A GUIDE TO THE INTERPRETIVE SIGNAGE AT WETUMPKA IMPACT CRATER, ELMORE COUNTY, ALABAMA

HOW TO SEE THE WETUMPKA IMPACT CRATER

David T. King, Jr.
Professor of Geology at Auburn University
kingdat @ auburn.edu

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The author acknowledges the invaluable contributions of several Auburn University colleagues, many former graduate students, and key colleagues outside Auburn in the global crater community. The author recognizes especially the numerous contributions of his co-researcher, Lucille W. Petruny.

This guide is dedicated to Thornton L. "Tony" Neathery (1932-2015) who was the first to propose that the unusual geological features at Wetumpka were likely of meteorite-impact origin. Tony helped to facilitate the 1998 scientific borehole drilling that led to the discovery of key proof-of-impact evidence in 2002.

The Wetumpka Impact Crater Commission (WICC) is acknowledged especially for their untiring work in creating, producing, and placing these important educational viewpoint signs and in making related information publicly available regarding Wetumpka's self-guided driving tour. Visitors should see WICC information at https://www.wetumpkaimpactcratercommission.org/.

Some images used in this guide were provided by the Wetumpka Impact Crater Commission or were obtained from the on-line Historical Marker Data Base (HMdb.org) collection of Wetumpka's Viewpoint signs. I am very appreciative of permission to use of these photos.

Image origins are as follows (in order of appearance with the description of each viewpoint location: Viewpoint #1 – WICC and HMdb.org (2); Viewpoint #2 – WICC (2); Viewpoint #3 – WICC, HBdb.org (2), and the author (mosaic); Viewpoint #4 – HBdb.org, WICC, and the author; Viewpoint #5 – HMdb.org (3); Viewpoint #6 – HMdb.org (3); and Viewpoint #7 – HMdb.org (3) and the author (cross section). Cover photo: the author. Location Map: WICC. AHA marker: the author and HMdb.org (2). And, the Appendix LiDAR image: the author. Images from HMdb.org are attributed to Mark Hilton of Montgomery, Alabama.

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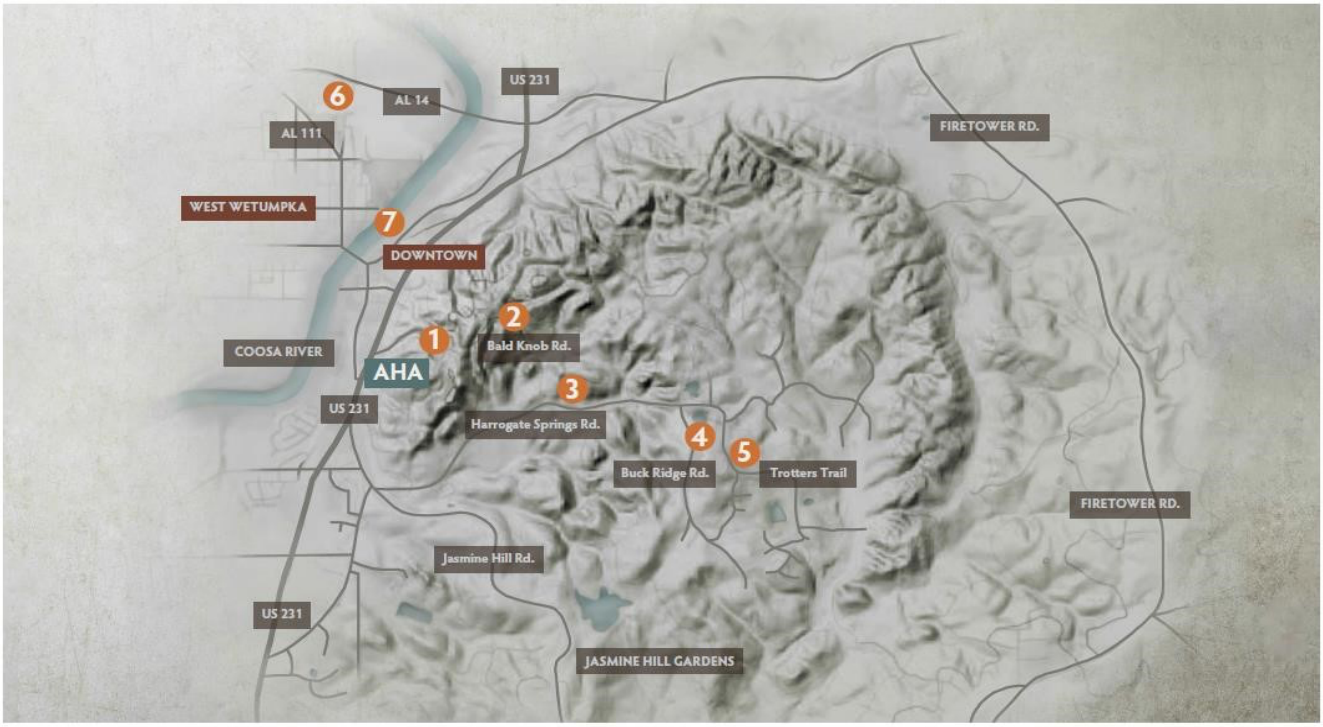
LOCATION MAP FOR EDUCATIONAL VIEWPOINT SIGNS and the AHA MARKER

This map, which was made by the Wetumpka Impact Crater Commission, shows the crater-area relief, the main roads, the locations of the seven Educational Viewpoint signs (#1-7) placed by the Commission, as well as the Alabama Historical Association (AHA) Marker. The stops in this guide follow the numbering system shown on this map.



WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINTS

- AHA **ALABAMA HISTORICAL ASSOCIATION MARKER:** 6501 US Highway 231
- 1 **EDUCATIONAL VIEW #1:** 715 Wilson Street, behind First Community Bank
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SEE THE WETUMPKA IMPACT CRATER

