National Park Service
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Natural Resource Stewardship and Science

Vicksburg National Military Park

Paleontological Resource Inventory (Public Version)

Natural Resource Report NPS/VICK/NRR—2023/2516

ON THE COVER
The Mint Spring Formation type locality of Vicksburg National Military Park.
Photo by Megan Rich (NPS).

Vicksburg National Military Park

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Executive Summary

Vicksburg National Military Park (VICK) was established for its historical significance as a one of the principle military sieges resulting in a turning point during the American Civil War. The steep terrain around the city of Vicksburg was integral in the military siege, providing high vantage points and a substrate that was easy to entrench for the armies, but unknown to many is the fossil content, particularly a diversity of fossil mollusks. These fossils at VICK are important paleontological resources which have yet to receive focused attention from park staff, visitors, and researchers. The park's geology is dominated by windblown silt from the last Ice Age which overlays river-transported gravels and bedrock of the late Oligocene–early Miocene-age Catahoula Formation or early Oligocene Vicksburg Group. The park is home to the type section (a geological reference locality upon which a formation is based) for the Mint Spring Formation, one of the most fossiliferous formations in this group (Henderson et al. 2022).

Beginning roughly 32 million years ago (Dockery 2019), the early Oligocene deposits of the Vicksburg Group were deposited as the sea level along the Gulf Coast shore repeatedly rose and fell. The eponymously named Vicksburg Group is comprised of, from oldest to youngest, the Forest Hill, Mint Spring, Marianna Limestone, Glendon Limestone, Byram, and Bucatunna Formations. Each of these formations are within VICK's boundaries, in addition to outcrops of the younger Catahoula Formation. Paleozoic fossils transported by the ancestral Mississippi River have also been redeposited within VICK as pre-loess stream gravels. Overlying these layers is the Quaternary-age silt which composes the loess found throughout VICK, meaning the park's fossils span the entire Phanerozoic Eon. The fossils of VICK consist mostly of near-shore marine Oligocene invertebrates including corals, bryozoans, bivalves, gastropods, scaphopods, ostracods, and more, though terrestrial and freshwater snails of the loess, microfossils, plant fossils, occasional vertebrates, and others can also be found in the park. Notable historical figures such as Charles Alexandre Lesueur, Charles Lyell, and John Wesley Powell all collected fossils or studied geology in the Vicksburg area. The Vicksburg Group is culturally relevant as well, as the Glendon Limestone Formation has been identified by its embedded fossils as a source rock for Native American effigy pipes.

This paleontological resource inventory is the first of its kind for VICK. Although Vicksburg fossils have most recently been studied as part of the Gulf Coast Inventory & Monitoring Network (Kenworthy et al. 2007), the park has never received a comprehensive, dedicated fossil inventory before this report. At least 27 fossil species have been named and described from specimens collected from within VICK's lands, and VICK fossils can be found at six or more non-NPS museum repositories. Beginning in January 2022, field surveys were undertaken at VICK, covering a majority of the park. Fossils were collected or observed at 72 localities. These specimens will be added into VICK's museum collections, which previously contained no paleontological resources. Considering the minimal attention dedicated to these resources in the past, these newly acquired fossil specimens may be used in the future for educational, interpretive, or research purposes. Future park construction needs should take into account the protection of these resources by avoiding important localities or allowing collection efforts before localities become inaccessible or lost.

Acknowledgments

The authors of this report would like to acknowledge the original inhabitants of this land before European colonization. The natural history described herein is incomplete without understanding and acknowledging the inclusion of indigenous communities in that narrative. We pay our respects to tribal members of past and present who are connected to these lands.

We extend our thanks to the park staff at Vicksburg National Military Park (VICK) for their patience and many contributions. Interpretive park rangers Brendan Wilson and Andrew Miller helped provide an overview of the park's interpretive and educational efforts, described the current impressions held by visitors of VICK's natural history, and were crucial in considering potential long-term interpretation goals relating to VICK's paleontological resources. Interpretative rangers Taylor Hegler and Emma Murphy also helped to understand what is necessary in the construction of VICK's interpretive programming, which informed the authors how to most efficiently communicate the findings of this report. Cultural resources manager and museum curator Jennifer Leasor was supportive of the collection of fossil specimens and provided guidance and clearance in the fossil collection and accessioning processes. Law enforcement rangers Rachel Davidson and John Castaldo were always receptive during this survey and gave insight into the level of concern of fossil digging or theft in the park compared to relic hunting, as well as how to mitigate such risks in this future. We also thank all the VICK staff for their assistance in the review process.

