1:24,000, showing mine sites.

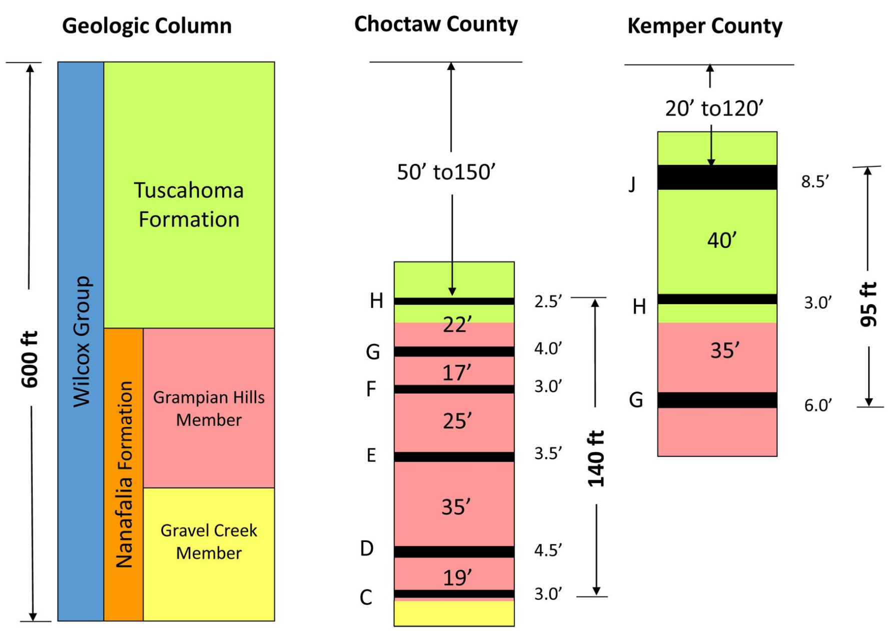


Figure 6. North American Coal Corporation’s correlation of lignite seams between the Choctaw and Kemper County lignite mines based on MDEQ’s geologic maps.

Figure 7. Covered conveyer belt and storage dome for lignite at the Kemper County mine and power plant. Picture was taken on September 30, 2014.

Environmental News, February 2015, volume 12, issue 2, pages 17-22

WHEN TUNNEL DIGGERS BECAME FOSSIL COLLECTORS: CONSTRUCTION OF the JACKSON SEWER MAIN, 1973-1974

By David T. Dockery III, RPG, Office of Geology

The Office of Geology's numbered list of fossil localities contains many construction sites, which were available for fossil collecting for a brief period of time. Fossils from such sites are only found today in old collections. On September 3, 2014, George Phillips of the Mississippi Museum of Natural Science brought two boxes of fossil mollusks (some of which are illustrated in Figure 1), which had been donated to the museum from the collections of Leslie and Sue Pitts. He wanted to verify that the locality information for the boxes was correct. The collection labels were found to be correct based on fossils from the Office of Geology collection, old photographs of the construction site in our photograph collection, and my recollections. The Pitts' collections corresponded to: (1) MGS (Mississippi Geological Survey) locality 7, "Moodys Branch Formation: Sewer excavation across Town Creek …," and (2) MGS locality 8, "Moodys Branch Formation: Tunnel excavations for sewer …. ." The following is an account of fossils collected at MGS localities 7 and 8 during the construction of the seven-foot-diameter sewer main through South Jackson in 1973 and 1974, an occasion when tunnel diggers became fossil collectors.

Figure 1. Fossil mollusks from the Moodys Branch Formation collected by Leslie and Sue Pitts from the excavation site of the Jackson sewer main in 1974. This collection was donated to the Mississippi Museum of Natural Science. At lower left are the interior and exterior views of the arc shell *Barbatia (Cucullaearca) cuculloides*. Picture was taken by George Phillips on September 8, 2014.

Construction of the sewer main through South Jackson, leading to the sewage treatment plant in Byram, consisted of a tunnel under streets and a deep trench crossing Town Creek and the Pearl River flood plain. Tunnel excavations required underground labor using hand-held chisel-tipped pneumatic diggers to cut through bedrock, a stiff stratum of fossiliferous, clay-rich sands of the Moodys Branch Formation. In late summer of 1973, word came from the site that tunnel diggers had discovered some large fossil shells. Upon visiting the vertical shaft connecting the tunnel to Commerce Street, workers showed me a large specimen of the extinct nautiloid *Aturia alabamensis* (Figure 2,) which they donated to the Mississippi Geological Survey collections. Also among the finds was a small *Aturia* with a broken shell that exposed the interior chambers and spiral tube called the siphuncle (Figure 3). The construction company allowed me access to the tunnel to photograph the fossiliferous strata at the tunnel's working end (Figure 4). Access to the site required climbing down a ladder and walking on rail tracks through a cylindrical corridor of bolted steel plates to the fresh excavation (Figure 5). Spoils excavated from the tunnel were loaded onto dump trucks, transported to the Westbrook Manufacturing Plant, and dumped as fill material on the Pearl River flood plain (Figure 6). Here they provided another fossil collecting opportunity as rainfall exposed the fossil shells on the spoil piles.

Figure 2. *Aturia alabamensis* excavated and saved by tunnel diggers at MGS locality 8. Picture has a film process date of September 1973.

Figure 3. A small broken specimen of *Aturia alabamensis* showing (at right) the interior chambers and siphuncle from MGS locality 8. Picture has a film process date of September 1973.

Figure 4. Fossil shells in the tunnel excavation of the Moodys Branch Formation at MGS locality 8. Picture has a process date of September 1973.

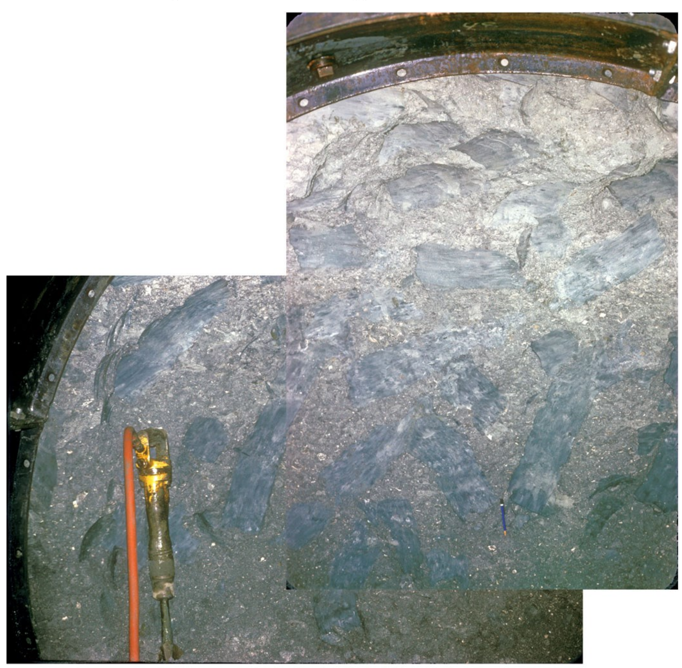


Figure 5. Composite photographs of the end of the tunnel with bolted steel plates against the excavated terminus and the pneumatic digger at lower left and a pencil for scale at lower right. Picture has a process date of September 1973.

Figure 6. Spoil piles of the Moodys Branch Formation adjacent to the Westbrook Manufacturing Plant from the tunnel excavation. Picture has a process date of September 1973.

The main site for fossil collecting (MGS locality 7) was the spoils and walls of the open trench leading to Town Creek (Figure 7). This exposure included the Moodys Branch Formation at the bottom, overlain by unweathered gray Yazoo Clay and then weathered brown Yazoo Clay (Figure 8). Figure 9 shows pictures of the spoil piles with specimens of the arc shell *Barbatia* (one of the species common in the Pitts' collection) and the venericard *Venericardia apodensata* (Figure 9). The prize from the trench site was a rare cypraeid *Jenneria ludoviciana* found in place in the upper Moodys Branch Formation. With this find, the total count of tropical cypraeid species (cowrie shells) from the Moodys Branch at Jackson is ten. These species are illustrated in Figure 10, including, (1) *Cypraeorbis ventripotens* (Cossmann, 1903), (2) *Cypraeorbis towncreekensis* (Dockery, 1977), (3) *Jenneria ludoviciana* Johnson, 1899, (4) *Cypraedia fenestralis* Conrad *in* Wailes, 1854, (5*) Transovula (Oxycypreaea) product* (Dockery, 1977), (6) *Cypraedia (Eucypraedia) multicarinata* (Dall, 1890), (7) *Sulcocypraea healeyi* (Aldrich, 1923), (8) *Sulcocypraea conradi* (Schilder, 1927), (9) S*imnia* sp., and (10) *Sphaerocypraea jacksonensis* (Johnson, 1899).

Figure 7. Sewer excavation and pipe on the north bank of Town Creek. Spoil berms serve as levees to keep out the flood waters of the Pearl River. Picture has a process date of May 1974.

Figure 8. Moodys Branch Formation and Yazoo Clay exposed at sewer excavation (MGS locality 7). Counting ladder steps, the Moodys Branch-Yazoo Clay contact is the 5th step above the water. The upper Yazoo Clay is weathered to a brown color. Picture has a process date of May 1974.

Figure 9. *Venericardia apodensata* (left) and *Barbatia (Cucullaearca) cuculloides* (right) on the spoil piles at MGS locality 7. Picture has a process date of May 1974.

The diversity of tropical taxa, such as cypraeids, is a proxy for ancient sea-water temperature and climate. In this regard, Mississippi has made important contributions to the understanding of Earth's climate history. In Columbia University Press' volume entitled *From Greenhouse to Icehouse, the Marine Eocene-Oligocene Transition* (2003), the molluscan species from both the Jackson Group (Late Eocene containing the Moodys Branch Formation) and the Vicksburg Group (Early Oligocene) in Mississippi are listed. Eleven cypraeid species are listed from the Moodys Branch Formation of the Jackson Group, while only five species are listed from seven formations of the Vicksburg Group. As indicated by this drop in diversity, the Eocene-Oligocene boundary was a transition from a warm planet to a cool planet with the formation of ice sheets over Antarctica (Figure 11).

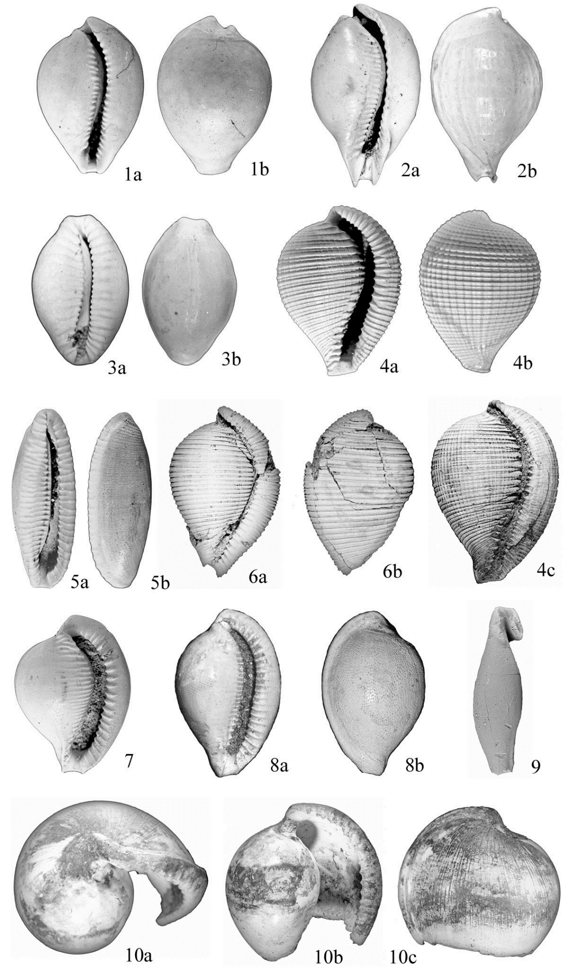


Figure 10. Cypraeid (cowrie) species from the Moodys Branch Formation at Jackson, Mississippi. Specimen images not to scale.

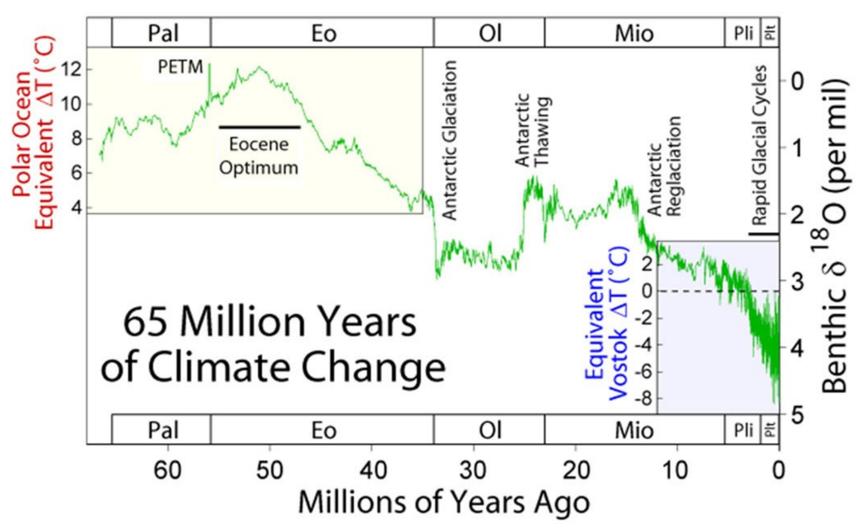
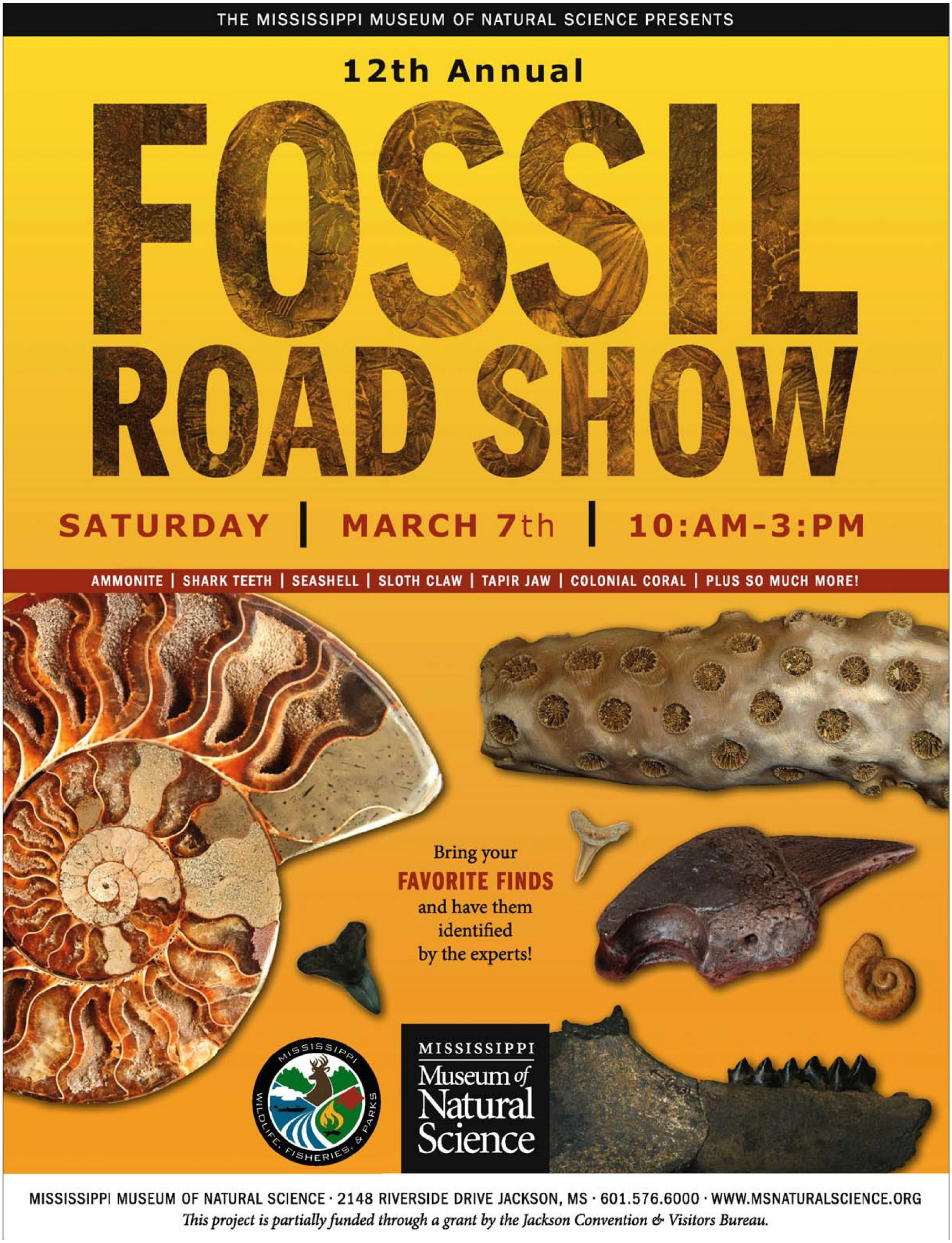


Figure 11. Climate record for the Cenozoic Era from Wikimedia Common. The transition from the warm Eocene Period (Eo) to Antarctic Glaciation in the Oligocene Period (Ol) occurs at the Jackson-Vicksburg Group boundary in Mississippi. The horizontal dashed line extending from 0 delta T at right indicates our present climate, one of four warm periods punctuating the present Ice Age.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This project is partially funded through a grant by the Jackson Convention & Visitors Bureau.