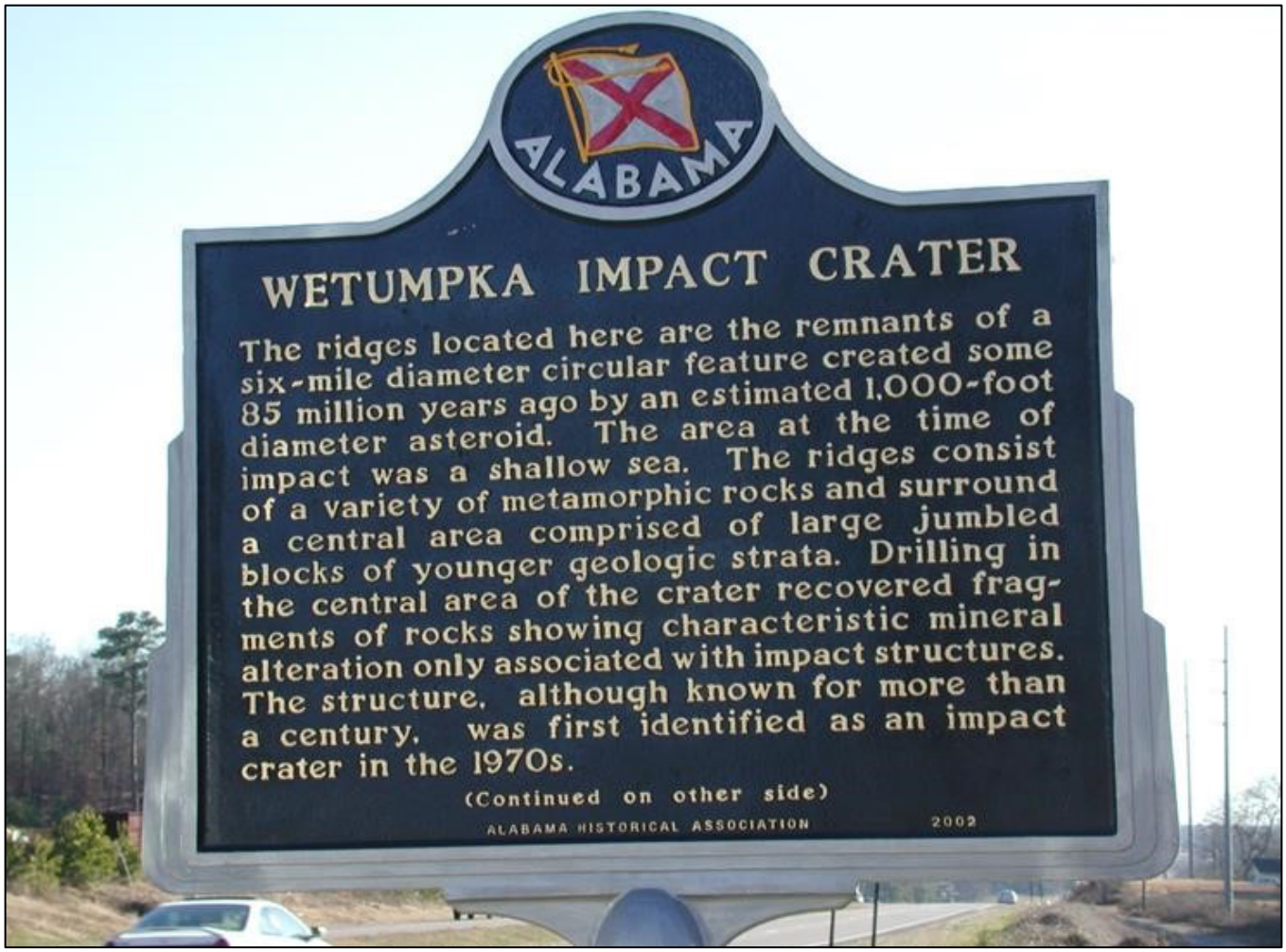
One of the most common questions asked by visitors to Wetumpka, Alabama is “How can I see the Wetumpka Impact Crater?” It is very visible, but most area residents take the unusual terrain for granted. The Wetumpka Impact Crater Commission reminds individuals, who want to tour, that many of the best views are on private property, and it is important to respect property owner’s rights.[16]

However, the Crater Commission has placed “Educational Viewpoint Signs” in public places so that visitors can view, and better understand, the crater. Our maps (pages 1 & 2) and self-guided directions are meant to serve only as suggestions for your tour route. The order of visiting Viewpoint Sign sites is not important, but signs are numbered for location and identification. Driving towards the city of Wetumpka, you can see the large hills rising up on the east side of US Highway 231 and south of Alabama Highway 14. The eastern crater rim also is visible along Fire Tower Road. From US Highway 231, several communication towers can be seen at Bald Knob, the highest point along the crater rim (elevation 587 feet). From Wallsboro, to the north; Prattville, west; and Montgomery, south, there are excellent vista views of the crater rim as you approach Wetumpka.

Dennis Pillion writes of his Crater Tour in a 2021 article *84 million years ago, a massive meteorite strikes ancient Alabama,* which was published at al.com*,* “Driving back down from the summit (Bald Knob) at dusk offers a sunset view far better that it has any right to be, as the ridge stands hundreds of feet higher than anything else off to the west, letting you see the flat, anthill countryside of the Black Belt stretching all the way to Mississippi. On the other side of that hill, you’ll see strange-looking “cliffs” of white rock swirled with veins of deep red as rainwater eats away at the hillside, exposing the earth beneath. Further down in the canyon floor, yellow-orange ridges reach up toward the sky like some miniaturized version of Badlands National Park, but with more pine trees."

WETUMPKA IMPACT CRATER
ALABAMA HISTORICAL ASSOCIATION MARKER
LOCATION: ELMORE COUNTY HEALTH DEPARTMENT, 6501 U.S. HIGHWAY 231

A good place to start your tour is in front of the *Elmore County Health Department* on US Highway 231. An Alabama Historical Association marker (See AHA on the map) has been erected to recount the story of the Wetumpka Impact Crater. The location of the marker is approximately halfway between Bald Knob (Sign #2) and the rocks from the crater in the Coosa River (Sign #7)



Text printed on the sign: "The ridges here are the remnants of a six-mile diameter circular feature created some 85 million years ago by an estimated 1,000-foot diameter asteroid. The area at the time of impact was a shallow sea. The ridges consist of a variety of metamorphic rocks and surround a central area comprised of large jumbled blocks of younger geologic strata. Drilling in the central area of the crater recovered fragments of rocks showing characteristic mineral alteration only associated with impact structures. The structure, although known for more than a century, was first identified as an impact crater in the 1970s."

Location with respect to the whole of the impact crater: As shown on the map at the outset of this guidebook (see point marked AHA), this location is on the western rim of Wetumpka impact crater. Rocks exposed in an old quarry on the opposite side of U.S. Highway 231 are the same crater-rim metamorphic rocks, which are tilted toward the west, as seen at Viewpoints #1 and #7. Adjacent to this marker, on the north side of E-S Boundary Street where it joins U.S. Highway 231, you can see deeply weathered craterrim metamorphic rocks with layers that are inclined toward the river (to the west).

Scientific research conducted at or near this site: This area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They obtained samples of metamorphic crater-rim rocks from the old quarry across the highway from this marker and used them to check for microscopic evidence of meteorite impact, but they were not successful in finding this evidence.

Historical notes about this site: This historical marker was placed at this site during 2003. The marker was not installed until Auburn University researchers established clearly that Wetumpka impact structure was in fact a meteorite crater. Findings about Wetumpka, including two strong lines of evidence, were published in 2002. The lines of evidence presented in the peer-reviewed scientific paper were (1) abundant and convincing instances of impact-related, high-pressure damage to mineral grains, especially quartz grains, and (2) clear and convincing evidence of contaminating elements within the crater-filling sediments that came from the exploding asteroid. These elements were cobalt, chromium, nickel and iridium. The sign's text about "characteristic mineral alteration only associated with impact structures" refers to point (1) above. With the 2002 publication of the proof-of-impact scientific paper, Wetumpka impact crater became the 157th known impact crater on Earth and the 57th known impact crater in North America. The age date given on the historical marker ("some 85 million years ago") was a general estimate in 2003. In 2012, results of radiometric age dating using a new laboratory technique that allows age dating of small impact craters like Wetumpka, showed that the age is actually 84.4 million years, plus or minus 1.4 million years. This finding was fortunately consistent with the sign text that had been written nine years earlier. It should be noted that the width of Wetumpka impact crater is more nearly three miles, not six as noted on the sign. Also, the size of the asteroid (1,000 ft diameter) is speculative at best and in fact may be slightly larger than this.