This report would not have been possible without the invaluable assistance of the Mississippi Department of Environmental Quality (MDEQ). Geologists James Starnes and Jonathan Leard provided their expertise firsthand, answering many inquiries from the authors and helping to identify outcrops within the park. The state geologist of Mississippi, David T. Dockery III, laid much of the groundwork upon which this investigation was built, and his publications and work on the Vicksburg Group helped immensely in understanding VICK's geologic landscape. Through direct collaboration, he also provided numerous additional resources that have been crucial to the development of this report. We thank David A. Grimley of the Illinois State Geological Survey for his aid in examining loess specimens. Christopher Hall (SM Energy) gave permission to use Figure 38, originally from his thesis (Hall 2003). We also extend our thanks to David Dockery and James Starnes for their full formal reviews of the report, as well as Martha Segura and Linda York for serving as peer review managers.

Several other individuals and institutions assisted by providing information. We thank Beckie Dyer (Illinois State University), Stephen O. Moshier (Wheaton College), and Illinois Wesleyan University for their assistance in our investigation of possible John Wesley Powell collections from Vicksburg.

This project originally started as an investigation during the pilot phase of the Paleontology in the Parks Fellowship program supported by the Paleontological Society and National Park Service. The research and development of this report was then made possible through the National Park Service Scientists in Parks program (SIP), which supports science-based internships for students and early career professionals across the United States. Thanks to Kiersten Jarvis and Chelsea Bitting who coordinate the SIP program for the NPS for their support for this paleontology internship at VICK.

Thanks to VICK's official partner organization, the Friends of Vicksburg National Military Park and Campaign, for funding the park housing for interns and temporary employees working in the park, such as SIP participants like the lead author. We also extend our thanks to Ali Jones and other individuals of Conservation Legacy and the Stewards Individual Placement Program, whose partnership with the National Park Service and Geological Society of America buoys the SIP Program and aids in the proliferation of such projects as this inventory effort. Finally, we recognize the staff of the NPS Geologic Resources Division, including Stephanie Gaswirth, Hal Pranger, Julia Brunner, Jim Wood, Jack Wood, and Jason Kenworthy.

Dedication

The authors are proud to dedicate this inventory to Mississippi state geologist Dr. David T. Dockery III. Dr. Dockery has made countless contributions to Mississippi geology and paleontology over the course of his career. He grew up in Jackson, Mississippi collecting rocks and fossils, and later earned his doctorate in paleontology from Tulane University. Alongside David E. Thompson, he co-authored the encyclopedic book, *The Geology of Mississippi*, the largest volume ever published by University Press of Mississippi at the time. This textbook, which took 12 years to compose, was one of the most important references for this report. Dr. Dockery was named the state geologist the year following its publication, in 2017.

Dr. Dockery's strides in expanding the geologic knowledge of the Vicksburg area were also instrumental to this report. He was the first to publish the original plates of Charles Alexandre Lesueur, whose illustrations of the fossils of Walnut Hills near Vicksburg represent one of the earliest geologic investigations in Mississippi. Following this, Dr. Dockery was involved in the publication of two other important works that provided a comprehensive overview of molluscan fauna from the Oligocene Vicksburg Group (Dockery 1982a and MacNeil and Dockery 1984), upon which this report heavily depended. These works also played an integral role in the master's thesis of Dr. Christy Visaggi, an author on this report who collected and identified fauna, mostly mollusks, from localities nearby in the Byram Formation of Vicksburg.

This inventory would not have been possible without the intellectual contributions of Dr. Dockery. The authors thank him for his endless, gracious, and invaluable support.