Environmental News, March 2015, volume 12, issue 3, pages 17-22

2015 GEM AND MINERAL SOCIETY ROCK SHOW AND FOSSIL ROAD SHOW

David T. Dockery III, RPG, Office of Geology

The Mississippi Gem and Mineral Society's (MGMS) 56th Annual Rock Show at the Trade Mart Building in Jackson on February 28 and March 1 and the 12th Annual Fossil Road Show at the Mississippi Museum of Natural Science on March 7 were opportunities for geologists and paleontologists to meet the public and see their rock and fossil finds. At this year's Rock Show the traveling exhibit of a table set with stone food, or at least stones that looked like food, was back. The table exhibit originated with Bill and Lois Pattilo of the Gulf Coast Gem and Mineral Society in Corpus Christi, but recently the Pattilos retired from exhibiting and passed the torch and exhibit on to others. My favorite from the table this year was the slice of key lime pie (Figure 1).

Figure 1. George and Judy Johnson of Michigan at left view a table set with appetizing-looking stones, including the slice of chrysoprase key lime pie at right. Mississippi Gem and Mineral Society Rock Show, February 28, 2015.

Geology departments from the University of Mississippi, the University of Southern Mississippi, and Mississippi State University were represented at booths staffed with students and professors as was MDEQ's Office of Geology (figures 2-3). The Office of Geology booth gives MDEQ geologists the opportunity to share the agency's work and to see what rocks and fossils the public has found lately. It is also a chance to see other MDEQ employees fascinated with rocks and fossils (Figure 4).

Figure 2. State geology departments were represented at the 2015 Mississippi Gem and Mineral Society Rock Show. At left is the University of Mississippi booth (Dr. Terry Panhorst in blue shirt); at right is the University of Southern Mississippi booth. Pictures were taken on February 28, 2015.

Figure 3. At left is the Mississippi State University booth and at right is the MDEQ Office of Geology booth with swim team champion Abby Starnes and her dad James Starnes and Tyler Berry. Pictures were taken at the Gem and Mineral Society Rock Show on March 1, 2015.

Figure 4. MDEQ staff visiting the Rock Show; at left, Wayne Stover, center, with wife Ginger and former Office of Geology geologist Dr. James May, and, at right, Lyndsey Henley, center, with husband Eames and sister-in-law Virginia. Pictures were taken on February 28, 2015.

The two most puzzling finds examined were a fossil whale vertebra (Figure 5) from the Homochitto River in southwestern Mississippi, a place where only plant fossils and fossil land mammal bones had been found before, and the internal mold of a large pholid marine clam (Figure 6) dredged deep from the Mississippi River. The clam internal mold must have come from bedrock as it showed no wear from rolling down the river, but the matrix was like that of other fossil molds from the Tombigbee Sand at Plymouth Bluff on the Tombigbee River near Columbus.

Figure 5. The first of two puzzling finds presented to the Office of Geology booth was a fossil whale vertebra found by DeAnna Blailock and shown by her daughter Estelle Walden at left, from the Homochitto River in southwestern Mississippi. Pictures were taken on February 28, 2015.

Figure 6. The second of two puzzling finds presented to the Office of Geology booth at the Rock Show was this internal mold of a large pholid marine clam as held by Kathy Blackwell at left. The matrix appears to be from the Cretaceous Tombigbee Sand, but the specimen was given to Kathy by an Arkansas cousin, who was given two such specimens by a man who said he dredged it really deep from the Mississippi River. Pictures were taken on February 28, 2015.

The Fossil Road Show at the Mississippi Museum of Natural Science on the following Saturday was attended by over a thousand visitors, some coming to look and others bringing their rocks and fossils to be looked at. University of Mississippi professors Brian Platt and Lou Zachos helped with the identification process, as did Gary Stringer, professor emeritus of the Department of Geosciences, University of Louisiana Monroe (Figure 7, left). Platt is new to the Ole Miss faculty and is an expert in trace fossils such as tracks, trails, and burrows. Zachos is an expert in fossil echinoids, such as heart urchins and sanddollars. Stringer is an expert in otoliths, calcium carbonate structures in the inner ear of fish sensitive to gravity and linear acceleration.

Figure 7. At left Brian Platt and Lou Zachos of the University of Mississippi Geology Department talk with fossil otolith expert Gary Stringer. At right Abby Starnes, her dad James Starnes, and Tyler Berry and his nephew visit James' fossil identification table. Pictures were taken on March 7, 2015.

MDEQ was represented by tables manned by James Starnes (Figure 7) and David Dockery. Interesting finds brought to the Fossil Road Show include the fossil trilobite found by Kyrie Spooner (Figure 8) and the 13-inch long bill of the extinct fish *Cylindrocanthus* from the Cane River Formation in Louisiana found by Guy McLain (Figure 9, left). New at the Fossil Road Show this year was the painting of fossils by the Museum's illustrator Sam Biebers. His water color of the fossil ammonite *Menabites* (*Delawarella*) *danei* from the Coffee Sand at Mantachie, Mississippi, looked better than the actual fossil (Figure 9, right).

Figure 8. At left, Kyrie Spooner holds the external mold of a trilobite tail she found in chert gravel. At right is a closeup of the fossil and on the reverse side the stone is labeled with the collector's name and date. Pictures were taken on March 7, 2015.

Figure 9. At left, Guy, Josh, and Katie McLain hold a 13-inch-long specimen of the genus *Cylindrocanthus*, which is believed to be the rostral bill of an extinct fish species from the Cane River Formation in Louisiana. At right Sam Biebers paints a fossil ammonite *Menabites* (*Delawarella*) *danei* from Mantachie, Mississippi, at the Fossil Road Show. Pictures were taken on March 7, 2015.

Environmental News, April/May 2015, volume 12, issue 4, pages 18-22

GEOLOGY IN THE NEWS: SLOPE FAILURE ON INTERSTATE 220 NORTH AT HIGHWAY 80

David T. Dockery III, RPG, Office of Geology

The recent slope failure on Interstate 220 North at Highway 80, the interchange between Interstate 20 West and Interstate 220 North in Hinds County, was a hot news topic in late February and March of 2015. Mississippi Department of Transportation personnel scrambled to stabilize the slope before it took out the heavily used interchange. One lane of the interchange was closed as heavy equipment moved dirt and a pile driver drove in some 50 steel beams, nailing the slump to the bedrock (figures 1-3).

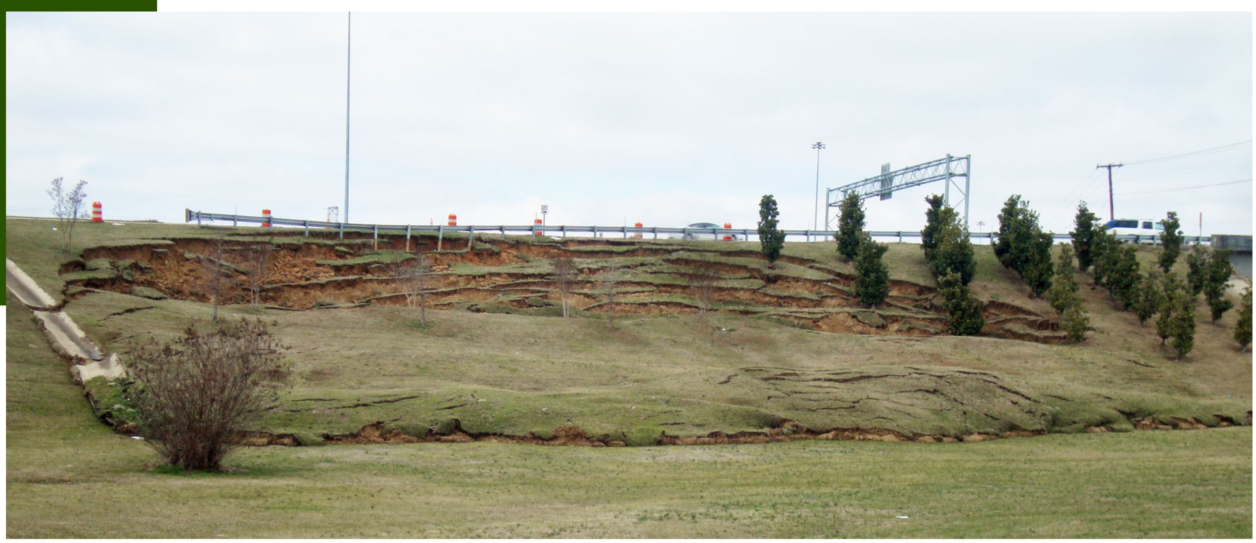


Figure 1. Slump in Yazoo Clay on Interstate 220 North just south of Highway 80 in Jackson. Picture was taken on February 27, 2015.

Figure 2. Left, looking north at slump in Yazoo Clay on Interstate 220 North just south of Highway 80 in Jackson. Right, looking south at slump. Pictures were taken on February 27, 2015.

Figure 3. Left, looking south at slump in Yazoo Clay on Interstate 220 North at Highway 80 in Jackson on February 27, 2015. Right, looking north at slump after repairs on March 17, 2015.

An online search of news articles found a publication on the Yazoo Clay by the U.S. Army Corps of Engineers, Engineer Research and Development Center. The report, sponsored by MDOT, *State Study 151 and 236: Yazoo Clay Investigation*, by Landris T. Lee, Jr., P.E. (June 2012) is available online: http://mdot.ms.gov/documents/research/Reports/Interim%20and%20Final%20Reports/State%20Study%20151%20and%20236%20Yazoo%20Clay%20Investigation.pdf.

The Corps of Engineers' publication cited several articles in MDEQ's *Environmental News*. In total there were 20 articles cited for Dockery, Starnes, and Bograd, including eleven articles published in the Office of Geology's journal *Mississippi Geology* and five articles on the Yazoo Clay in MDEQ's *Environmental News*. The publication also cited Office of Geology county geology bulletins, including those for Rankin, Scott, Smith, Yazoo, Hinds, and Madison counties. Figure 4 shows the outcrop belt of the Yazoo Clay superimposed on the Interstate system across central Mississippi from Lee's publication (2012, Figure 3). The accompanying text with the figure states: "Unfortunately the metropolitan Jackson area is located directly on top of the Yazoo Clay. Any overlying non-clay deposits (alluvium, loess, etc.) are generally not thick enough to prevent moisture and water intrusion into the Yazoo clay, and these moisture changes result in expansive, swelling, shrinkage, and otherwise destructive behavior so detrimental to the roads, foundations, and related infrastructure in the central Mississippi region." The publication noted the Yazoo Clay to be 462 feet thick in the Mossy Grove core in northwestern Hinds County.

The Mossy Grove core, drilled by the Office of Geology (Figure 5) in cooperation with the Geology Department of the University of Southern Mississippi on August 19 to September 4, 1991, has been and continues to be the subject of many scientific studies (five publications cited in Lee, 2012).

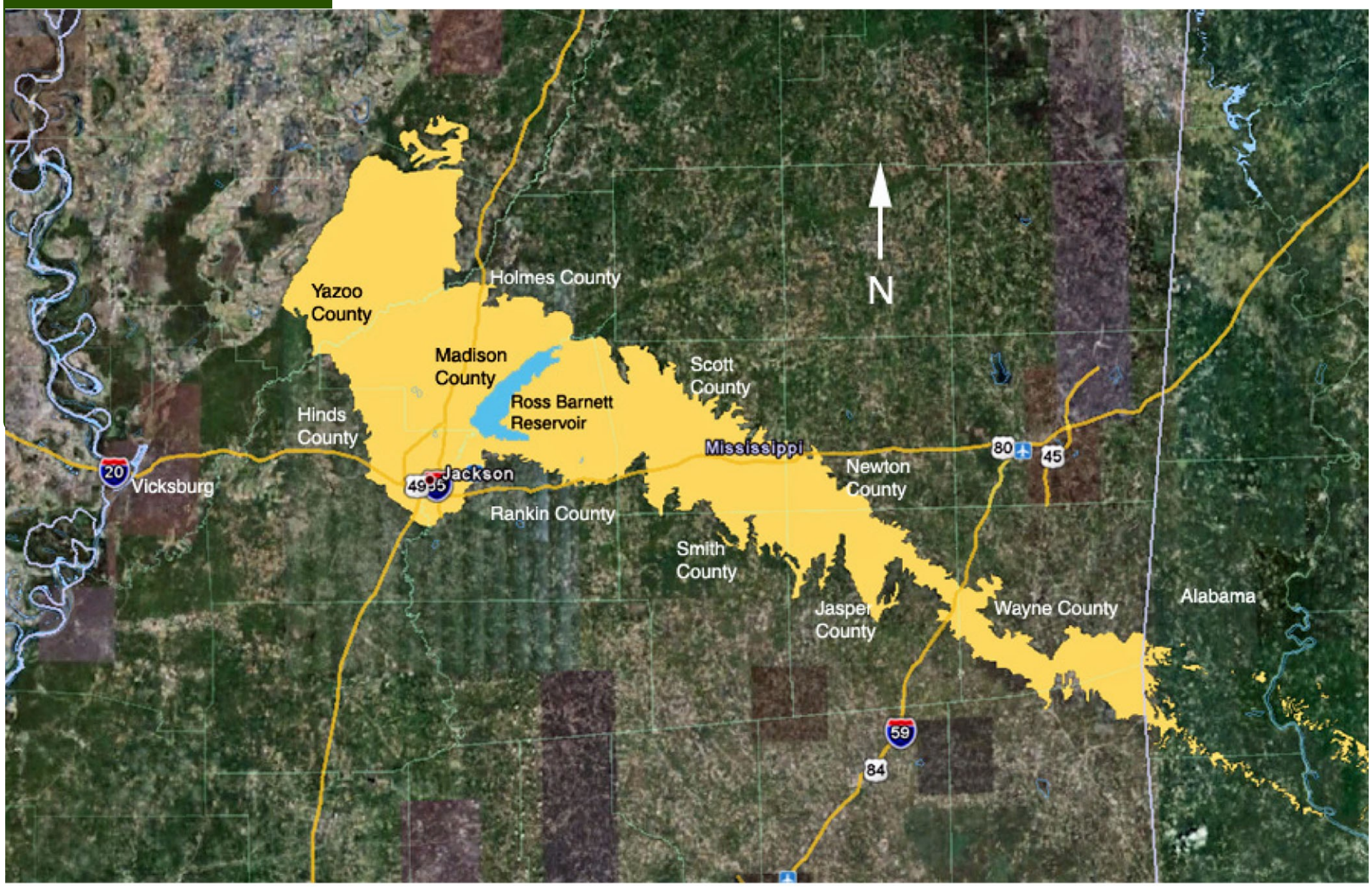


Figure 4. The Yazoo Clay outcrop belt superimposed on the Interstate system across central Mississippi from Figure 3 of Lee, June 2012, *State Study 151 and 236: Yazoo Clay Investigation*.