Glossary

Peer-reviewed – a scientific screening process for publication of papers that involves obtaining detailed comments and insightful written reviews from a small group of scientific peers of the paper's author(s) who are not known to the author(s)

High-pressure damage – tiny layers of crushed and melted material within mineral grains that have been suddenly subjected to high-pressure shock waves that formed when the impacting meteor detonates in the target rock

Contaminating elements – elements that were part of the impacting asteroid but are now imbued in the local bedrock of the impact crater and/or in the crater-filling materials; these elements were liberated from the asteroid when it vaporized on impact

Radiometric age dating – a general term for a collection of laboratory processes that involve measuring the tiny amounts of radioactive decay products versus the content of original radioactive atoms within mineral crystals

Context photograph 1 – This image shows the historical marker, the County Health Department sign, and U.S. Highway 231. Across the highway, an outcrop of metamorphic crater-rim rocks can be seen.

Context photograph 2 – This image shows the other side of the Wetumpka impact crater's historical marker. This map was taken from a guidebook article written by the author in 1997.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #1
LOCATION: BEHIND FIRST COMMUNITY BANK ON US 231 IN WETUMPKA

From the Health Department, drive south on US Highway 231 to (Sign #1) located behind *First Community Bank*. The rear parking area is one of the best places to see "up-close" rock representative of the crater rim. The bedrock of the north and northwestern crater rim is comprised of mica schist, a type of metamorphic rock common in the Alabama Piedmont. In this area, the bedrock dips in a north to northwest direction due to displacement caused by the explosion when the meteor impacted the Earth's surface

Text printed on the sign: "You are on the northwestern rim of the Wetumpka Impact Crater. In this area of the crater rim, there are several man-made cuts into the metamorphic bedrock. Mica schist forms the bedrock in this area down to depths of several thousand feet. After the meteor impact's explosion, the layers of rock were reconfigured so that they dip away from the crater center. The layers and their telltale westward inclination can be seen well at this site."

Location with respect to the whole of the impact crater: The eroded remains of the western rim of the Wetumpka impact crater are relatively wide on the crater's western side (where the sign is located). The crater rim extends from the Coosa River to a few hundred meters east of this location. U.S. Highway 231 lies upon the crater rim as it goes through this area. The crater rim was excavated in order to have space to build the highway and the adjacent commercial buildings like the First Community Bank and Waffle House.

Scientific research conducted at or near this site: In 2009, a scientific borehole was drilled a few hundred meters north of this location. The drill penetrated the metamorphic rocks of the rim that are inclined toward the west, then entered a thin, crushed zone of rock near the elevation of the Coosa River, and below river level drilling penetrated metamorphic rock that was not affected by the impact. The rock outcrop behind the Viewpoint #1 sign and other rock outcrops in the area, such as the rock wall north of the Waffle House and behind the First Community Bank, have been shown in figures within several scientific papers published on Wetumpka impact crater. Research for one geology Master of Science student's thesis was conducted on these metamorphic rocks (2012), which also occur in outcrops near the County Courthouse and in the Coosa River near the old bridge. This student research revealed that the inclination of the rock layers is consistent with the expected structure of a crater rim (see also the cross-section diagram included with the explanation of Viewpoint #7).

Historical notes about this site: This area was visited by State Geologist Eugene Allen Smith (1841-1927) during August 1891 when he was engaged in the first geological mapping work ever done in this area. He noted that these metamorphic rocks were not expected to be at the surface at this location and speculated about forces of "unknown origin" that may have deformed the rocks in this area. He was not aware of other impact craters on Earth and did not attribute the disturbance of rocks at Wetumpka to cosmic impact. This area was visited by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They observed the disturbed rocks in this area and noted how the metamorphic rocks were part of an arc-shaped zone of hard, dense rocks, which has a diameter of about five kilometers (3.1 miles). They speculated in a published paper
(1976) that these metamorphic rocks might represent the deeply eroded rim of an ancient impact crater.

Glossary

Mica – a silver or black mineral that occurs in the form of flat sheets; the surfaces of these sheets are smooth and shiny

Mica Schist – a metamorphic rock made of mica, quartz, and other hard minerals; organized into flat layers called foliation and breaks into flat pieces

Metamorphic rocks – rocks that have formed mainly because of heat and pressure affecting pre-existing rocks

Impact crater – a concentric or circular depression in the Earth's surface that was formed by the energy of an impacting meteor, asteroid, or comet

Inclination – in geology, the departure from horizontal of a rock layer or foliation in metamorphic rocks; measured as the angle between horizontal and the top of the inclined layer

Disturbance – a general term in geology for the cause of a disruption in the normal organization of rocks in an area; may be due to internal forces of the Earth (fault movement, tectonics, etc.), volcanism, or cosmic forces from meteorite impact

Context photograph 1 – In this side view, you can see the layers of metamorphic rock (mica schist) that are inclined toward the parking lot. The direction of inclination is down toward the west, which is in turn away from the center of the crater, which is located about 2.5 kilometers (about 1.6 miles) to the right (east) of this interpretive sign location. The area above the rock outcrop is private property and visitors should not trespass.

Context photograph 2 – In this view of the First Community Bank outcrop, you can see the layers of metamorphic rock (mica schist) that are inclined toward the parking lot. The direction of inclination is down toward the west, and the inclination of the rock layers is about 48 degrees from horizontal according to the geological map by Neathery et al. (1976). The area above the rock outcrop is private property and visitors should not trespass.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #2
LOCATION: BALD KNOB ROAD AT THE ALABAMA POWER COMPANY POWERLINE

From the bank, continue south on Highway 231 and turn left onto Knight Street (beside *Smokin' S Bar-B-Que*), left onto Hillside Drive, left onto Enslen Road, then left onto Bald Knob Road. Be careful on Bald Knob Road; it is narrow and will not always allow for two cars to pass. Continue along Bald Knob Road for almost a mile. The unusual terrain here is quite beautiful. Watch for the Educational Viewpoint (Sign #2) on your right (9/10th of a mile). There is limited parking. From this vantage point along the rim, you can look down the utility line right-of-way, across the floor of the crater

Text printed on the sign: "The beautiful vista across the Wetumpka Impact Crater is best seen from the highest point on the northwestern rim here at Bald Knob. A favored area for communication towers, Bald Knob is almost 600 feet above sea level. Looking down the power line cut-through shows the rim on the east side and some of the disruption and changing terrain inside the crater. Best views of the other side of the crater are from private property also pictured here."

Location with respect to the whole of the impact crater: This site is nearly atop the western rim of the Wetumpka impact crater. A view to the east along the power-line cut shows the interior of the crater and a view to the west shows the wide floodplain area of the Coosa and Tallapoosa rivers, which abuts the western crater rim. The crater floor, which can be seen here (downhill, along the power-line cut) consists of red, brown, and tan sediments that are directly adjacent to the crater-rim rocks (seen on the side of the road driving up Bald Knob Road to the sign's location). The crater-rim rocks are the same metamorphic rocks (specifically mica schist) as seen at Viewpoint #1. The sediments and sedimentary rocks of the cliffs area will be described more specifically at Viewpoint #3.