Mississippi State Geologist David Dockery

Introduction

Vicksburg National Military Park (VICK) is situated on the steep loess bluffs flanking the Mississippi River and commemorates the 47-day Civil War siege that transpired in 1863. This decisive and consequential military event ended with the surrender of the Confederate stronghold of Vicksburg on July 4, transferring full control of the Mississippi River to the Union (National Park Service 2014). The park was established in 1899 under the jurisdiction of the US War Department and became a unit of the National Park Service (NPS) in 1933 (Public Law 62, 30 Stat. 841). The Vicksburg National Cemetery, located on park grounds, is the final resting place of 17,000 Union soldiers who died during the campaign as well as many US veterans of later wars (National Park Service 2014). In addition, VICK is host to around 1,400 historic monuments and markers that commemorate the troops who fought during the siege, the most of any national or other park. These are viewable via its 26-km (16-mi) tour road (Figure 1), which snakes through more than 7 km^2 of the park property (1,806 acres) (National Park Service 2014).

Fossils at VICK are globally significant as they represent some of the most well-preserved early[1] Oligocene fossil specimens in the world. Most of the park's fossil resources are associated with the eponymously named Vicksburg Group, a stratigraphic unit stretching across many southern coastal states and outcropping most notably in Vicksburg. The ancestral Mississippi River facilitated the movement of gravels, the remnants of which can be found in the streams of VICK overlying either the Catahoula Formation or Vicksburg Group. Transported gravels yield the oldest evidence of life found within the park's boundaries. Also noteworthy at VICK are its prominent loess bluffs known for their structural integrity, as shown by the construction of earthworks, trenches, and caves during the siege. Abundant specimens of terrestrial and freshwater snails are found within the loess, as well as other Pleistocene fossils, which are in need of more thorough documentation.

For more than 120 years, visitors have learned about the historical significance of this battle site and occasionally the natural resources preserved herein. Absent from these conversations has largely been the discussion of VICK's fossil resources, which are not only plentiful, but also noteworthy in the field of paleontology. The objective of this report is to provide a launching pad from which park staff can familiarize themselves with VICK's fossil resources and communicate that information to visitors. With this baseline inventory for reference, future research needs can be discerned, interpretive programs can be conceptualized, and a comprehensive understanding of the present knowledge can be achieved.

[1] "Early" and "late" refer to age, whereas "lower" and "upper" refer to stratigraphic position.

Figure 1. Park map of VICK (NPS).

This inventory report provides detailed information on the scope, significance, distribution, and management issues associated with VICK's paleontological resources. This includes information on the history of paleontological work in the lands now within the historical park, geologic units, taxonomic groups, fossil localities, museum collections, research, interpretation, along with resource management and protection considerations. In addition to the main body of text, this report includes seven appendices: Appendix A, tables of paleontological taxa arranged by stratigraphy; Appendix B, taxa named from VICK fossils; Appendix C, taxa potentially named from VICK fossils; Appendix D, contact information for repositories; Appendix E, paleontological resource law and policy; Appendix F, paleontological locality data; and Appendix G, a geologic time scale.

Significance of Paleontological Resources at VICK

Fossils are recognized as important non-renewable resources by the NPS and managed under the authority of the NPS Organic Act (1916), the Paleontological Resources Preservation Act (2009), and other federal laws and regulations. VICK and its surrounding areas have abundant, globally important paleontological specimens. Every formation of the Oligocene Vicksburg Group crops out within park boundaries. The Vicksburg Group of Mississippi contains an estimated 547 molluscan taxa, making it the best record of early Oligocene marine faunas of the North American continent and possibly of the Western Hemisphere (Dockery and Thompson 2016). Many of these fossil taxa are found in VICK and the area. Study of fossils from in and around what is now VICK date back to the 1820s, owing to prominent researchers such as Charles Alexandre Lesueur, Charles Lyell, John Wesley Powell, and others (see "History of Paleontological Work at VICK" below), though interest in these paleontological resources may extend back even further with Glendon Limestone of the Vicksburg Group being identified at Native American sites by its characteristic fossils (Steponaitis and Dockery 2011). At least 27 taxa have been named from specimens collected within VICK (Appendix B), and more than 200 from Vicksburg more generally (Appendix C).

Purpose and Need

The NPS is required to manage its lands and resources in accordance with federal laws, regulations, management policies, guidelines, and scientific principles and expertise. Those authorities and guidance directly applicable to paleontological resources are cited below in Appendix E. Paleontological resource inventories have been developed by the NPS in order to compile information regarding the scope, significance, distribution, and management issues associated with fossil resources present within parks. This information is intended to increase awareness of park fossils and paleontological issues in order to inform management decisions and actions that comply with these laws, directives, and policies. Options for paleontological resource management are locality-specific, and may include no action, surveys, site monitoring, cyclic prospecting, stabilization and reburial, shelter construction, excavation, closure, patrols, and alarm systems or electronic surveillance. See Appendix E for additional information on applicable laws and legislation.