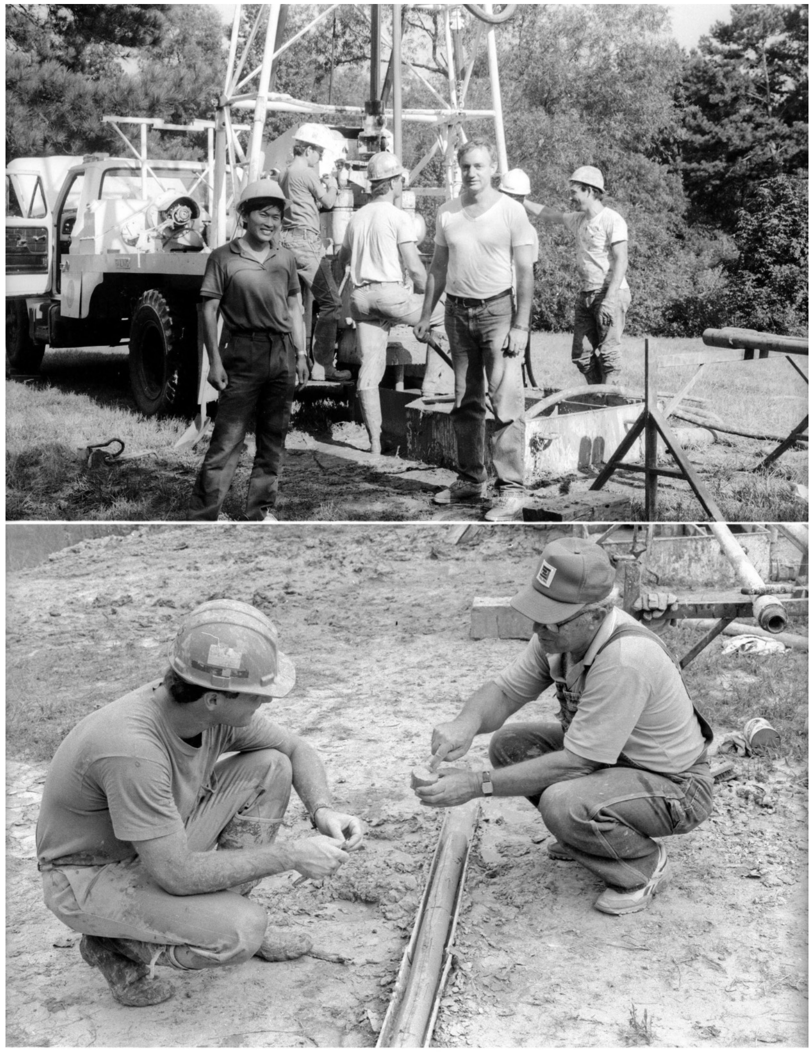


Figure 5. Top, facing the camera at left is University of Southern Mississippi graduate student Jianxin Hou and at right David Dockery. Bottom, at right is Curtis Stover, author of Office of Geology Circular 1 on the Yazoo Clay, telling his son Wayne Stover a thing or two about a freshly extruded Yazoo Clay core from the Mossy Grove core hole. Pictures were taken in September 1991.

One article cited by Lee, "A slope too steep: slumps in the Yazoo clay in central Mississippi" published in the July 2010 edition of MDEQ's *Environmental News*, showed four slumps in February of 2010, two of which were located on Interstate 20 and on Interstate 220 (Figure 6). The current slump is between the two Interstate slope failures of 2010. *Environmental News* articles on slumps in the Yazoo Clay include: (1) the Millsaps College slump of January 2008, (2) the Dogwood Festival slump of February 2009, (3) the Interstate 20 and Interstate 220 slumps of February 2010, (4) the Farmer's Market slump of February 2010, (5) the Natchez Trace Parkway slump of March 2012, (6) the Clinton Walmart slump of April 2012, (7) the Interstate 20 slump at McRaven Street of March 2013, and (8) this article on the Interstate 220 at Highway 80 slump in February 2015.

All of these are winter or early spring slope failures that were caused by increased winter rainfall totals coupled with a decreased evaporation potential due to the gray, overcast, colder, shorter winter days. Water saturation decreases the strength and cohesion of the soil and greatly increases soil weight.

Figure 6. Top, slump in Yazoo Clay on Terry Road at Interstate 20 in Jackson. Bottom, slump in Yazoo Clay on the east side of Interstate 220 North near the I-20 interchange. Pictures were taken on February 10, 2010.

Environmental News, June 2015, volume 12, issue 5, page 15

James Starnes from MDEQ's Office of Geology presented a program on rocks, minerals, dinosaurs, and the environment on June 11 as part of the Richard Wright Library's Children Summer Reading Program in Jackson.

Environmental News, June 2015, volume 12, issue 5, pages 16

THE CANTON EARTHQUAKES

David T. Dockery III RPG and Barbara Yassin, Office of Geology

The Jackson-Canton area of central Mississippi has experienced only three earthquakes over the last hundred years, an intensity IV (Modified Mercalli Intensity Scale) in the vicinity of Jackson on November 13, 1927, and magnitude 3.2 (Richter Scale) and 3.0 earthquakes at a depth of five kilometers (3.1 miles) just south of Canton on May 2, 2015. The fault responsible for the May 2, 2015, earthquakes was mapped from 2-D seismic data by Steve Walkinshaw in 2008 and published as a cross section in the July 2008 issue of *Environmental News* (page 4). Figure 1 is a modified version of that cross section and locator map, showing the epicenters of the May 2 earthquakes. The associated fault terminates at a hinge line and overlying fold at the northern margin of the Flora-Ridgeland Syncline, a down-folded trough between Madison and the Jackson Dome named by Priddy (1960) in the Madison County Geology Bulletin (#88). Figures 2 and 3 show the location of respondents to the U.S. Geological Survey earthquake website. Below are two felt reports provided to the Office of Geology.

One earthquake report from a Gluckstadt resident described the first Canton earthquake as like ten cars hitting his house. When he went outside, he found that the gaping cracks marring his driveway had closed up. The following is an account from an Environmental Professional with Neel-Schaffer, Inc. and wife of Paul Parrish (MDEQ's Office of Land and Water Resources) Julie Parrish as experienced from her home on Moss Woods Drive in Madison.

"I was standing on our back deck around 7:30 pm facing East (deck length is oriented North-South) watching my husband and son throw the baseball in the backyard. I felt vibrations and then a quick rumble on the deck for a few seconds. I thought maybe a piece of heavy equipment could have been driving down the street in front of the house, and wondered what the city was doing on a Saturday evening. The vibrations and rumbling were noticeable, but not as if I were standing by railroad tracks with a train passing through. The vibrations became soft or imperceptible for a few seconds. Then it started up noticeably again with what felt like a ripple beneath me. The ripple felt as if it were traveling from North to South along the length of the deck with a slight bump pushing the boards up beneath me.

At the same time, I was more attuned to it after the first vibrations, and I heard muffled pops. It sounded like distant thunder with at least three or four separate pops. I immediately thought there was an explosion of some magnitude nearby (all of our homes in the neighborhood utilize natural gas for heating) or that something had crashed through or exploded (water heater/hvac) in our house. I yelled for my husband to come to where I was standing and asked if he would check the water heater and the upstairs as I explained what I felt and heard. I immediately turned to look inside, through the glass doors, and saw our cats hunkered down staring up at the ceiling. I was then certain that something in the house was the culprit, especially since my husband felt nothing while standing in the yard (20 feet from where I was on the deck). He walked inside with me for a few seconds and concluded that our house was still sound. We walked back outside to the sounds of two neighborhoods worth of dogs barking in unison. Some neighbors were standing outside in the street with their children with what appeared to be looks of concern on their faces. The dogs continued barking for 10 minutes or so. This prompted us to check the USGS earthquake hazards page to check for local activity, but there were no updates for our area at the time. We checked local news sources and social media to see if there was a pipeline explosion nearby, but found no useful information. At about that time I received a text from someone in the Gluckstadt area asking if we felt anything. We knew something big had happened at that moment, but still thought it was an explosion of some sort. Finally the USGS updated (10-15 minutes later) providing the earthquake activity as a 3.2. Since we heard no sirens and no reports of explosions we came around to the fact that we had experienced a small earthquake.

"A few minutes after the first earthquake showed up on the USGS site, my husband left to go to the store. My son and I were in the living room when the second quake hit. At this point I really believed the first activity was an earthquake when our living room began to vibrate with a couple of rumbling shakes. They were not as distinct as the first quake, but the end was bumpier than the beginning. We were also paying attention more closely to this one. It seemed to last around seven seconds. My six year old son was sitting in a chair situated on scored concrete floor and described it as "bouncy." All in all it was quite exciting for my husband and me as we both have geology degrees. We had no noticeable structural damage and no wall hangings out of place."

Figures 1, 2, and 3 from previous article

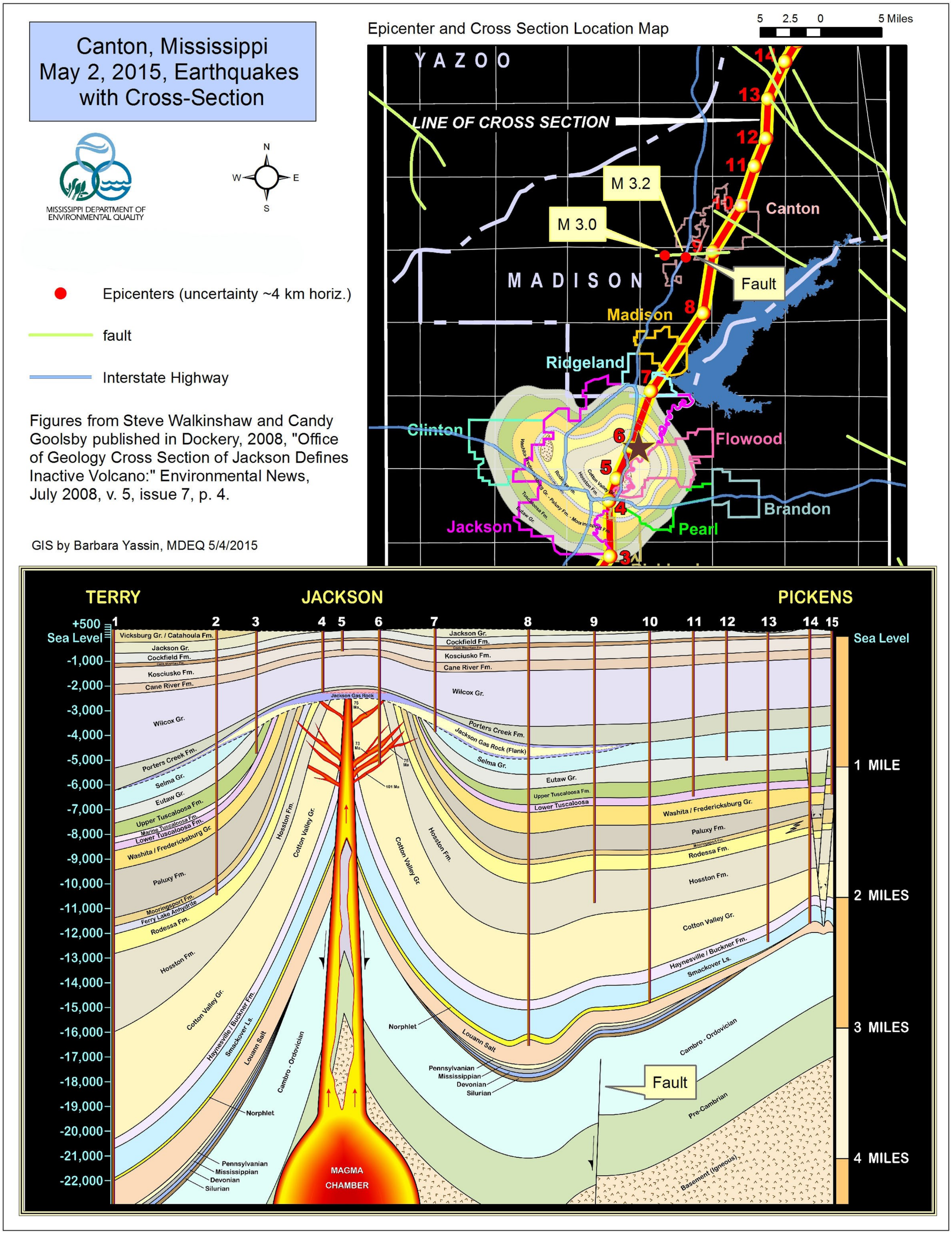


Figure 1. Top: Locator map showing line of cross section, the earthquake fault south of Canton, and the Jurassic-Cretaceous subcrop beneath the Jackson Gas Rock on the Jackson Dome. Bottom: Cross section of the earthquake fault and the Jackson Dome from Walkinshaw and Goolsby (in Dockery, 2008).

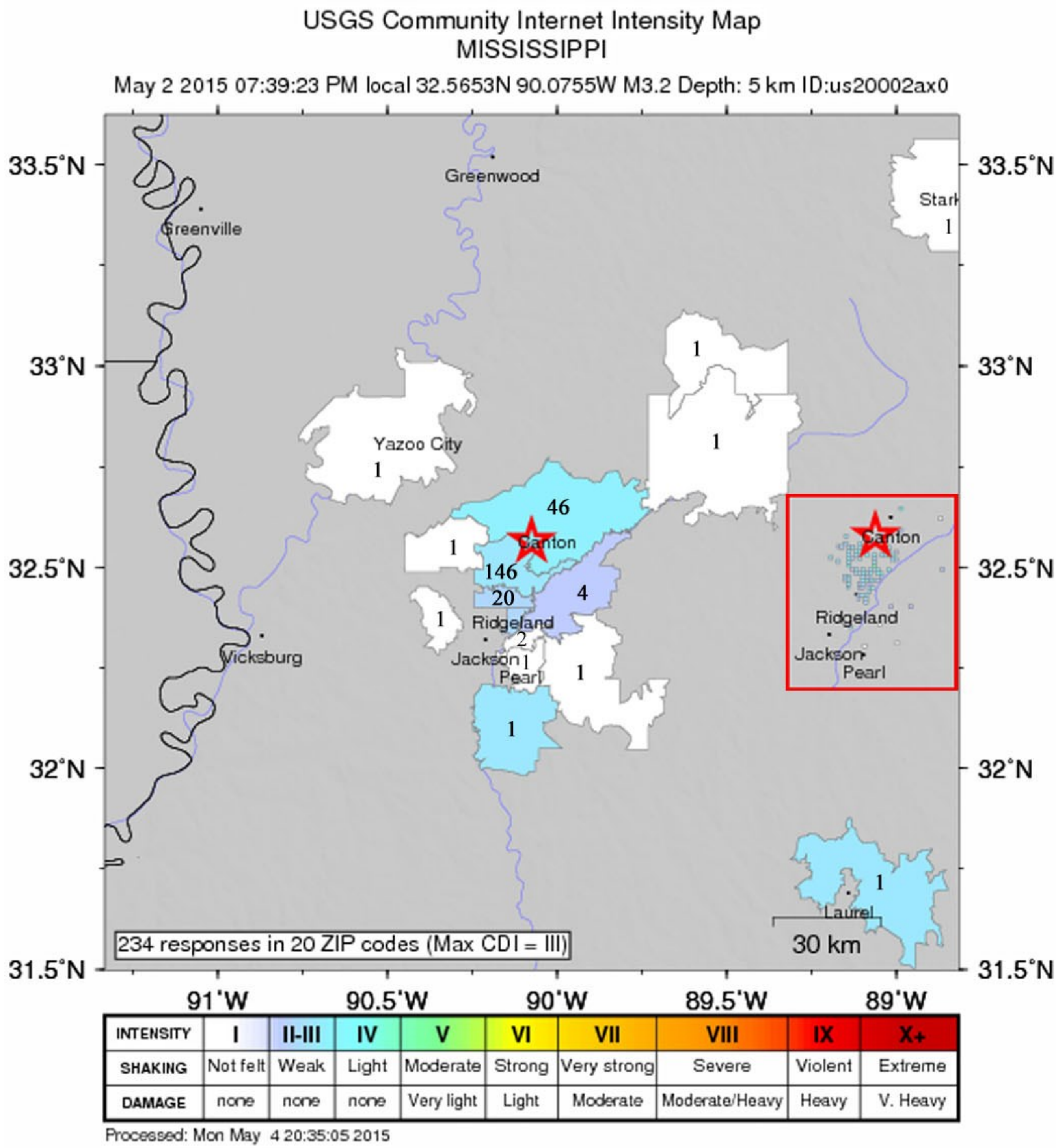


Figure 2. Felt reports to the USGS site of first earthquake according to ZIP code areas. White areas are Intensity I or not felt. Lavender areas are Intensity II. Blue areas are Intensity III. Of 234 responses in 20 ZIP codes, there were: 146 reports from Madison (39110), 46 reports from Canton (39046), 20 reports from Ridgeland (39157), 4 reports from Brandon (39047), and one report from each of the other ZIP code areas. The red-bordered insert at right gives the locations of 65 responses in 48 blocks, most of which are south of the epicenter (red star). The maximum reported intensity for the event was IV.