Scientific research conducted at or near this site: In 2012, research at Auburn University for a geology Master of Science student's thesis was conducted on the metamorphic rocks of the crater rim in this area. This research helped us understand the structure of the western crater rim, and its relationship to the sediments and sedimentary rocks of the crater floor (as seen at the cliffs). Two Master of Science student theses, both finished in 2015, showed that the sediments and sedimentary rock layers at the cliffs were moved to that location during a huge landslide event (described more specifically in Viewpoint #3).

Historical notes about this site: This area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They observed the rocks in this area and noted how they were part of an arc-shaped zone of metamorphic rock, which has a diameter of about five kilometers (about 3.1 miles). They speculated in a published paper that these metamorphic rocks might be rocks of the deeply eroded rim of an ancient impact crater. Samples were taken near this location to look for microscopic evidence of high-pressure alteration of minerals, but this effort was not successful. Later, it was found that high-pressure effects of the Wetumpka impact are only confined to a small area near the crater's center. They also carefully mapped the boundary between the metamorphic rocks of the crater rim and the sediments of the crater floor in this area. They traversed this power-line cut and studied the cliffs area as well.

Glossary

Metamorphic rocks – rocks that have formed mainly because of heat and pressure affecting pre-existing rocks

Impact crater – a concentric or circular depression in the Earth's surface that was formed by the energy of an impacting meteor, asteroid, or comet

Disruption – a general term in geology for the cause of a disturbance in the normal organization of rocks in an area; may be due to internal forces of the Earth (fault movement, tectonics, etc.), volcanism, or cosmic forces from meteorite impact

High-pressure effects – damage done to the crystal structure of a mineral by the thousands of atmospheres of pressure exerted by meteorite impact

Context photograph – In this oblique view of the interpretive sign, which is placed on the western rim of Wetumpka impact crater, you can see Alabama Power Company's right-of-way cut for its power lines, which is oriented approximately north-south in this area. The view here is looking approximately south. Just beyond the point where the power line cut passes through the notch in the trees and disappears from view, there is a large area of crater-floor sediments that have been exposed in a network of deep gullies formed by intensive stream erosion. This area is called "the cliffs," and is described in more detail in the next Viewpoint (#3). The power line cut is private property and visitors should not trespass.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #3
LOCATION: HARROGATE SPRINGS ROAD AT THE ENTRANCE TO "THE CLIFFS"

Retrace your path back to Highway 231, and drive south to the intersection of River Oaks and Old Montgomery Highway, turn left onto Old Montgomery Highway, and take the next left onto Jasmine Hill Road. In a short distance, turn left onto Harrogate Springs Road. Approximately one mile east of the Jasmine Hill Road intersection is an area referred to locally as *"The Cliffs." "The Cliffs"* (Sign #3) can be viewed from the north side of Harrogate Springs Road. The Educational Viewpoint Sign #3 is in a low area where a utility line right-of-way is located. Be careful pulling off the road here. The best viewing at this location may be when you return, driving on the north side of the road

Text printed on the sign: "You are on the crater floor inside the western rim of the Wetumpka impact crater, in an area called the "cliffs." After the meteor's impact, there was a massive landslide from the southern rim that brought vast quantities of clay and sandy sediment back into the crater. The effect of this event can be seen in the wide-spread red and tan crater-filling deposits along Harrogate Springs Road. At the cliffs, the slide layers

folded up against the harder rocks of the crater rim. The large gully is due to erosion when groundwater emerges from the buried crater rim."

Location with respect to the whole of the impact crater: This site is on the western side of the crater floor area, which is adjacent to the western rim. The western rim can be seen in the distance in the photograph on the Viewpoint #3 sign. At this site, the cliffs – which are located on private property – can be seen in the distance through a gap in the trees. The sign shows a close-up photograph of results of intensive stream erosion that has laid bare many layers of deformed sediments and sedimentary rocks, which were part of a colossal landslide that moved from the southern rim and thus brought vast quantities of clay and sandy sediment back into the crater. Thus, these sediments were originally part of a shortlived southern crater rim, which no longer exists. This modification of the southern rim by massive landslide accounts for the present arc-shaped (or "horse-shoe" shaped) crater rim (note this shape in the crater relief map shown in the lower right-side corner of the interpretive viewpoint signs).

Scientific research conducted at or near this site: In 2015, research at Auburn University for two geology Master of Science students' theses was conducted on these sediments and sedimentary rocks, which showed that they are deformed and folded in a manner consistent with a "trans-crater" landslide. Outcrops of deformed sediments on Harrogate Springs Road, which are also related to this trans-crater landslide, are in some places upside down and in other places, intensively deformed. In 2009, a scientific borehole was drilled a few hundred meters east of the cliffs (in the meadow located behind the Viewpoint #3 sign). The drill penetrated the nearly 30 m (90 ft) of chalk, which is interpreted to have washed back into the crater by the return of sea water (as a muddy tsunami wave). There is no chalk, which is a distinctive marine shelf sediment, located in the cliffs area proper, which indicates that the adjacent meadow area was likely a depression upon the crater floor that was filled by the chalk, which settled out from the chalk-laden sea water of the tsunami. In 2018, study of sand grains removed from the chalk layer revealed that the chalk in the crater contains fine particles of shocked and melted materials that were ejected from the crater during the impact process and then fell into the adjacent waters of the Gulf of Mexico where they were mixed into the chalk deposits of the shelf area.

Historical notes about this site: A recent review of the 1894 writings of the second state geologist, Dr. Eugene Allen Smith (1841-1927), shows that he visited this general area during his passage through the Wetumpka area during the field season of 1891. He was shown sediments and fossils from the crater floor area by the German immigrant farmer, Adam Enslen, whose farm encompassed this area. Dr. Smith noted in his narrative that it appeared there was once a depression of significant depth and a profound disturbance of the area, but he did not speculate on meteor impact, which was not known about at that time. About eighty years later, this area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They studied the crater rim and also observed the highly deformed sediments in the cliffs area and other sites on Harrogate Springs Road, and speculated that these features were part of an impact crater or astrobleme ("star wound"). Their ideas were published in a 1976 research paper in the *Bulletin of the Geological Society of America*. Neathery et al. described the cliffs as a "borrow pit" made for removal of road-building materials, but there is no evidence that the cliffs formed in any way other than groundwater flowing out of fractures in the underlying bedrock. More recent research (2011) suggested a massive landslide accounts for much of sediments at the surface within the crater floor area. Evidence supporting this interpretation was discovered during drilling of a scientific borehole (2009) near Trotter's Trail (about 2.5 km (about 1.5 mi) southwest of this location) and during studies of outcrops adjacent to Harrogate Springs Road a few years later.

Glossary

Tsunami – a wave in the ocean that is caused by a large earthquake or meteor impact; in an impact, the tsunami wave first moves away from the crater, and then returns to the crater (usually laden with eroded sediment from the adjacent sea floor)

Landslide – a mass movement of Earth materials that is driven by the force gravity; the materials move from higher to lower places, or from less stable to more stable sites

Sandy sediment – sediment that is rich in sand grains, which are particles of broken rocks and mineral in the size range of 0.02 to 2 mm (0.0008–0.08 inch); typically contains other fine sediments such as silt and clay in varying proportions

Deformed sedimentary rocks and sediments – sedimentary rocks, and sediments, are deposited by water or wind in horizontal layers that are laterally continuous, therefore any configuration of sedimentary rocks and sediments that is other than horizontal and laterally continuous means the sedimentary rocks and sediments have been deformed (e.g., compressed or broken)

Context photograph 1 – Looking at the Alabama Power Company right-of-way cut behind the Viewpoint #3 sign, a small area of brown and tan sediments can be seen in the distance. The following context photograph shows this small area in more detail.