Project Objectives

This park-focused paleontological resource inventory project was initiated to provide information to VICK staff for use in formulating management activities and procedures that would enable compliance with related laws, regulations, policy, and management guidelines. Additionally, this project will facilitate future research, proper curation of specimens, and resource management practices associated with the paleontological resources at VICK. Methods and tasks addressed in this inventory report include:

- Locating, identifying, and documenting paleontological resource localities through field reconnaissance and perusal of archives, using photography, GPS data, and standardized forms.
- Relocating and assessing historic fossil localities.
- Assessing collections of VICK fossils maintained within park collections and in outside repositories.
- Documenting current information on ancient faunal assemblages and paleoecological reconstructions.
- Interviewing park staff to gather information on the current status of paleontological resources, to aid in formulating plans for management, ideas for interpretation, and recommendations.
- Conducting a thorough search for relevant publications and records, unpublished geologic field notes, maps, photographs, and fossil collections from VICK.

History of Paleontological Work at VICK

In 1828, French naturalist Charles Alexandre Lesueur was traveling down the Mississippi River by flatboat on his way to New Orleans when he came upon beds of fossils at a place called Walnut Hills. A year later, he illustrated his findings in a series of twelve plates, accompanied by a manuscript which may likely be the earliest detailed geologic investigation in Mississippi (Figures 2 and 3). From this locality, Lesueur made an exceptional collection of fossil corals, bryozoans ("moss animals"), bivalves, gastropods, scaphopods, crab claws, echinoids (sea urchins), shark teeth, ray teeth, fish vertebrae and otoliths (ear bones), foraminifera (single-celled "shelled" organisms), and potential manatee ribs from the Byram and Mint Spring Formations (Dockery 1982a, 1982b). Lesueur's collection, sketches, and notes were divided between the Paris Museum and the Museum of Natural History in Le Havre, France where his original manuscript is preserved (Gardner 1938). Copies are held at both the Academy of Natural Sciences of Drexel University (formerly the Academy of Natural Sciences of Philadelphia) and the Smithsonian National Museum of Natural History. However, his paleontological findings were not officially published until Dockery (1982a, 1982b).

Lesueur's investigations were followed by another naturalist, Benjamin L. C. Wailes, who authored the first book on Mississippi geology titled "The Agriculture and Geology of Mississippi" in 1854. In this text, Wailes describes the extent of Walnut Hills and defines it as including VICK. He writes, "This rock [limestone] is seen occasionally from Vicksburg, exposed along the Walnut Hills to Hayne's Bluff, or Old Fort St. Peter's on the Yazoo River, and probably extends higher." Wailes was selected to conduct a survey of the state in preparation for this publication in 1852 and met regularly with trustees of the University of Mississippi and the first state geologist, John Millington, to report his progress (David Dockery, pers. comm., 2022). Before this appointment, he had previously collected fossils from the bluffs of Vicksburg, later showing his collections to renowned British geologist Charles Lyell in 1846 (David Dockery, pers. comm., 2022). Wailes kept a daily journal starting at the beginning of his survey. Eight books of this journal record can be found in the Mississippi Department of Archives and History, and the remaining 28 books are held in the library of Duke University.

Charles Lyell, one of the founding fathers of modern geoscience, made two extended visits to the United States in the early to mid-1800s, touring the country, observing the geology, and making fossil collections. During his second visit in 1846, Lyell visited the Vicksburg area in March, collecting "many shells and corals" from what is now known as the Vicksburg Group (Bograd 1996). He recognized the Vicksburg fauna as younger than those of nearby Eocene beds but older than the Miocene Epoch (Dockery and Thompson 2016). As the Oligocene Epoch had not yet been named (Beyrich 1854), Lyell identified the Vicksburg beds at the time as belonging to the upper Eocene. His collections, particularly mollusks from the upper and middle Eocene and lower Oligocene, helped future paleontologists place fossils in the proper stratigraphic order (Hazel et al. 1980). For more information about Charles Lyell, see his accounts from Vicksburg in Lyell (1849) or Wilson (1998).