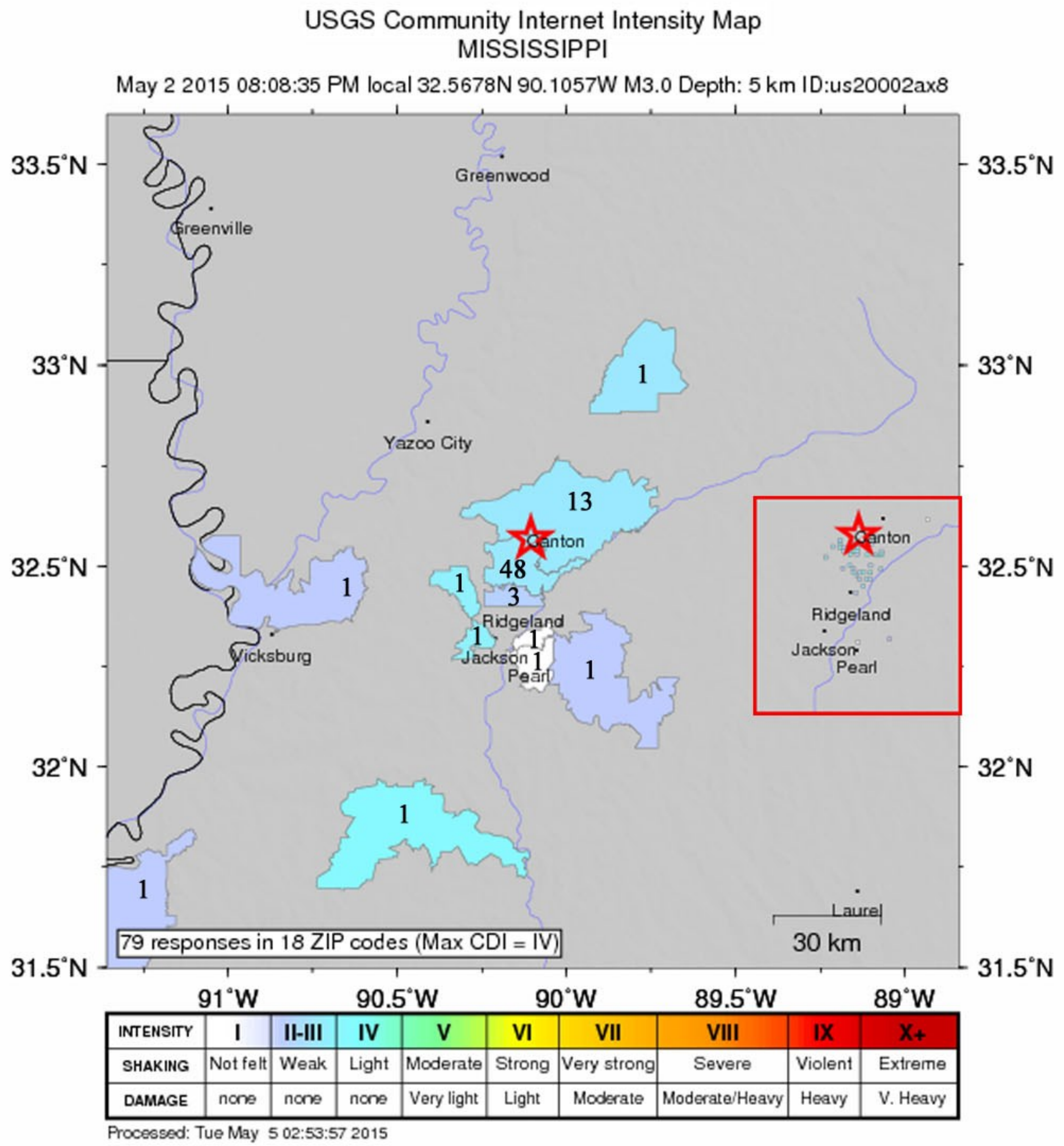


Figure 3. Felt reports to the USGS site of second earthquake according to ZIP code areas. White areas are Intensity I or not felt. Lavender areas are Intensity II. Blue areas are Intensity III. Of 79 responses in 18 ZIP codes, there were: 48 reports from Madison (39110), 13 reports from Canton (39046), 3 reports from Ridgland (39157), and one report each in the other ZIP code areas. The red-bordered insert at right gives the location of 65 responses in 48 blocks, most of which are south of the epicenter (red star). The maximum reported intensity for the event was IV.

Environmental News, June 2015, volume 12, issue 5, page 22

PICTURE OF THE MONTH

Egret at Low Head Dam (Scott County).

Taken by Jonathan McKinnon, Office of Geology.

Environmental News, July 2015, volume 12, issue 6, page 22

ANOTHER CANTON EARTHQUAKE

David T. Dockery III, RPG and Barbara Yassin, Office of Geology

On Monday June 29, 2015, David Dockery received a call from his sister-in-law, Ida Marshall, at Lake Caroline in Madison County, reporting that she heard a "boom" like an explosion at 8:23 am and then the house shook and rattled the furniture. Patsy Turner Benson of Madison reported to the *Madison County Journal* that the Monday morning earthquake "felt like a wrecking ball hit the house, and it knocked it off the foundation. That was freaky bad!" (Michael Simmons, 7/1/2015, 6:00 PM). This 3.2 magnitude earthquake was the third earthquake for the area in a period of two months. Others also reported hearing a boom associated with the June 29 event. According to a U.S. Geological Survey website, residents of Spokane, Washington, reported "booming sounds" in a series of earthquakes that unnerved the city in 2001. The earthquakes, like those in Canton, were shallow, which probably contributed to the noise. The booming sounds are caused by higher-frequency vibrations, which do not reach the surface in deeper earthquakes. Sometimes the earthquakes boom even when no vibration is felt.

Figure 1 shows the location of the June 29 earthquake near the epicenter of the first earthquake, also of a 3.2 magnitude, that occurred on May 2, 2015. Figure 2 shows the number of responses to the earthquake recorded on the U.S. Geological Survey earthquake website. Figure 3 is a seismogram of the earthquake recorded by Louis Lyell on the seismograph at his home on Old Canton Road in Jackson.

The Canton earthquakes are a natural phenomenon associated with a buried fault identified in the cross section in Figure 1. All three earthquakes cluster around that fault. Will there be other earthquakes to follow?—we can't say. Some sixteen earthquakes have occurred over the period of a year in Greene County, Alabama.

Canton, Mississippi May 2nd & June 29th 2015, Earthquakes with Cross-Section

MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

Figure 1

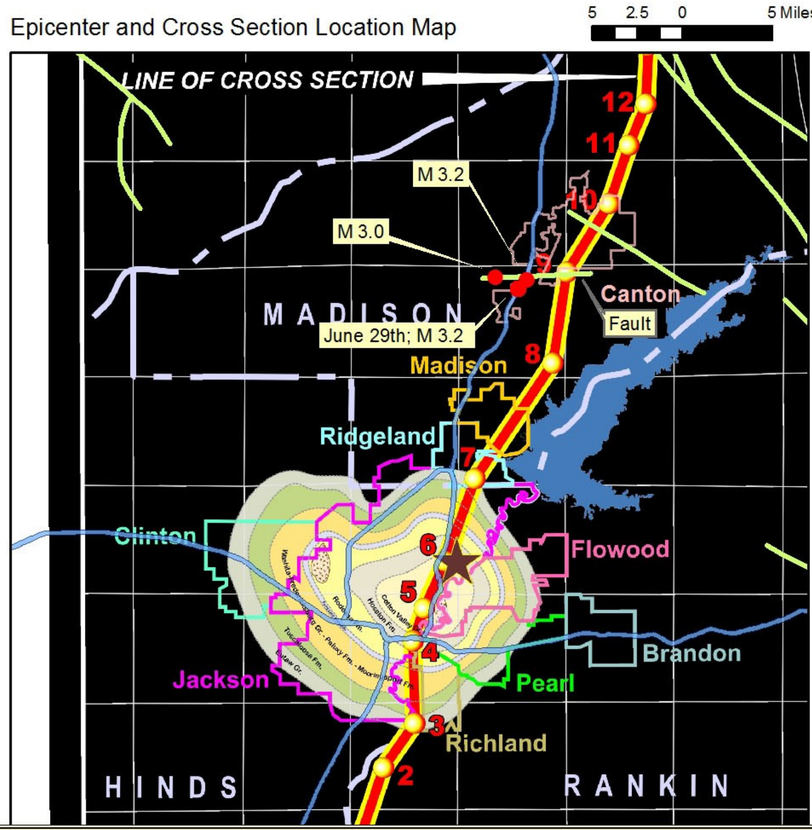
● Epicenters (uncertainty ~4 km horiz.)

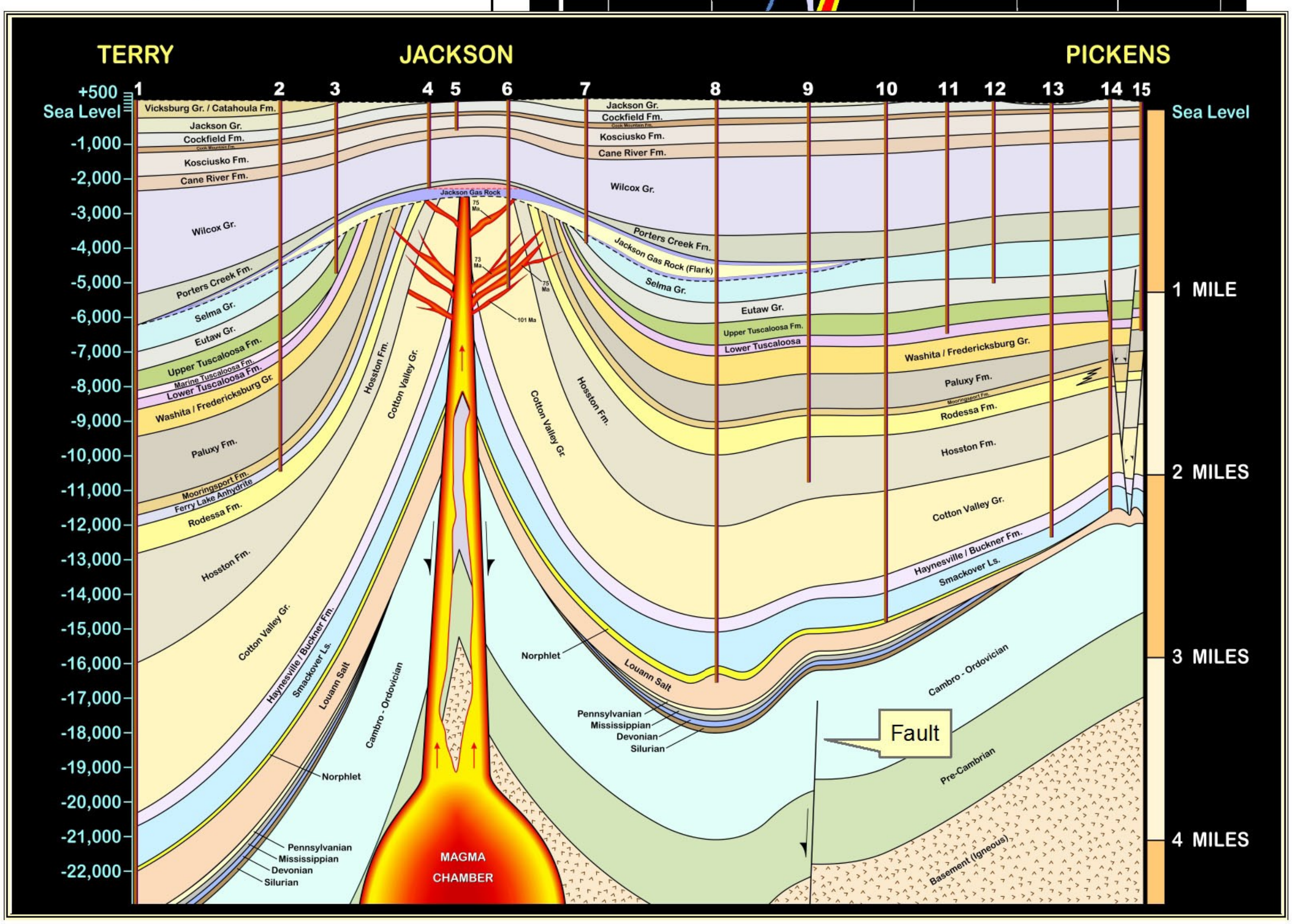
fault

Interstate Highway

Figures from Steve Walkinshaw and Candy Goolsby published in Dockery, 2008, "Office of Geology Cross Section of Jackson Defines Inactive Volcano:" Environmental News, July 2008, v. 5, issue 7, p. 4.

GIS by Barbara Yassin, MDEQ 6/29/2015





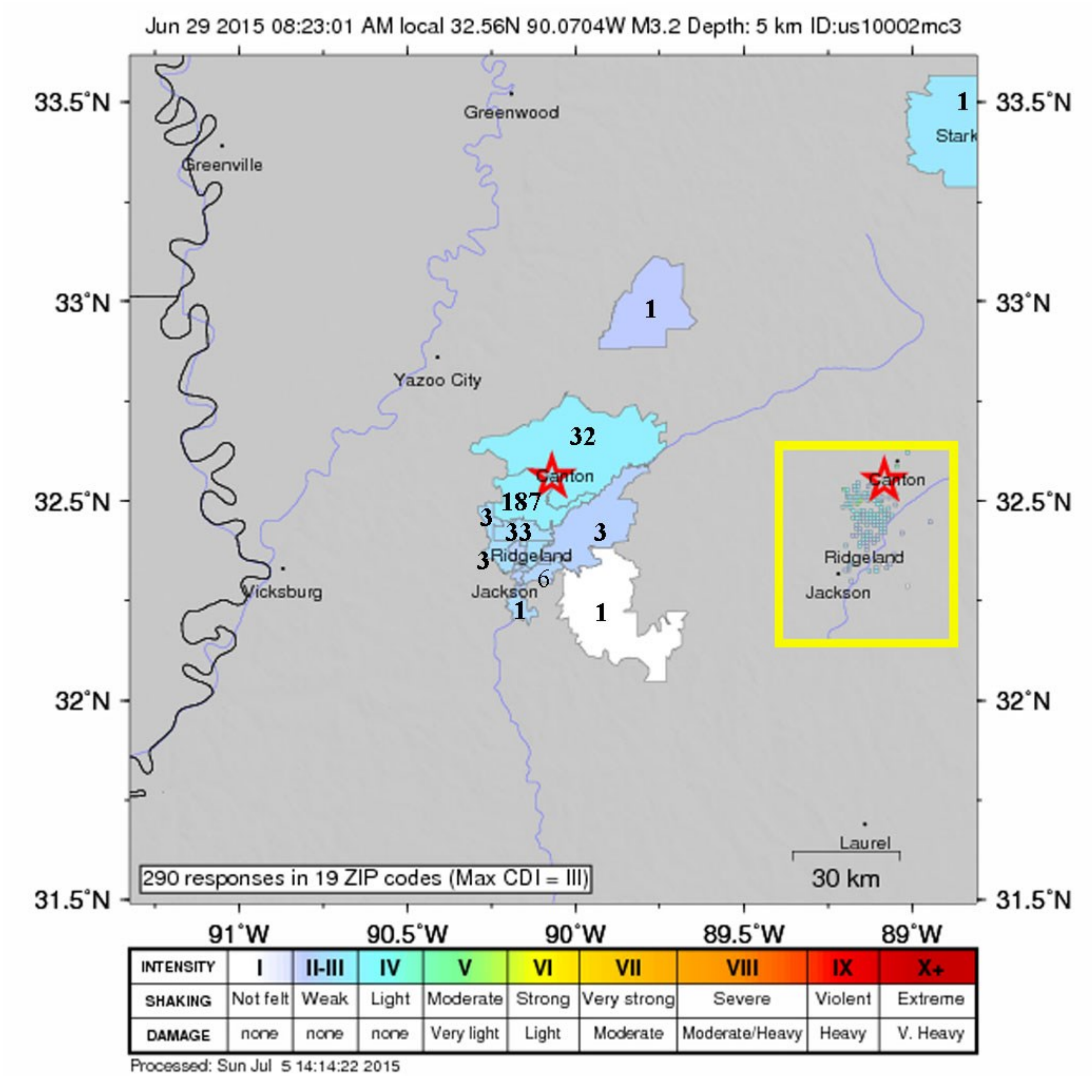


Figure 2. USGS Community Internet Intensity Map, Mississippi, June 29, 2015, 08:23:01 AM local time. Responses by Zip Code: Madison 39110, 187 responses; Ridgeland 39157, 33 responses; Canton 39046, 32 responses; Jackson 39213, 3 responses; Brandon 39047, 3 responses; all others 1 response. The yellow-bordered insert at right gives the locations of 238 reponses in 131 blocks, most of which are south of the epicenter (red star). The maximum reported intensity for the event was V.