Context photograph 2 – In this telephoto view, deformed, brown and tan sediments are visible beyond the second telephone pole and below the third telephone pole in this view. This area is part of the cliffs, a deep gully cut into trans-crater landslide deposits of the crater floor. Viewpoint #2 sign is located near the top of the hill where the brown and tan sediments are exposed.

Context photograph 3 – In this overlapping mosaic of photographs of the cliffs taken from a vantage point on the eastern side of the cliffs, looking toward the west, the deformed layers (marked here with dashed yellow lines) are revealed by intensive erosion. These photographs were made during the late 1990s when the vegetation was much less in the cliffs area versus today. These images, and their interpretation as evidence for a massive trans-crater landslide, were published in 2011. Width of the imaged area is approximately 100 m (approximately 328 ft). The sediments shown in the previous context photo occur on the far left side of this image. The cliffs area is private property and visitors should not trespass.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #4
LOCATION: BUCK RIDGE ROAD AT THE EL PASO NATURAL GAS PIPELINE

Continuing east on Harrogate Springs Road from "the cliffs" area, you will come to the intersection of Buck Ridge Road and Trotter's Trail, the geographic center of the impact crater. Turn right on Buck Ridge and see the central outcrops (Sign #4) at the heart of Alabama's greatest natural disaster, equal to an earthquake measuring 8.5 to 9 on the Richter scale.

Text printed on the sign: "This section of Buck Ridge Road is unusual because you can easily see hills created on both sides of the road that are related to the impact of a large meteor, 85 million years ago. These hills contain large boulders that came to rest near the center of the Wetumpka impact crater. Scientists say the impact would have caused Alabama's greatest earthquake, measuring 8.5 to 9.0 on the Richter scale."

Location with respect to the whole of the impact crater: This site is very near to the geographic center of the Wetumpka impact crater, and is part of the hilly central region of the crater floor. Unlike the deformed sedimentary rocks and sediments seen at the cliffs (Viewpoint #3), the impact materials at the surface in this region of the crater floor (within the road loop formed by Buck Ridge Road and Trotter's Trail) are composed of sandy and gravelly clay-rich sediment that contains very large boulders of metamorphic bedrock. To date, research has revealed at least 20 of these immense metamorphic bedrock boulders, some of which are more than 20 m (66 ft) across.

Scientific research conducted at or near this site: Research published in 2011, showed that this "boulder layer" lies on top of the sedimentary rocks and sediments seen at Viewpoint #3. This superpositional relationship was revealed by careful field studies of outcrops along and near Harrogate Springs Road and the 2009 scientific borehole drilling through this "boulder layer" at a site near the driveway to the home at 205 Buck Ridge Road. In 2012, pipeline construction revealed a large boulder near the top of the hill shown in the photograph on the Viewpoint #4 sign. In 2018, the Elmore County highway office kindly scraped down outcrops along Buck Ridge Road's west side between the home at 205 Buck Ridge Road and the pipeline crossing where the Viewpoint #4 sign is located. Some large boulders were uncovered in the process of scraping by heavy equipment, and they are still visible today on the western side of Buck Ridge Road (on the right side as one drives south). In 2019, research at Auburn University for a geology Master of Science student's thesis on the "boulder layer" showed that the boulders were likely ejected during impact from the deeper bedrock under the crater, and likely landed on the original crater rim, not far from their source. Their appearance on the crater floor suggests that the boulder layer moved from the inner rim to the crater center by gravity sliding very early in the crater's history, perhaps within hours or days of the impact. The presence of shocked minerals within the finer parts of the boulder layer supports the interpretation of the boulder layer as crater ejecta.

Historical notes about this site: This area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They observed some of the larger boulders in stream valley area adjacent to Harrogate Springs Road and interpreted them as deeper bedrock that had been uplifted by impact. This hypothesis did not hold after drilling of two scientific boreholes in 1998 near crater center (with a few 100 m of the Viewpoint #4 sign). The metamorphic bedrock was not under the central area of the crater, as revealed by description of drilled core from these two boreholes published in 2002. In 2019, research at Auburn University for a geology Master of Science student's thesis on the "boulder layer" showed in addition to shocked minerals the layer contained accretionary lapilli, which are small spheres made of mineral grains that were adhered to one another while the impact's dust cloud was swirling above the impact location. Thus, Wetumpka is one of the few impact craters on Earth with documented accretionary lapilli preserved in its deposits.

Glossary

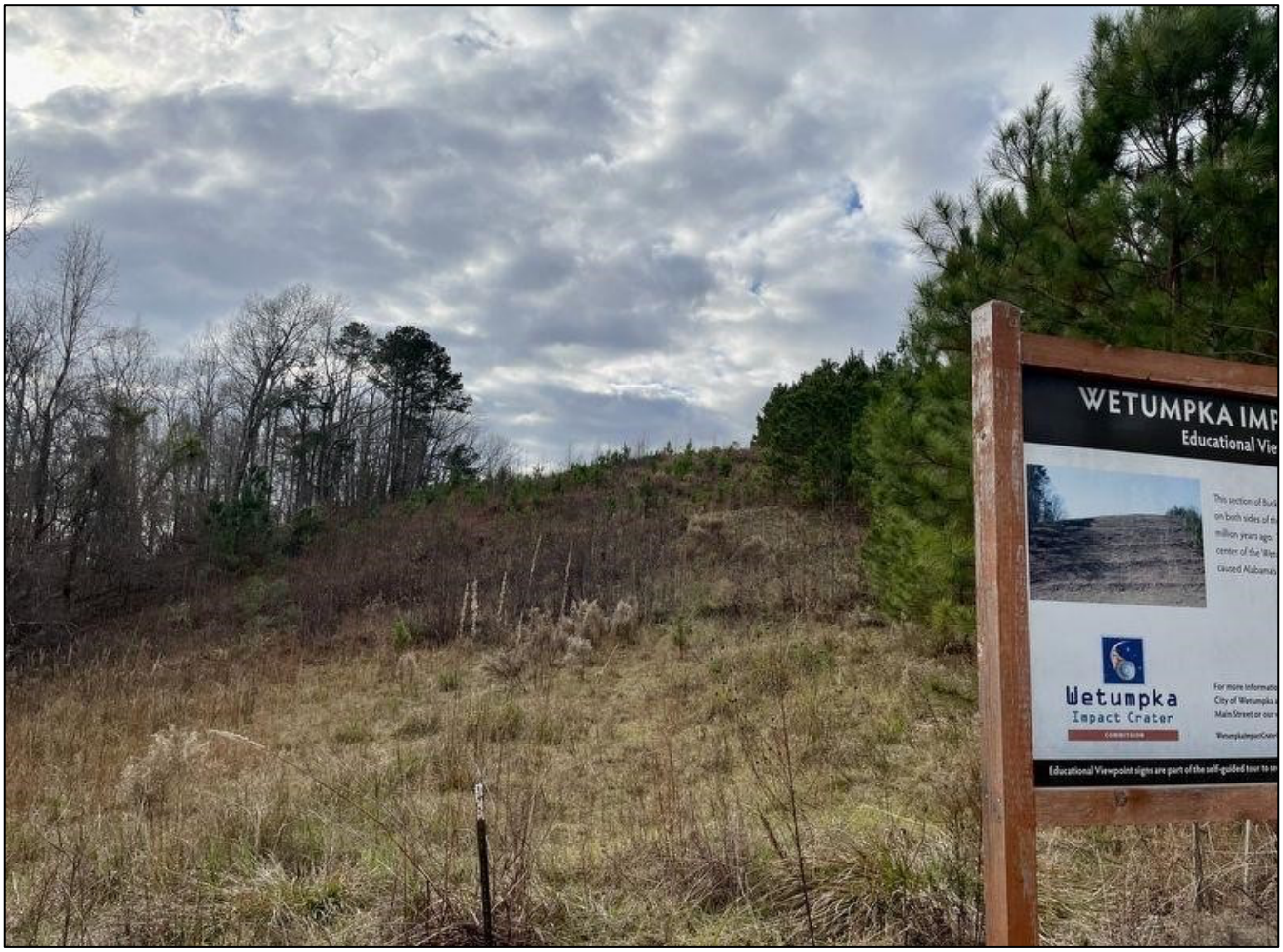
Boulder – a broken fragment of rock with size greater than 25.6 cm (10.1 in) in diameter up to 10 m (32.8 ft) in diameter; fragments larger than boulder are sometimes called megaboulders