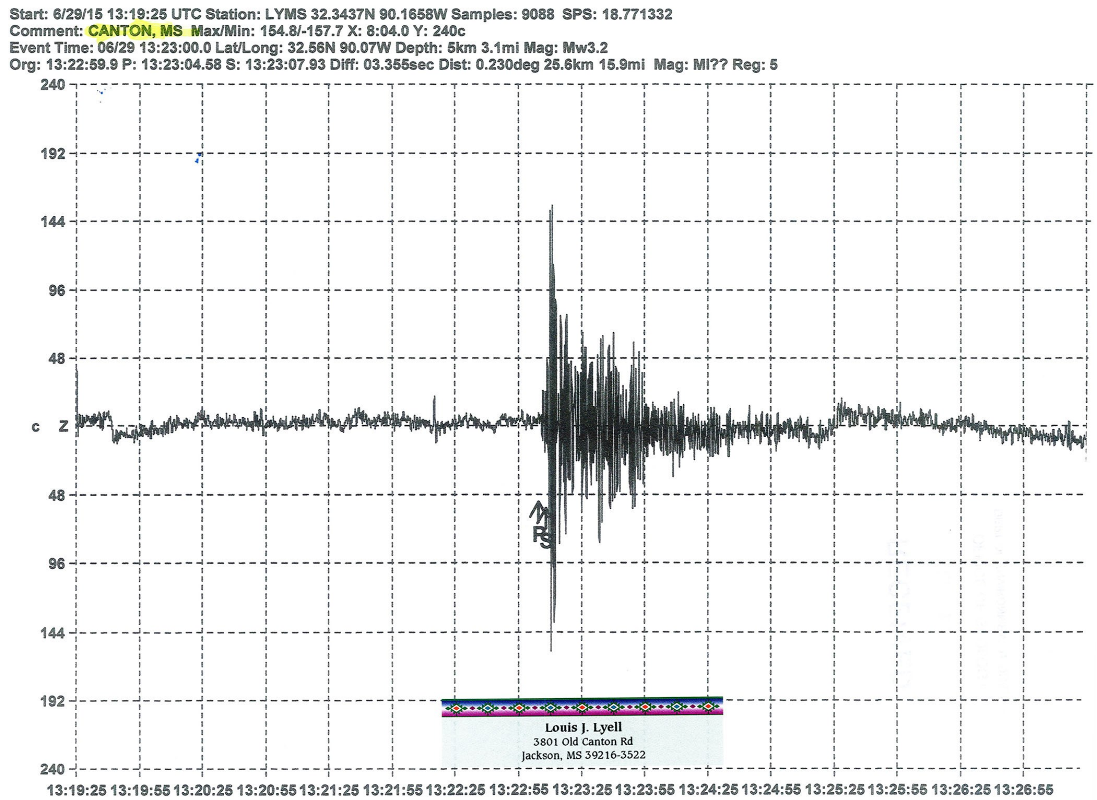


Figure 3. Seismogram of the Canton earthquake recorded by Louis Lyell's seismograph at his home on Old Canton Road in Jackson, Mississippi.

On the same day as Canton's June 29 earthquake, a 3.8 magnitude earthquake at a depth of 3.1 kilometers shook Greene County, Alabama, at 1:44 a.m. The epicenter was some 12 miles northeast of Eutaw (Figure 4). This earthquake was the latest in a cluster of sixteen seismic events to strike that county since November of 2014. Sandy Ebersole of the Geological Survey of Alabama was quoted by Melissa Brown of AL.com (posted June 30, 2015) as saying, "These earthquake clusters or swarms are very rarely followed by a large magnitude earthquake." Ebersole also said, "The cause and location of the earthquakes is several kilometers below the earth's surface…. We have previously mapped subsurface faults in Greene County, and thus far our interpretation of these earthquakes is that they are an expression of movement along these faults." Most earthquakes of the 2015 cluster occurred within a Precambrian graben as shown by parallel green fault lines in Figure 5.

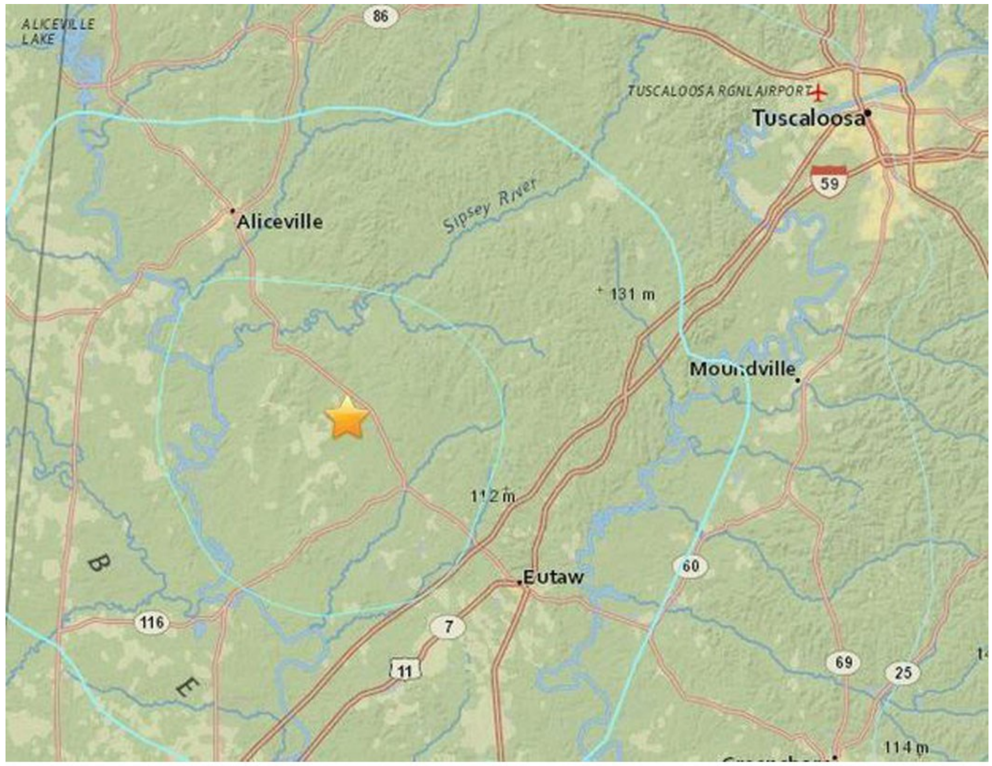


Figure 4. Location (star) of the Greene County, Alabama, June 29, 2015, earthquake (3.8M).

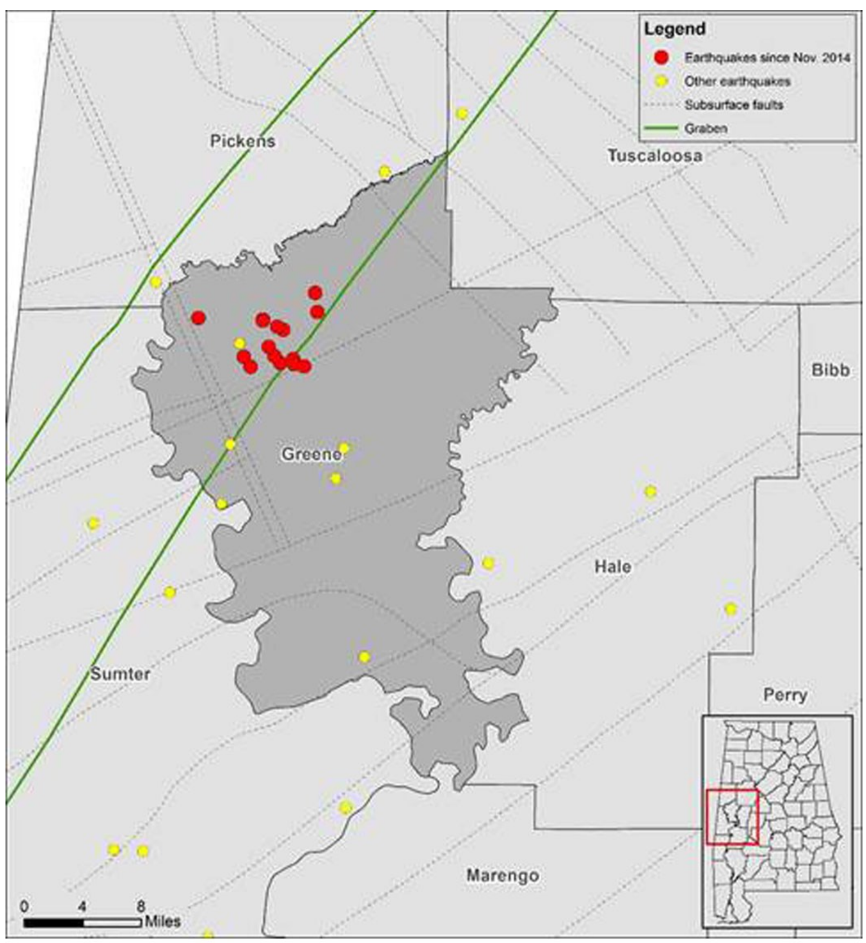


Figure 5. Location of recent Greene County, Alabama, earthquakes associated with a Precambrian graben as outlined by bounding faults in green.

Environmental News, August 2015, volume 12, issue 7, page 18-23

Resource Assessment and Science at MDEQ's Core and Sample Library

David T. Dockery III RPG, Office of Geology

The Tuscaloosa Marine Shale (TMS) is the object of oil exploration in southwestern Mississippi., and oil companies are hopeful that this formation might be as productive as the Eagle Ford Shale in southern Texas, a formation of similar age to the TMS. The Texas oil boom began in 2008 when geologist Gregg Robertson studied the cuttings of Eagle Ford Shale from an exploration well drilled in 1952. Those cutting samples were stored at a core and sample library in Austin, Texas, and analyses of the cuttings were promising for oil production and set off an oil boom that hit a fever pitch in 2012. Several Texas ranchers and farmers suddenly became millionaires.

Now, Paul Hackley, Brett Valentine, and Celeste Lohr, with the U.S. Geological Survey, are studying the oil potential of well cutting samples from the TMS in Mississippi stored at MDEQ's Office of Geology Core and Sample Library in Jackson (Figure 1). They collected 85 samples from the TMS and 10 samples from sands of the Lower Tuscaloosa. Figure 2 shows a sample of the shale cuttings in a glass dish.

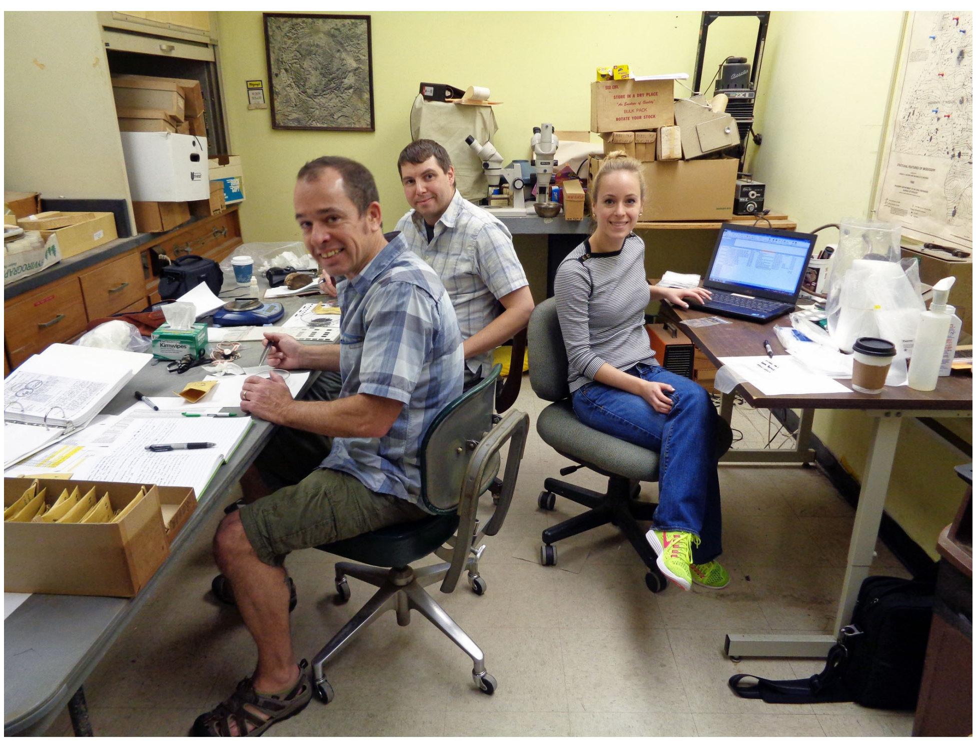


Figure 1. Paul Hackley (left), Brett Valentine (center), and Celeste Lohr of the U.S. Geological Survey examining samples at MDEQ's Core and Sample Library in Jackson on March 2, 2015.

Figure 2. Well cuttings of the Tuscaloosa Marine Shale from MDEQ's Core and Sample Library in Jackson as examined on March 2, 2015.

We have recently enjoyed the pictures of Pluto sent back by the New Horizons spacecraft after a nine-year-long mission to our outermost planet. What new explorations are left for us? How about this: getting in a time capsule and traveling back millions of years to Earth's early history and studying ancient climates, habitats, and animals? That is exactly what scientists do routinely at MDEQ's Core and Sample Library as illustrated in the next two studies. The total cost of the New Horizons mission was about $700 million. The total replacement cost of the cores and samples in MDEQ's Core and Sample Library is about $13.548 billion, or more than 19 times the cost of the New Horizons mission!

The research interest in Mississippi's Core and Sample Library is worldwide. Stuart Robinson and his Ph.D. graduate student Lauren O'Conner of the Department of Earth Sciences, University of Oxford, Oxford, England, recently sampled cores of Cretaceous chalk from Shuqualak, Mississippi (Figure 3). An earlier study of these cores had provided excellent data, and they then sampled the core at finer intervals. Using fossil molecules (TEX_{86}) of the distinct lipids of marine archaea bacteria as a proxy for seawater temperature, the cores showed a cooling trend during the Campanian Stage of the globally warm Late Cretaceous Period (Figure 4). Also in the Shuqualak cores were fossil shells and biotite mica ash from the eruption of the Jackson Volcano some 75 million years ago (Figure 5).

Figure 3. Lauren O'Conner and Stuart Robinson of the University of Oxford sampling a Cretaceous chalk core from Shuqualak, Mississippi, at MDEQ's Core and Sample Library in Jackson on April 27, 2015.

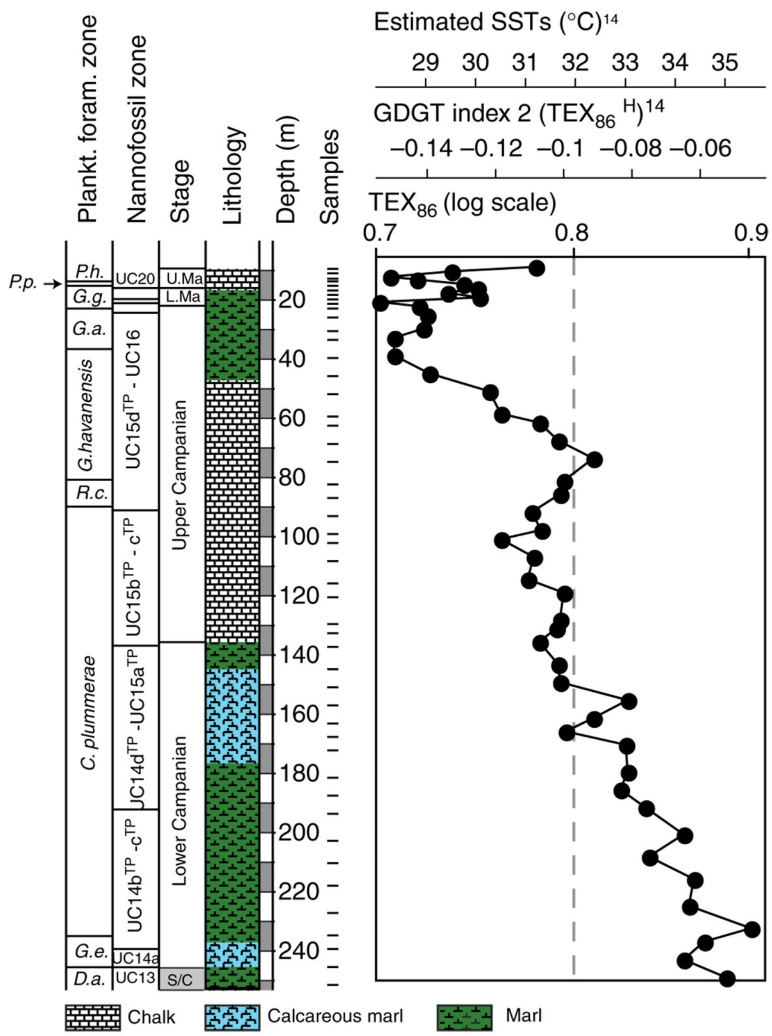


Figure 4. TEX86 data and calculated surface seawater temperatures from the Shuqualak core from Linnert et al., 2014, Evidence for global cooling in the Late Cretaceous: *Nature Communications*, June 2014, 7 p.

Figure 5. Bedding planes in the Cretaceous chalk core from Shuqualak, Mississippi, in MDEQ's Core and Sample Library in Jackson. At left is the fossil pecten *Neithea quinquecostata* and at right are biotite crystals (black) from a volcanic eruption at Jackson 75 million years ago.

Another researcher, Guy Harrington (Figure 6), is getting to be an old friend of the Office of Geology, working with us on the geology of the Walmart site in Meridian and the Red Hills Lignite Mine in 2000. He recently took a position as Senior Palynologist/Stratigrapher with PetroStrat of Wales, UK, and is assisting in the exploration for oil in the North Sea. Guy was first to discover the carbon isotope excursion event at the base of the Paleocene-Eocene Thermal Maximum (PETM) in the Harrell and Walmart cores in Lauderdale County, Mississippi (see the October 2009 issue of *Environmental News*, p. 13-18). The PETM was a 170,000-year-long warm spell that occurred 55.8 million years ago. It is the subject of considerable research as it provides the best past analog of global warming from massive carbon input to the ocean and the atmosphere. Harrington explained the importance (internationally) of the Harrell and Walmart cores in that they are the only cores with plant fossils that preserve the PETM in the Western Hemisphere between localities in Colombia, South America, and Wyoming (Wing and Currano, 2013, Plant response to a global greenhouse event 56 million years ago: *American Journal of Botany*, v. 100, no. 7, p. 1234-1254).

Harrington returned to MDEQ's Core and Sample Library this year to take additional samples of the Harrell and Walmart cores. Figure 7 is an analysis of the PETM in the Harrell core as published in A. Sluijs, L. van Roij, G. J. Harrington, S. Schouten, J. A. Sessa, L. J. LeVay, G.-J. Reichart, and C. P. Slomp, 2013, Extreme warming, photic zone euxinia and sea level rise during the Paleocene/Eocene Thermal Maximum onthe Gulf of Mexico Coastal Plain; connecting marginal marine biotic signals, nutrient cycling and ocean deoxygenation: Climate Past Discussion, 9, 6459-6494.

Figure 6. Guy Harrington, Senior Palynologist/Stratigrapher with PetroStrat of Wales, United Kingdom, collecting samples from the Harrell core in Lauderdale County, Mississippi, at MDEQ's Core and Sample Library in Jackson on June 1, 2015.

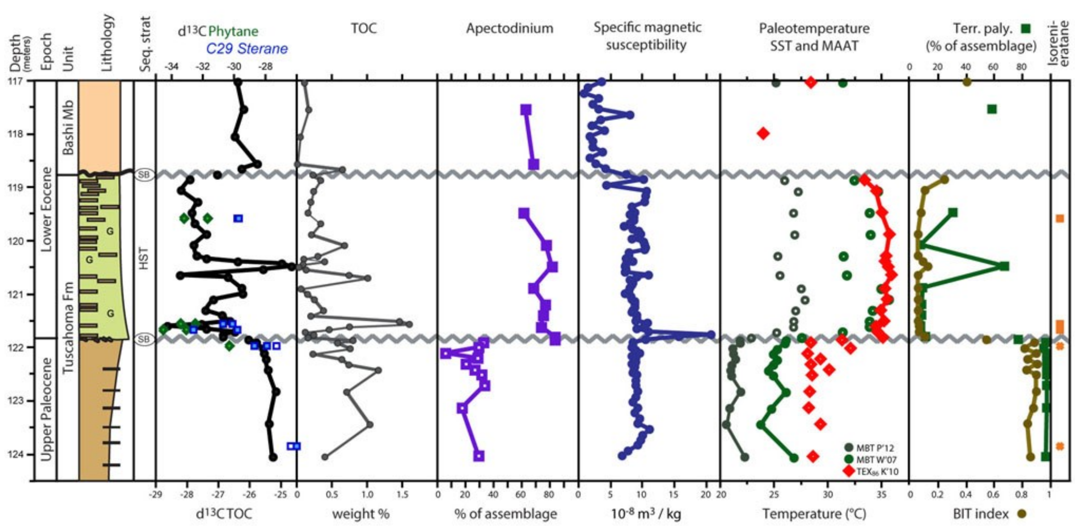
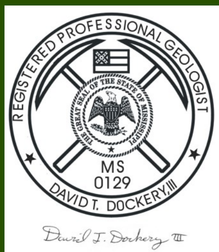


Figure 7. Analyses of the PETM in the Harrell core from Lauderdale County, Mississippi, as published in Sluijs et al., 2013, Extreme warming, photic zone euxinia and sea level rise during the Paleocene/Eocene Thermal Maximum on the Gulf of Mexico Coastal Plain; connecting marginal marine biotic signals, nutrient cycling and ocean deoxygenation: Climate Past Discussion, 9, 6459-6494, fig. 2.

The research above follows the proverb: "For the want of a nail the shoe was lost; for want of the shoe the horse was lost; for want of a horse the rider was lost; for want of a rider the message was lost; for want of a message the battle was lost; for want of a battle the kingdom was lost." What if Texas had no core and sample library, and someone had disposed of cutting samples from a dry hole drilled in 1952? What if Gregg Robertson had no samples to test the Eagle Ford Shale? What if the oil industry found it too risky to invest in an unconventional oil prospect without sound data from samples? The answer is: many struggling Texas ranchers would still be struggling, and the state would have missed out on a tax windfall. The U.S. would have imported that amount of oil from foreign nations, increasing our trade deficit. Like the Texas facility, MDEQ's Core and Sample Library continues to be a valuable asset for Mississippi's future.

Interior, Core and Sample Library.

Environmental News, September 2015, volume 12, issue 8, page 14-16



A Fourth Madison County Earthquake

David T. Dockery III, RPG, and Barbara Yassin, Office of Geology

The fourth in a series of earthquakes this year in Madison County struck southwest of Canton, Mississippi, a little after 1:00 pm on Monday, August 17, 2015. Media outlets began receiving calls of the event around 1:30 pm that afternoon. WLBT-TV cited a Gluckstadt resident as saying: “she felt her whole house shake about 2 or 3 seconds.” It would be several hours before the U.S. Geological Survey confirmed that a magnitude 2.6 earthquake had occurred at 1:00 pm, with an epicenter near Germantown Middle School located five miles north of Madison. Roslyn Anderson of WLBT-TV interviewed Principal Wesley Quick who was inside Germantown Middle School when he heard a loud boom followed by slight shaking. Minutes after the earthquake, the school took the opportunity to conduct an earthquake drill.

Figure 1 (at top) gives the epicenters of the four Canton area earthquakes and the fault attributed to them. The buried fault is also shown in cross section at bottom. Figure 2 compares the felt reports received at the U.S. Geological Survey earthquake report website between the third and fourth Canton earthquakes. The third earthquake, with a magnitude of 3.2, was the most widely felt of the four; the fourth was the least felt. Figure 3 compares the seismograms of earthquakes 3 and 4 as recorded by the AS1 seismograph of Louis Lyell at his home on Old Canton Road in Jackson. The fourth earthquake seismogram at right, with vertical units extending to 100 top and bottom, is reduced to match the scale of the larger earthquake, with vertical units extending to 240 top and bottom. The vertical scale measures amplitude (wave height) in digital units, which is a relative scale in an AS1 seismogram. According to Dr. Jamie Harris, Professor of Geology at Millsaps College, the shaking for the magnitude 3.2 earthquake was about four times greater than the magnitude 2.6 earthquake, and the energy release was about eight times greater.

Madison County, Mississippi 2015 Earthquakes with Volcano Cross-Section

MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY

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Figure 1

Epicenters (uncertainty ~4 km horiz.)

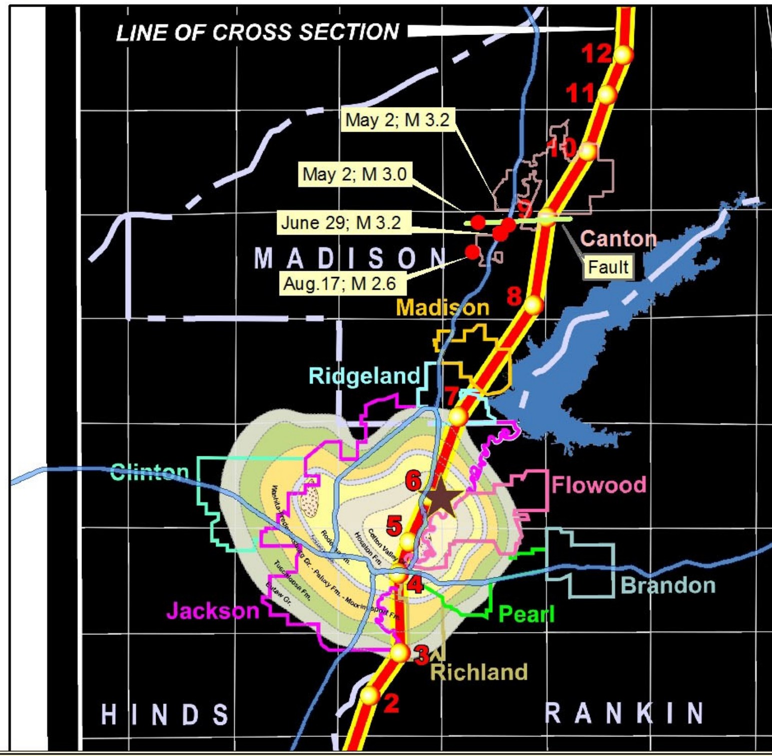
fault

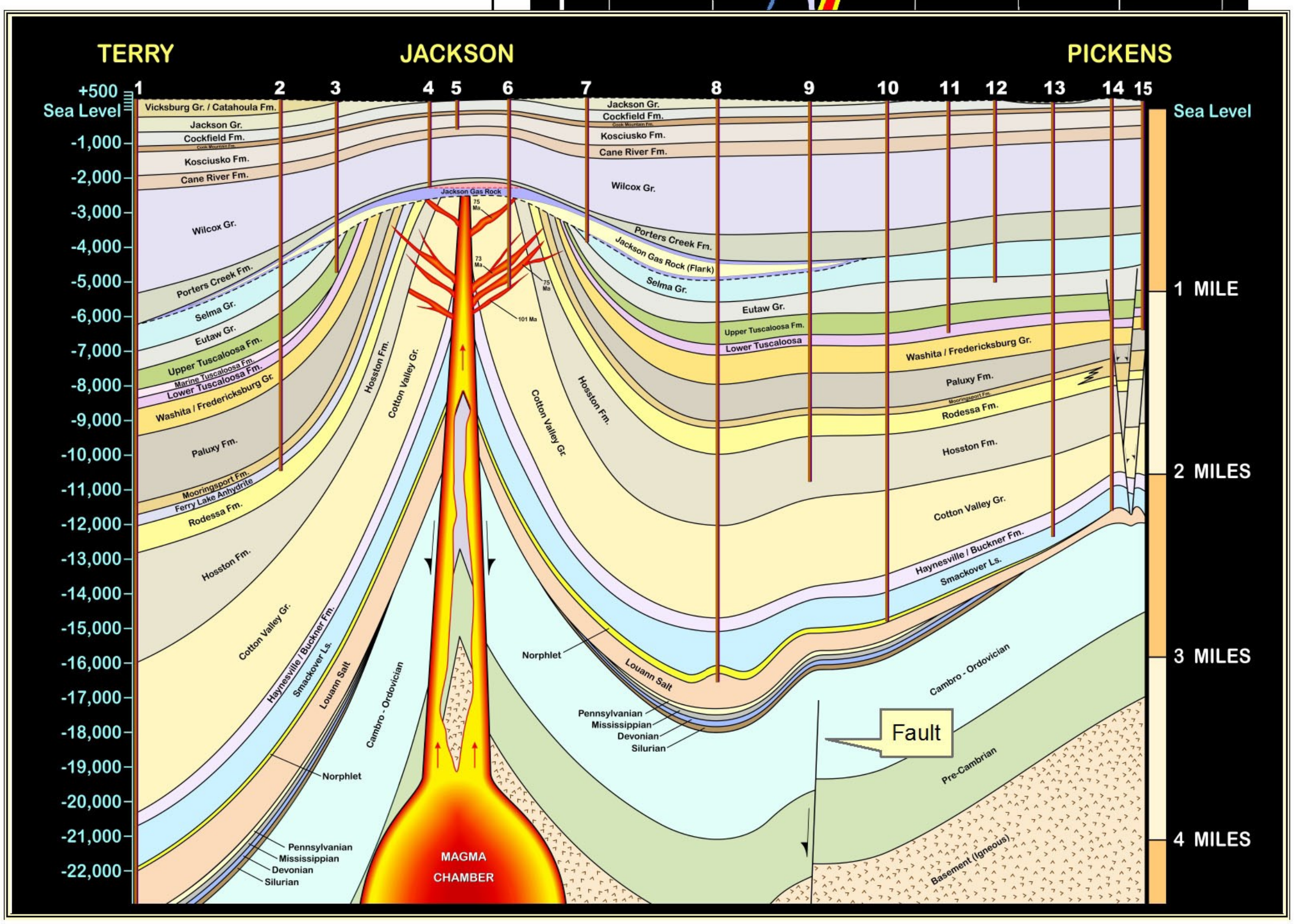
Interstate Highway

Figures from Steve Walkinshaw and Candy Goolsby published in Dockery, 2008, "Office of Geology Cross Section of Jackson Defines Inactive Volcano:" Environmental News, July 2008, v. 5, issue 7, p. 4.

GIS by Barbara Yassin, MDEQ 8/17/2015

Epicenter and Cross Section Location Map





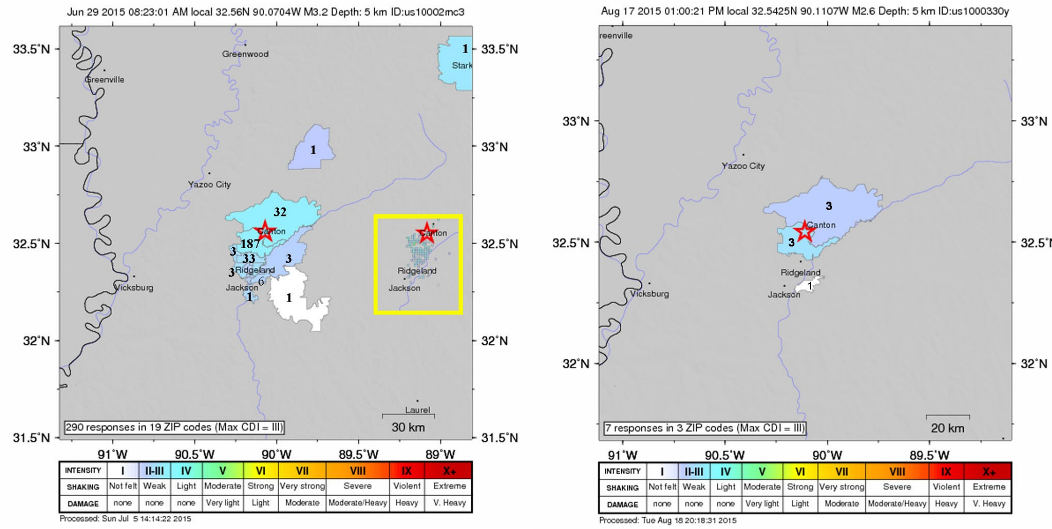


Figure 2. Composite of the USGS Community Internet Intensity Map for the third Canton, Mississippi, earthquake, June 29, 2015, 08:23:01 AM local time (left) and the fourth Canton earthquake, August 17, 2015, 01:00:21 PM local time (right). Responses by Zip Code for the fourth earthquake: Madison 39110, 3 responses; Canton 39046, 3 responses, and Flowood 39232, 1 response. The red star indicates the earthquake epicenter.