Accretionary lapilli – a small spherical object that forms in a dust cloud (volcanic, impact, etc.) by accretion or adding on layers due to static electric attraction; lapilli means "little stones" (Italian)

Superposition – where sedimentary rocks or sediments lie upon one another in a horizontal manner the lower layer is always considered to be the older one, unless there is good evidence to the contrary

Richter scale – a scale of measure of the strength of earthquakes, specifically their energy of motion, which is measured by a seismometer; magnitude 8 to 9 are considered catastrophic earthquakes and represent the largest known to people since the advent of earthquake studies

Context photograph 1 – This photograph shows the hill behind Viewpoint #4 sign. This hill contains a large boulder near the top, as revealed by pipeline construction operations during 2012. It is now buried in the soil. The El Paso natural gas pipeline crosses the hill at the notch in the trees and continues eastward under Buck Ridge Road, across the land area between Buck Ridge Road and Trotter's Trail, and then crosses under Trotter's Trail and continues eastward to the eastern crater rim and beyond (see also Viewpoint #5 sign). This is private property and visitors should not trespass.



Context photograph 2 – This photograph shows the Elmore County highway office equipment and crew scraping the sides of Buck Ridge Road during 2018 so that large boulders embedded in the red sandy and gravelly clay could be seen, measured, and sampled. This outcrop is on county road right-of-way and visitors should exercise caution because of limited visibility and significant traffic on this road.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #5
LOCATION: TROTTER'S TRAIL AT THE EL PASO NATURAL GAS PIPELINE

Follow Buck Ridge back to Trotter's Trail, turn left to return to Wetumpka. The natural gas pipeline right-of-way intersecting Trotter's Trail (Sign #5) provides an excellent view of the eastern rim of the crater.

Text printed on the sign: "Because of the cleared natural gas pipeline, this area provides an excellent view of the eastern Rim of the Wetumpka impact crater. The notch on the far rim is over a mile away. On the other side of Trotter's Trail (behind you), the high point is near the epicenter of the crater."

Location with respect to the whole of the impact crater: This site is slightly east of the geographic center of the Wetumpka impact crater, and is part of the hilly central region of the crater floor (as at Viewpoint #4). However, we do not find large boulders here as described at Viewpoint #4. Because of the relatively low relief of the crater floor in this part of the crater, and (as the sign text notes) the cleared corridor for the natural gas pipeline, one can see clearly all the way to the eastern rim. This distance is just over 1.6 km (or about 1 mile away). The notch where the natural gas pipeline crosses the eastern rim is marked by a red arrow on the Viewpoint #5 sign's image. The eastern rim is much lower than the western rim, and this is evident in the sign's image as well.

Scientific research conducted at or near this site: Research based on observations made during the placement of additional natural gas pipe at the El Paso natural gas pipeline here and published on during 2012, showed that there are both (1) sedimentary rocks and sediments of the trans-crater slide (as noted at Viewpoints #2 and #3) and (2) tsunami-related chalk deposits (seen at the natural gas pipeline crossing at Fairliewood Drive) on the crater floor between this location and the eastern rim.

Historical notes about this site: This area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They observed sedimentary rocks and sediments of the crater floor, including chalk deposits. They examined water well cuttings from three wells located about 0.5 km (0.3 mi) south of the natural gas pipeline and about 0.5 km (0.3 mi) west of the western rim (within sight of the Viewpoint #5 sign) and discovered that there is over 40 m (131 ft) of chalk that likely formed within a crater-floor depression similar to the one noted in the narrative for Viewpoint #3. Even though the crater has been modified by erosion since it formed, the view from Viewpoint #5 gives a sense of the original, gentle topographic relief of the crater floor.

Glossary

Chalk – an ancient marine sediment of the continental shelf that is composed mainly of the tiny fossil remains of marine plankton and other small organism that were floating in the ocean at time that the chalk formed; chalk is mainly associated with the geological time period called Cretaceous (*creta* is the latin word for chalk), which spanned 145 to 66 million years ago

Well cuttings – tiny fragments of rock or pieces of sediment that are ground up by the drill bit during subsurface borehole drilling and collected at the surface when they emerge from the borehole

Crater floor – the relatively low relief area of an impact crater that typically exists inside the crater rim and consists of geological materials that are typically more soft than the crater rim

Topographic relief – the difference in elevation between the lowest and highest points in a given area; topographic refers to topography, or the lay of the land

Context photograph 1 – This photograph shows the view looking east from the Viewpoint #5 sign. This view of the pipeline corridor shows the low-relief nature of the crater floor's topography. The high area with green trees in the distance is the eastern crater rim. The distance to the eastern rim is about 1.6 km (1 mi). The pipeline cut is private property and visitors should not trespass.

Context photograph 2 – This photograph shows the view looking west (behind you) from the Viewpoint #5 sign. This view of the pipeline corridor shows a hill; the beyond the crest and on the other side of that hill lies Buck Ridge Road and the Viewpoint #4 sign. This hill is composed of the boulder layer that was described in the previous Viewpoint (#4). This is private property and visitors should not trespass.

WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #6
LOCATION: WETUMPKA SPORTS COMPLEX, 2350 COOSA RIVER PKWY, WETUMPKA

Return on Harrogate Springs Road back to Highway 231 then drive north to Highway 14 and turn left to go across the Coosa River.[25] The Educational Viewpoint (Sign #6) is located near the entrance to the *Wetumpka Sportsplex* on the Coosa Parkway (Highway 14), west of the Coosa River. The view from the *Sportsplex* is of the eroded north and western crater rims. The visible communication towers are located at Bald Knob (Sign #2), 587 feet above sea level.