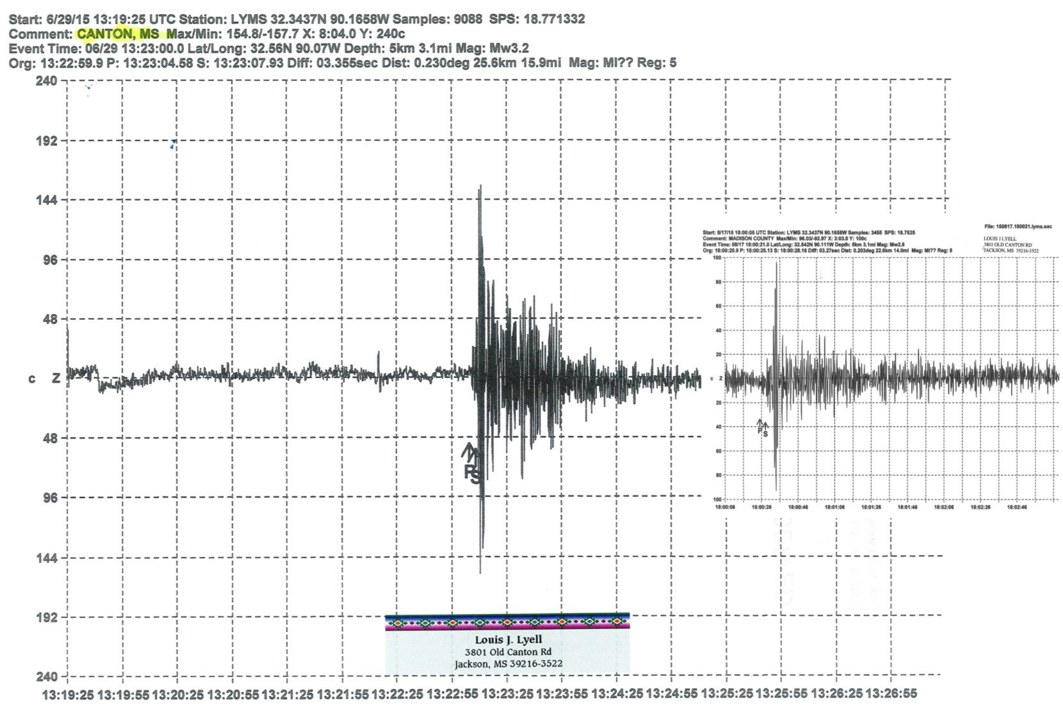


Figure 3. Seismogram of the 3.2 magnitude June 29, 2015, Canton earthquake at left. At right is the reduced to scale seismogram of the 2.6 magnitude August 17, 2015, Canton earthquake. Both seismograms are from the seismograph of Louis Lyell on Old Canton Road, Jackson, Mississippi.

Readers are encouraged to report their observations if they feel earthquakes in the future. One good way to do that is to use the "Did You Feel It?" feature on the website of the U. S. Geological Survey's Earthquake Hazards Program, http://earthquake.usgs.gov/.

Environmental News, October 2015, volume 12, issue 9, page 15-19

Geologic Map Day

Robert T. Berry, RPG, Office of Geology

Understanding the type of geology under your feet is the first step in understanding the world around you. Our understanding of the geology of an area has a significant effect on many things, from helping to sustain a healthy environment around us, to understanding and mitigating geologic hazards, from finding and understanding desirable minerals and natural resources, to understanding how the landscape is shaped and what kinds of plants grow best there.

What is a geologic map? Where can I find geologic maps of Mississippi? Who makes geologic maps for where I live?

A geologic map is designed to show where things are; however, unlike road maps or city maps, a geologic map is designed to illustrate the distribution of geologic features across an area of interest. A geologic map is usually printed on top of a base map, and the geology of the area is represented by colors, lines, and special symbols unique to geologic maps.

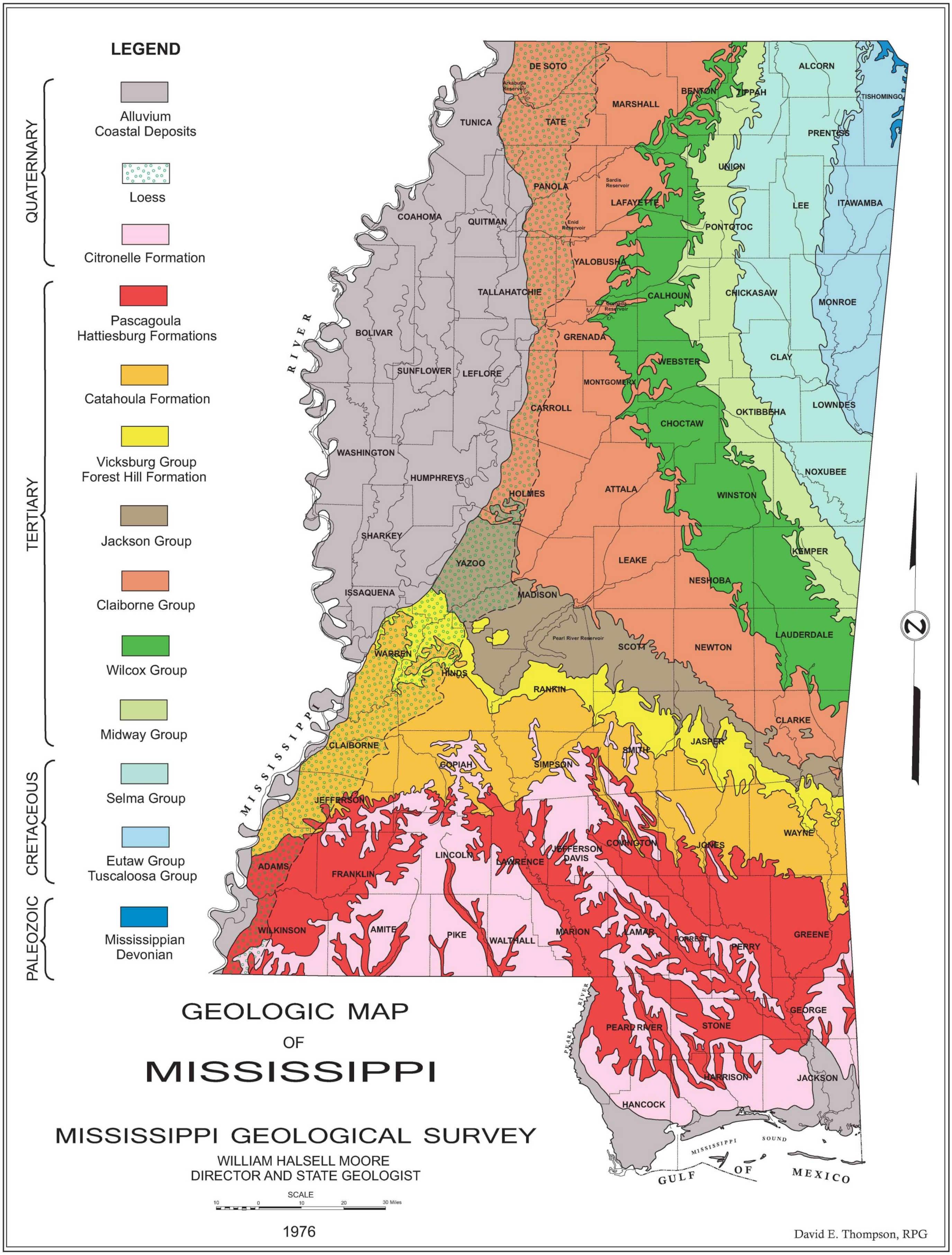
Topographic maps, typically used as the base maps for geologic maps, are produced by the U.S. Geological Survey in conjunction with each state. Geologic maps of each state are usually produced by their respective state agency. Thus, the geologic maps that are so essential to understanding our state are produced by MDEQ's Office of Geology.

October 16 was National Geologic Map Day, and the staff at MDEQ wants to illustrate geologic maps of Mississippi that are available from this agency. Geologic maps of the State of Mississippi, many of the counties, and 139 individual quadrangles may be viewed online and are available for free download at:

http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_surface?OpenDocument.

Now that you know who makes Mississippi's geology maps and where you can find them, you may ask yourself, "How can a geologic map help me?"

Following are a few interesting questions our map makers get asked regularly, with answers provided by geologic maps and associated links you can view online.



GEOLOGIC MAP
OF
MISSISSIPPI

MISSISSIPPI GEOLOGICAL SURVEY
WILLIAM HALSELL MOORE
DIRECTOR AND STATE GEOLOGIST

SCALE
10 0 10 20 30 Miles

1976

David E. Thompson, RPG

Is my house located on the Yazoo Clay that is responsible for foundation issues in the Jackson metro area?

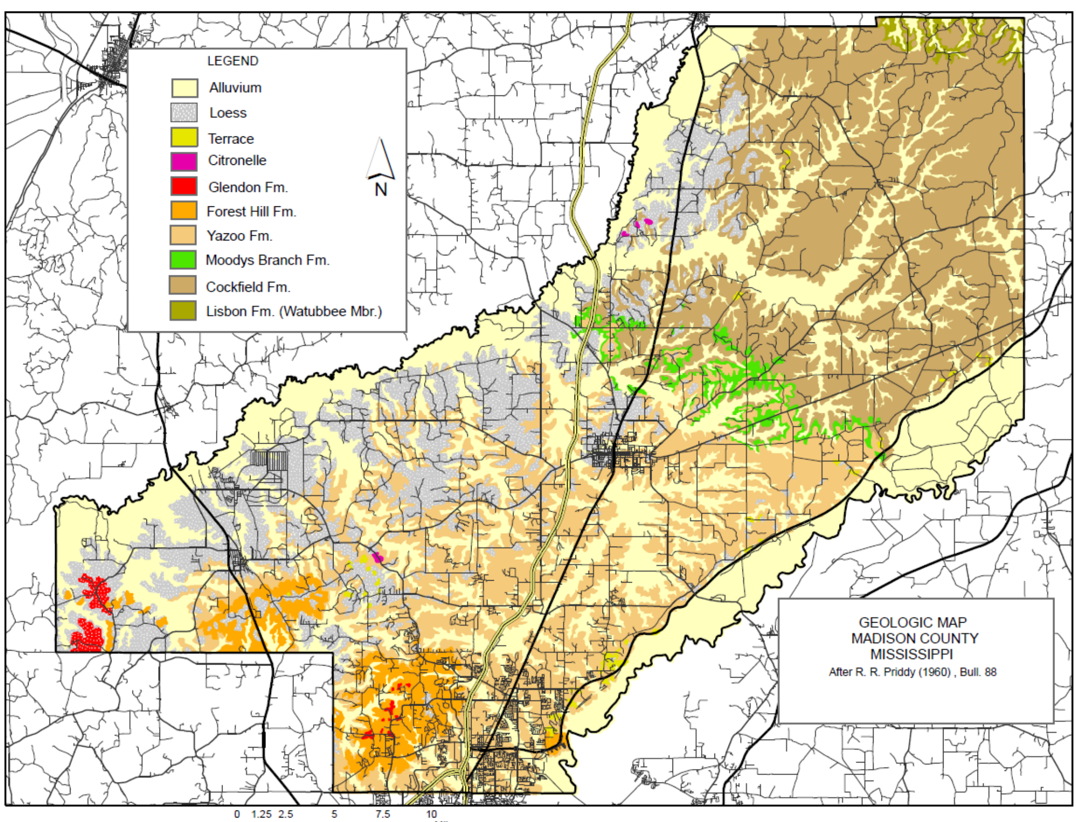
The answer to this question is very important to potential home buyers. Fortunately, there are geologic maps to help answer that question:

http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_Bulletin105?OpenDocument

http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_Bulletin115?OpenDocument

http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_Bulletin88?OpenDocument

These three links direct you to three separate geologic bulletins published for Hinds, Rankin, and Madison counties. Each of these bulletins includes geologic maps to help you understand the distribution and location of the Yazoo Clay and a scientific narrative to help understand its origin and nature. Prior to buying or building a new home, a prospective buyer or builder can view a geologic map to determine if their desired location is on the outcrop of an expansive clay.



Where can I find "Dinosaur age" fossils in Mississippi?

The answer is found on the state geologic map at:

http://www.deq.state.ms.us/MDEQ.nsf/pdf/Geology_MSGeology1969Map/$File/MS_Geology1969.pdf?OpenElement

"Dinosaur age" fossils are only found in areas of Mississippi where the rock layers exposed at the surface are between approximately 65 and 100 million years old, a span of geologic time known as the late Cretaceous Period. In Mississippi, these beds only occur at the surface in the northeastern part of the state. In the western, central, and southern regions of the state, they dip below the surface and are buried beneath successively younger beds.

In northeastern Mississippi, nine major Late Cretaceous beds, called "formations" by geologists, are exposed that contain "Dinosaur age" fossils and potentially dinosaur bones. These formations are depicted on the state's geologic map by the greenish and blueish colored units starting in the northeastern part of Kemper County and extending north through Tippah County.

A poster size Geologic Map of Mississippi is available for purchase at the Map and Publication Sales Office. Call 601-961-5523 for information about ordering and postage charges.

Is coal mined in Mississippi? If so, from what formation(s) is the coal being mined?

The answer to this question can be found in one of our recent 7.5-minute quadrangles, located at:

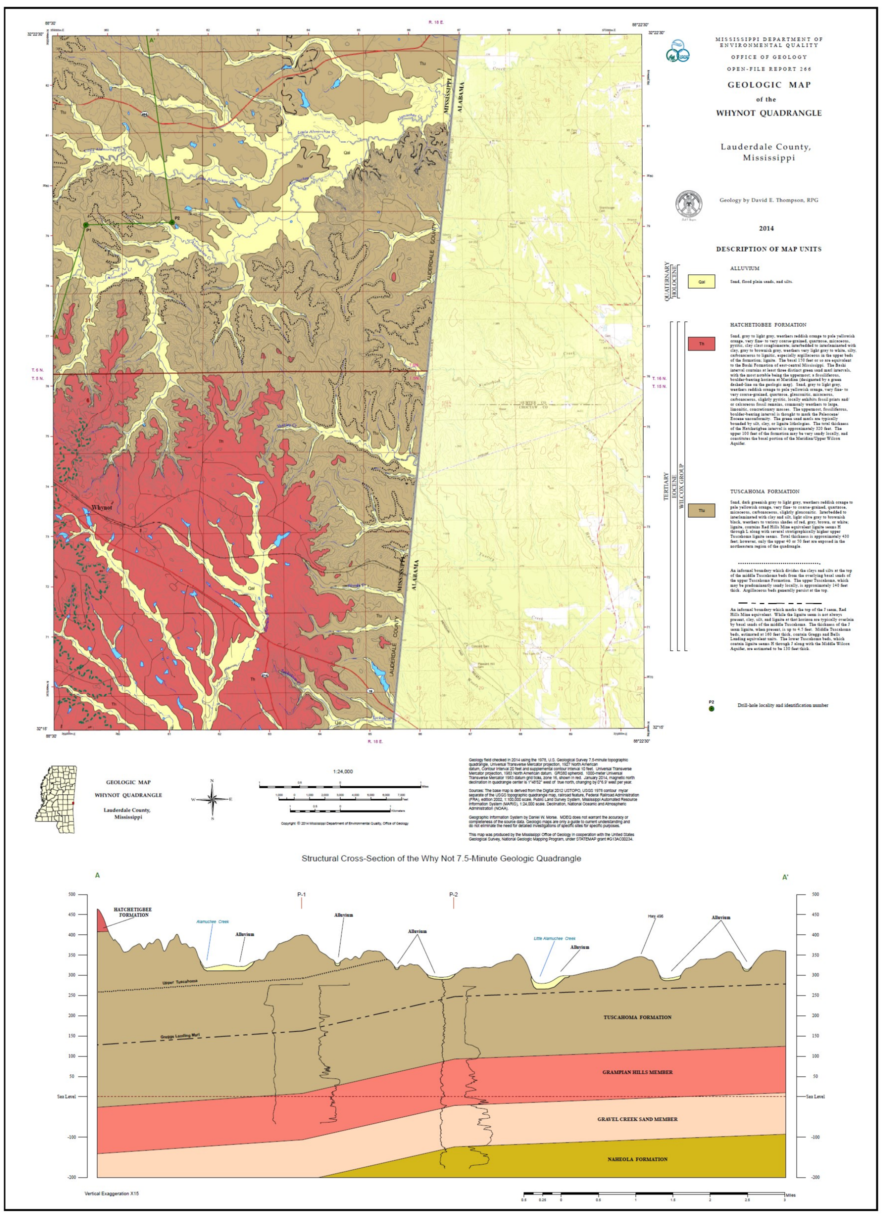
http://www.deq.state.ms.us/MDEQ.nsf/pdf/Geology_OF-266GeologicMapoftheWhyNotQuadrangle/$File/of_266_WhyNot_32088c4.pdf?OpenElement

Mississippi has an estimated five billion tons of surface minable lignite, or low grade coal. Currently, Mississippi has two active lignite mines. The majority of economic lignite deposits are found within the outcrop belts of the Wilcox and Claiborne groups.

The link above is the geologic map of the Whynot quadrangle, which is just one of many geologic maps used to understand the occurrence and nature of lignite in Mississippi. Geology outcropping at the surface of the Whynot quadrangle consists of mostly Wilcox Group sediments, which are described as "the great lignite-bearing formation in Mississippi."

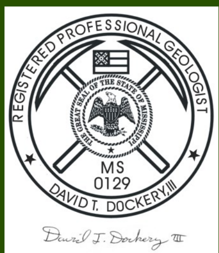
Illustrated on the Whynot quadrangle are the Hatchetigbee and Tuscahoma formations of the Wilcox group, which is identified by red and brown colors, respectively. Both of these formations contain multiple seams of lignite. The J-seam lignite, illustrated as a black dashed line, is located within the Tuscahoma Formation and has a thickness of up to 4.5 feet when present. Additionally, the lower Tuscahoma formation includes lignite seams H through J (130-foot section of lignite), which are not illustrated on the map.

What other questions do you have about geologic maps? To look for answers, go to MDEQ's website, scroll down to the Office of Geology link and start exploring. The List of Publications provides links to free downloads, and the county geologic reports are found in the list of Bulletins, and the geologic quadrangles are found under Open-File Reports.



Whynot Quadrangle.

Environmental News, October 2015, volume 12, issue 9, page 20-23



Coring The Eocene-Oligocene Boundary in Mississippi

David T. Dockery III, RPG, and James E. Starnes, RPG, Office of Geology

MDEQ's Office of Geology cooperated with LSU geology professor Dr. Brooks Ellwood to core the Eocene-Oligocene boundary near the Chickasawhay River at Hiwannee in Wayne County, Mississippi, on October 5 to 7, 2015. The core will be analyzed by Dr. Ellwood as part of a regional study of the boundary. Mississippi is well situated for such a study as the Late Eocene Shubuta Clay Member of the Yazoo Clay Formation of the Jackson Group and the overlying Early Oligocene Red Bluff Formation of the Vicksburg Group contain a well preserved marine fossil record, including a record of global events. A volcanic ash layer altered to bentonite in the uppermost Yazoo Clay in the Mossy Grove core in northwestern Hinds County placed the age of the Eocene-Oligocene boundary about 33.7 million years ago. The strontium isotopes of fossil oyster and pecten shells from the various formations of the Jackson and Vicksburg groups in Mississippi (sampled from the Office of Geology collections), as published by Denison et al. 1993, showed a continual shift in isotopic ratios upward through the section, with strontium from the erosion of continental rocks dominating over that contributed by seafloor volcanic eruptions (Figure 1).

Though halfway around the world, Mississippi's Eocene-Oligocene section records the continental collision of India and Asia and the uplift of the Himalayan Mountains and Tibetan Plateau. Associated events with this mountain-building episode were the exposure of new rock, sequestered carbon dioxide due to increased weathering, Antarctic glaciation, extinctions, and the transition from a "greenhouse to icehouse" global climate (Figure 2). In Mississippi the greenhouse to icehouse transition is recorded by the appearance of fossil oak pollen in the upper Yazoo Clay and the boundary extinction of certain Eocene planktonic Foraminifera, mollusks, and archaeocete whales (including the State Fossil).

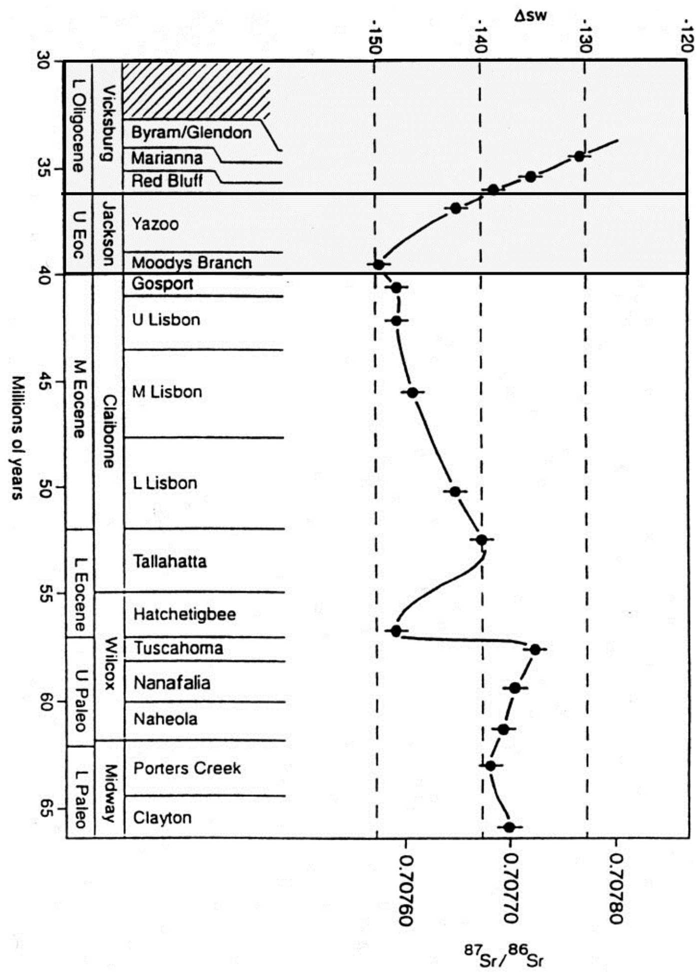


Figure 1. Strontium isotope ratios for ancient seawater as determined from Paleogene oyster and pecten shells collected from Mississippi and Alabama (Denison et al., 1993).

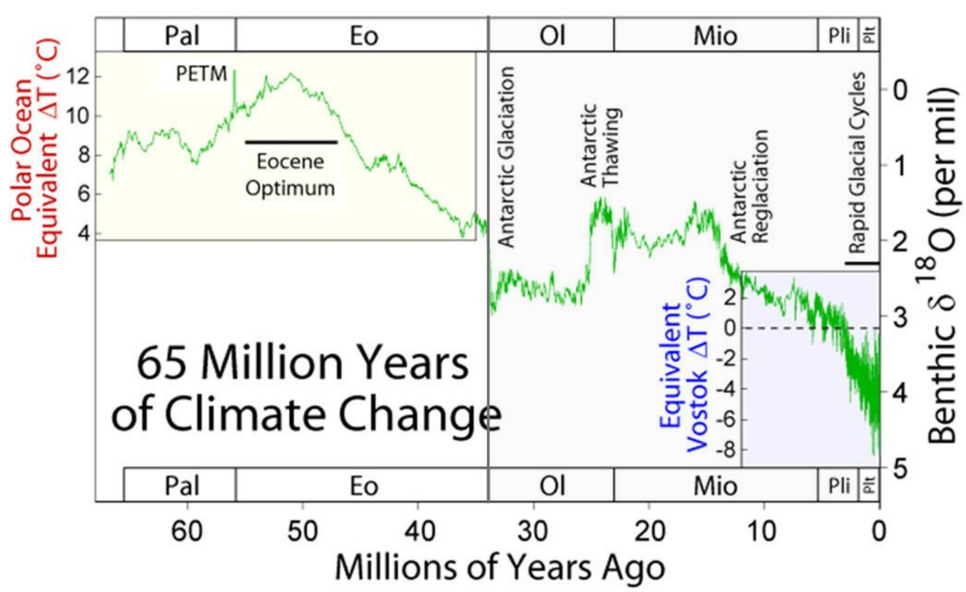


Figure 2. The Eocene-Oligocene boundary transition from “greenhouse to icehouse” climate and the inception of Antarctic Glaciation in the Oligocene Period (Ol), which occurs at the Jackson-Vicksburg Group boundary in Mississippi (Wikimedia Common).

Figure 3 shows Dr. Ellwood's sample site across the Eocene-Oligocene boundary on the east banks of the Chickasawhay River below the core-hole site. A second site on the river's west bank, where the boundary has been freshly scoured by the river, is shown in Figure 4. The drill site and the extrusion of a weathered section of the Forest Hill Formation are shown in Figure 5. Figure 6 shows the core containing the boundary and the location of the Eocene-Oligocene boundary in the core.

The core hole was drilled to a total depth of 214 feet and penetrated, in descending order: (1) colluvium, (2) the Forest Hill Formation, (3) the Red Bluff Formation, (4) the Shubuta Clay Member of the Yazoo Formation, (5) the Pachuta Marl Member of the Yazoo Formation, (6) the Cocoa Sand Member of the Yazoo Formation, and (7) the North Twistwood Creek Member of the Yazoo Clay Formation.

Figure 3. Left, Brooks and Sue Ellwood standing on the Shubuta Clay Member of the Yazoo Formation on the east bank of the Chickasawhay River at Hiwannee. The contact with the overlying Red Bluff Formation is marked by a yellow X here and at sample site at right.

Figure 4. The Shubuta-Red Bluff contact at MGS locality 34 on the west bank of the Chickasawhay River, where it is better exposed. Machete blade is stuck in contact at left and in the closeup view at right, where burrows in the Red Bluff extend downward into the Shubuta Clay.

Figure 5. Left, drill site at Hiwannee. Right, the first core from the weathered zone of the Forest Hill Formation, which overlies the Red Bluff Formation (October 5, 2015).

Figure 6. Left, Sue and Brooks Ellwood; Sue is pointing to the Shubuta-Red Bluff contact in the core. Right, a quarter is on the Red Bluff Formation; the contact with the Shubuta is marked by the red X.

We thank Rebecca Nored for giving us permission to drill on her property. The red color of the cliffs comes from the weathering of glauconite in the Red Bluff Formation to iron oxides such as limonite and goethite. The type locality of the Red Bluff Formation is on the west bank of the Chickasawhay River north of Hiwannee at Red Bluff, a name that appears on the 1860 State Geologic Map by Eugene Hilgard.

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EXPLODING SHELLS

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The title is not about military ordnance; it is about the damage caused to scientific specimens--fossil shells exploded slowly from within due to crystal growth and expanding matrix. Examples can be found in the collection of fossil shells from the Moodys Branch Formation in Mississippi, which were illustrated in Mississippi Geological Survey (now MDEQ Office of Geology) Bulletin 120 (Dockery, 1977). Subsequent to the publication, the shells were preserved in specimen-sized zip-lock plastic bags, placed in a metal cabinet, and stored in a building lacking climate control. Changing temperature and humidity, even within sealed zip-lock bags, can cause fossil shells to absorb moisture. Moisture reacts with pyrite (iron sulfide) within the shell's internal matrix (seafloor sediment that filled the shell), producing sulfuric acid and various hydrated sulfates, which expand and "explode" the shell. This malady is known as pyrite disease and affects fossil shells, fossil bones, and carbonized plant remains. Fossils are important in surface geologic mapping, stratigraphic correlations, mineral and petroleum exploration, and in scientific research on ancient life, climate, sea level, ocean currents, environments, and plate tectonics (movement of the continents).

Fortunately, most of the fossil shells figured in Bulletin 120 were preserved in good condition. Examples of two specimens that exploded are shown below. Figure 1 illustrates four side views of a figured specimen (in Bulletin 120) of the rare gastropod *Platyoptera extenta* from the Moodys Branch Formation in Jackson that is still beautifully preserved. Figure 2 shows a figured specimen of the same species that exploded while in storage. Figure 3 shows images of a figured specimen of *Architectonica bellistriata* as it was when originally photographed and as it is today as an exploded shell.

Figure 1. *Platyoptera extenta* (Conrad *in* Wailes, 1854), Height 40 mm, Width 29.5 mm, Moodys Branch Formation (Late Eocene), Town Creek locality, Jackson, MS, (figured in Dockery, 1977, Plate 4, figures 13A, 13B).

Figure 2. *Platyoptera extenta* (Conrad *in* Wailes, 1854), Height 35 mm, Width 25 mm (as originally measured), Moodys Branch Formation, Town Creek locality, Jackson, MS, (figured in Dockery, 1977, Plate 4, figures 2A and 2B).

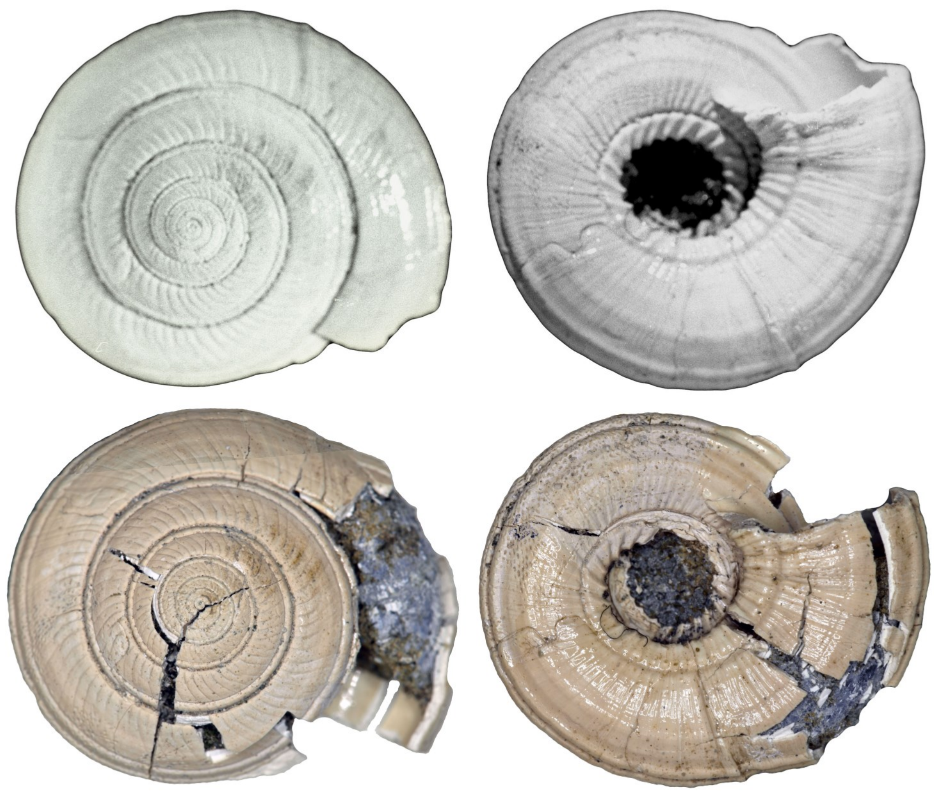

Figure 3. *Architectonica bellistriata* Conrad *in* Wailes, 1854, Height 11 mm, Width 21.5 mm, Moodys Branch Formation, Town Creek locality, Jackson, MS, figured in Dockery, 1977, Plate 1, figures 18A, 18B; as illustrated in 1977 at top, and recent picture at bottom.

The Family Architectonicidae contains a group of marine gastropods commonly known as staircase shells or sundials. The name is derived from the Latin word *architectus*, meaning master-builder. Members of this group have a larval shell that coils upward (toward the apex) and adult whorls that reverse direction and coil downward around a hollow conical axis called the umbilicus.

The umbilicus has the staircase appearance, which rivals the work of any master-builder. Two species of *Architectonica* live off the American coast today in warm temperate to tropical waters: *Architectonica nobilis* Röding, 1798, and *Architectonica peracuta* (Dall, 1889). The Moodys Branch Formation at Jackson contains four species of this genus as illustrated in Bulletin 120. Fossils from the Moodys Branch Formation are of interest to scientists worldwide. For this reason, the fossil Architectonicidae shells of Bulletin 120 were re-photographed with a Nikon D5500 camera, an AF-S VR Micro-Nikkor 105 mm lens, and lens-mounted ring lights. Two pictures were required of each specimen to fit the whole shell within the picture frame. These images were merged and appear in figures 4 and 5.

Figure 4. *Architectonica bellistriata* Conrad *in* Wailes, 1854 (top and middle), Height 13 mm, Width 22.5 mm, Dockery, 1977, Plate 1, figures 19A and 19B, at middle, Height 11 mm, Width 20 mm, Dockery, 1977, Plate 1, figure 17; *Architectonica billmoorei* Dockery, 1977 (bottom), Height 7 mm, Width 17.5 mm, Dockery, 1977, Plate 2, figure 4.

Figure 5. *Architectonica ornata jacksonia* Palmer, 1947 (top), Height 10.5 mm, Width 19 mm, Dockery, 1977, Plate 2, figures 3A and 3B; *Architectonica meekana subsplendida* Palmer, 1947 (middle), Height 9.5 mm, Width 22 mm, Dockery 1977, Plate 2, figures 1A and 1B; *Architectonica alveata* (Conrad, 1833) (bottom), Height 11.5 mm, Width 24.5 mm, Dockery, 1977, Plate 3, figures 1A and 1B.