Text printed on the sign: "From a distance, one of the best vistas of the Wetumpka impact crater is from the Wetumpka Sports Complex. Your view here is of the highest remains of the northwestern rim of the crater. In the center, several communication towers are located on Bald Knob (elevation 587 feet above sea level). Scientists estimate that the original rim was about twice that height."

Location with respect to the whole of the impact crater: This site is outside the Wetumpka impact crater rim and is located on the other side of the Coosa River from the crater. In this view, we are looking southwest toward the crater rim and the nearly flat land between the Viewpoint #6 location and the crater rim is the floodplain of the Coosa River. As can be seen in the map on the sign, the Coosa River approaches the crater rim from the north

and then makes a notable bend as it flows parallel to the curve of the western crater rim before it flows more nearly west toward its confluence with the Tallapoosa River.

Scientific research conducted at or near this site: Studies of the geology of this site, including the magnetic characteristics of the bedrock here and the local variations in gravity suggest that at this distance from the impact, there were no detectable disturbances to the bedrock. Any material that may have been ejected from the crater during impact (ejecta) has been washed away long ago and the area today contains only river floodplain sediments that are lying upon a thin layer of Cretaceous sediments that in turn lie upon the local metamorphic bedrock.

Historical notes about this site: This area was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They observed the river floodplain sediments and suggested that there was metamorphic bedrock at shallow depth here beneath the Coosa River floodplain sediments. A thin layer of Cretaceous sediments, which have yielded some remarkable fossil wood pieces, lies between the metamorphic bedrock and the much younger river-floodplain sediments. Farther downstream on the Coosa River, there are deeply eroded rocks of the crater rim (see Viewpoint #7). On the floodplain adjacent to the southern rim of the impact crater, the large Creek Indian gaming facility has been constructed.

Glossary

Ejecta – small particles of rock and minerals, including glass fragments, and larger particles such and pebbles and boulder that have been launched from the impact crater during the phase of excavation of the crater that immediately follows the impact

Floodplain – the low-lying area adjacent to a river channel that receives flood water from the river when the amount of water moving through the river exceeds the river channel's capacity to contain the water

Floodplain sediments – generally clays, silts, and fine sands that are entrained in the waters that flow over the flood plain during times of high river discharge (during a flood); sediments settle out on the floodplain and thus a layer of sediment is left behind when the flood water recedes

Crater rim – the elevated ring of rocks that encircles an impact crater and thus encircles the crater floor; crater rims can consist of harder rocks (as at Wetumpka) or rocks that have been significantly uplifted

Context photograph 1 – This photograph shows the view looking southeast from the Viewpoint #6 sign. This view shows the western rim of the Wetumpka impact crater. The next context photograph shows an enlarged view of the crater rim near the center of this image.

Context photograph 2 – This photograph shows a telephoto-view looking southeast from the Viewpoint #6 sign. This view shows the western rim of the Wetumpka impact crater. The cluster of communication towers are at Bald Knob, which is near the Viewpoint #2 sign. The high ridge in this photo is the crater rim, specifically the western part of that rim.

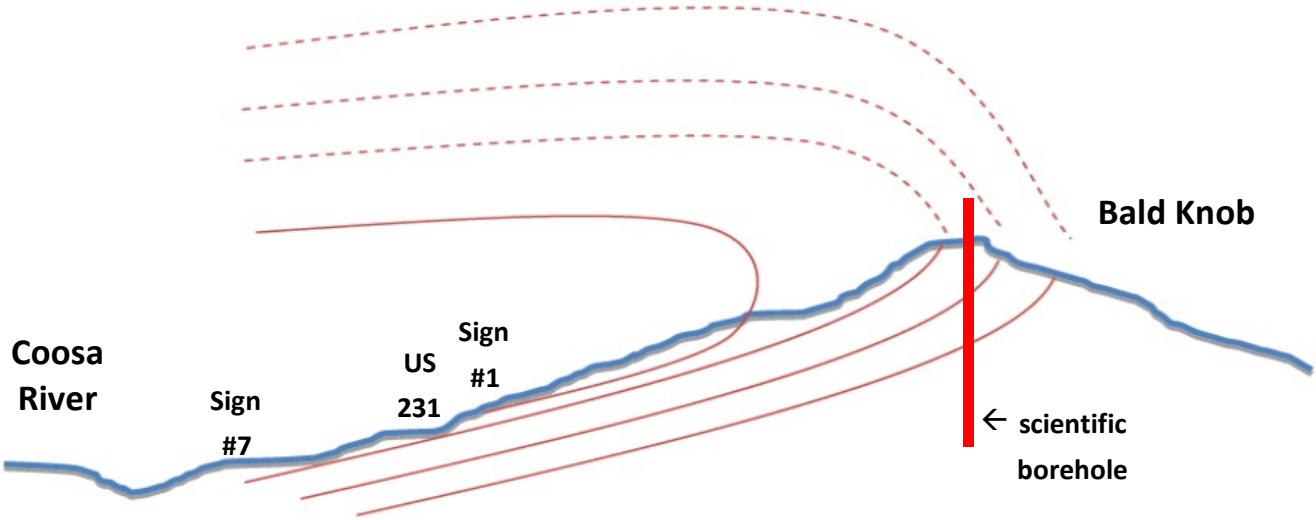
WETUMPKA IMPACT CRATER EDUCATIONAL VIEWPOINT #7
LOCATION: ON RIVER WALK BETWEEN ORLINE STREET AND THE COOSA RIVER

Returning to Wetumpka by Highway 111 and Bridge Street takes you over the *Bibb Graves Bridge*, downtown. As you travel over the bridge, you can see large rocks in the bed of the Coosa River (Sign #7) that were upturned when the crater was formed. If you look closely, you will notice that they tilt away from the crater rim. When the water level in the river is high, these rocks are not visible. Educational Viewpoint (Sign #7) is located on the east side of the Coosa River, behind Hill Street, near the *Old Calaboose*.

Text printed on the sign: "The rock layers here in the Coosa River are part of the deeply eroded western rim of the Wetumpka impact crater. The Coosa River curves around the rim in the downtown area and these rock layers tilt away from the crater center, typical of layers affected by meteor impact."

Location with respect to the whole of the impact crater: This site is located on the outside, low-relief part of the Wetumpka impact crater's western rim. The western rim is much wider than the eastern rim, and the rocks of the western rim underlie all the land area between US highway 231 and the Coosa River and considerable land area to the east of the highway. The rocks where the Viewpoint #7 sign is located and the rocks depicted in the image on the sign are all part of the western rim. The inclination (tilt) of the rock layers is evident in the image of the rocks within the river. They are inclined toward the west, which is the same direction of inclination seen at Viewpoint #1. The difference between Viewpoint #1 and here (#7) is that Viewpoint #1 is located on the steeper part of the western rim.

Scientific research conducted at or near this site: Research for one geology Master of Science student's thesis (2012) was conducted on the metamorphic rocks of the western crater rim. This work included the scientific borehole drilled through the crater rim in 2009 and extensive field studies. The interpretation of the western rim's structure coming out of this research is that the inclination of the rock layers in this vicinity is consistent with the expected structure of a crater rim. Most crater rims have an overturned flap, and Wetumpka was no exception. The diagram below shows a schematic, west-east, cross-sectional view of selected layers within both the existing impact crater rim and within the now-removed, original crater rim mass (dashed lines). The present ground surface is the blue line.



Historical notes about this site: The name Wetumpka is derived from the Native American words "wewau" (water) "tum-cau" (rumbling). It is speculated that river water flowing over the tilted rocks of the western crater rim, such as those shown on the Viewpoint #7 sign, was the natural origin of the "rumbling." On the Coosa River floodplain, approximately 1.5 km (about 1 mi) south of this site and adjacent to the southern rim of the impact crater, there is an important archaeological site called Hickory Ground. This important Native American ceremonial and burial site was visited by the noted American botanist and explorer, William Bartram (1739-1823) in the 1770s, but had been lost until it was documented anew by Auburn University archaeologists in 1968. This area of the crater rim adjacent to the river was studied and mapped by Thornton L. (Tony) Neathery and other geologists from the Geological Survey of Alabama during the period June 1969 to January 1970. They mapped the wide western crater rim, including the titled crater-rim rocks within the Coosa River, which they noted are inclined toward the northwest at a magnitude of 52 degrees.

Glossary

Tilt or inclination – the attitude of rock layers, including layers of metamorphic rock (called foliation) and layers of sedimentary rocks; if the attitude is not horizontal, the layer is said to have tilt or inclination; tilt or inclination has both (1) a compass direction and (2) a magnitude in degrees

Scientific borehole – a hole drilled into the ground by drilling equipment for the purpose of discovering and documenting the underlying geological materials and features; cylindrical drill cores of rock and sediment may be extracted during drilling of the borehole (as at Wetumpka impact crater)

Floodplain sediments – generally clays, silts, and fine sands that are entrained in the waters that flow over the floodplain during times of high river discharge (during a flood); sediments settle out on the floodplain and thus a layer of sediment is left behind when the flood water recedes

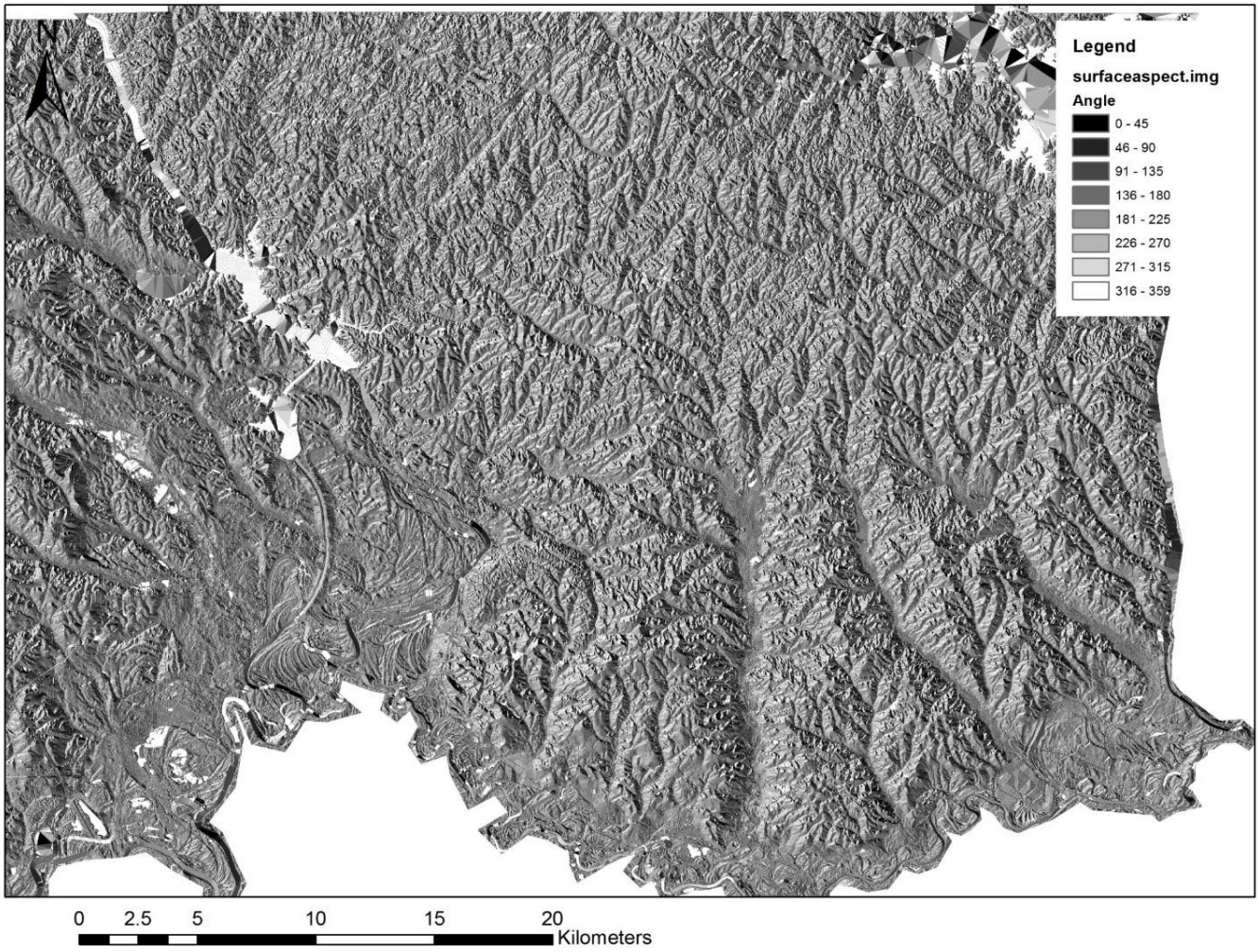
Crater rim – the elevated ring of rocks that encircles an impact crater and thus encircles the crater floor; crater rims can consist of harder rocks (as at Wetumpka) or rocks that have been significantly uplifted

Context photograph 1 – This photograph shows the view looking south from the Viewpoint #7 sign. This view shows the Coosa River, tilted rock layers in the river, and the Bibb Graves Bridge. The following context photograph shows a closer view of the tilted crater-rim rocks in the river. A walkway following the river bank can be seen adjacent to the Viewpoint #7 sign.

Context photograph 2 – This photograph shows a close-up view of the tilted crater-rim rocks that occur in the river south of the Viewpoint #7 sign. These tilted rock layers in the river, upstream from the Bibb Graves Bridge, were visited by Tony Neathery and other geologists during their field studies of 1969-1970.
The determined that the inclination of these metamorphic rock layers is 52 degrees toward the northwest.

APPENDIX

Digital model of the topography of Elmore County, Alabama. Data used to construct this model were obtained by laser altimetry (LiDAR) and were provided by the Elmore County Revenue Commissioner's Office. The Wetumpka impact crater is the remarkable, arc-shaped feature in southern Elmore County (arrow).



Web links of note about the Wetumpka impact crater

https://en.wikipedia.org/wiki/Wetumpka_crater http://encyclopediaofalabama.org/article/h-1035
http://www.wetumpkaimpactcratercommission.org/
https://www.al.com/news/2021/11/84-million-years-ago-a-massive-meteorite-strikes-ancientalabama.html

Filmography

Wetumpka impact crater (1998). © Alabama Public Television; APT's Discovering Alabama segment no. 31. 26 minutes, 28 seconds. Produced by Doug Phillips. Vimeo - https://www.discoveringalabama.org/31wetumpka-impact-crater.html

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