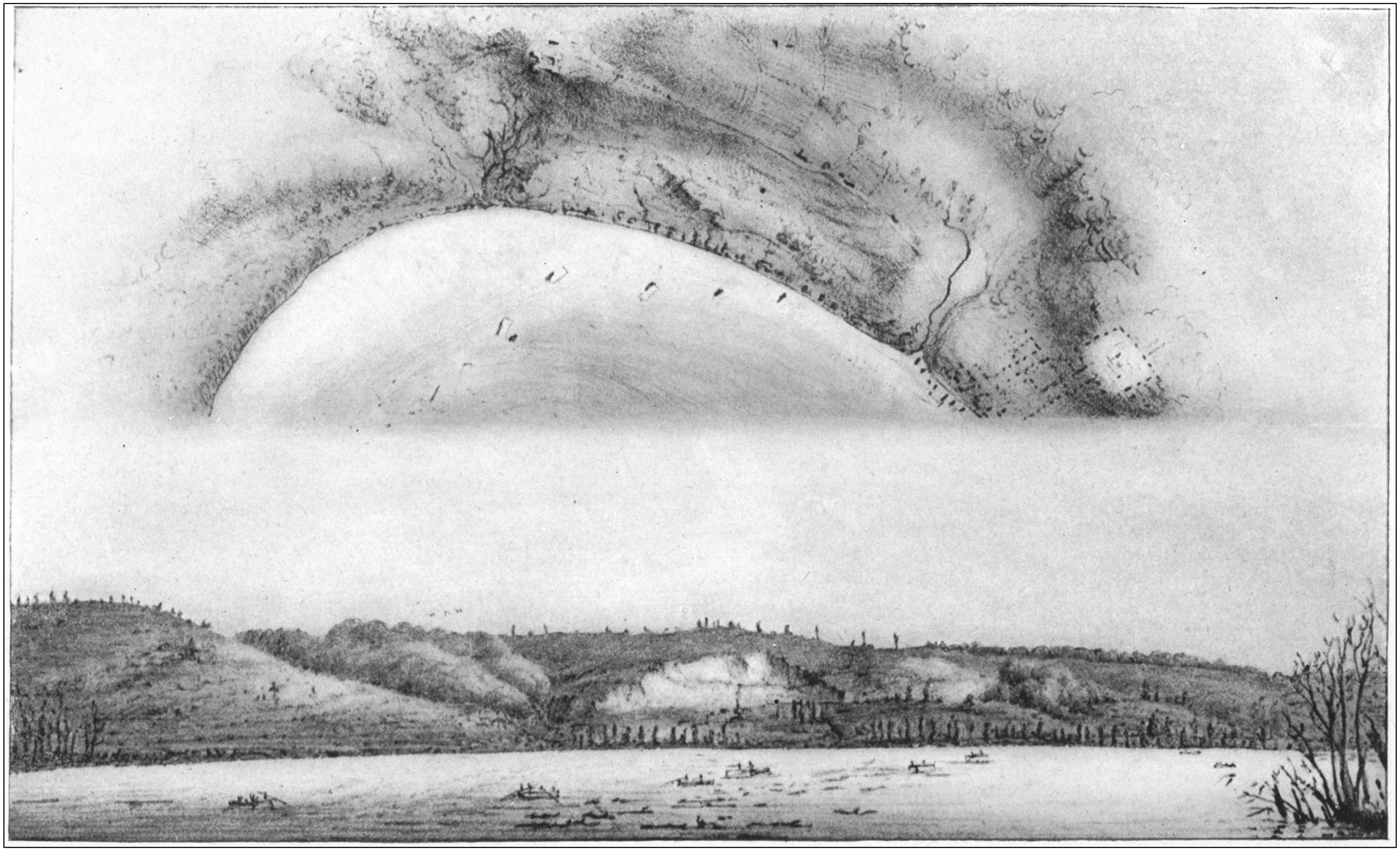

Figure 2. Lesueur's sketch of Walnut Hills in 1829 in aerial view (top) and as viewed looking east from a boat (bottom). In this image, Mint Spring Bayou is seen feeding into what was the Mississippi River but is today the Yazoo diversion canal. The high ground of Vicksburg National Cemetery can be seen at left (Hamy 1904: plate VI).

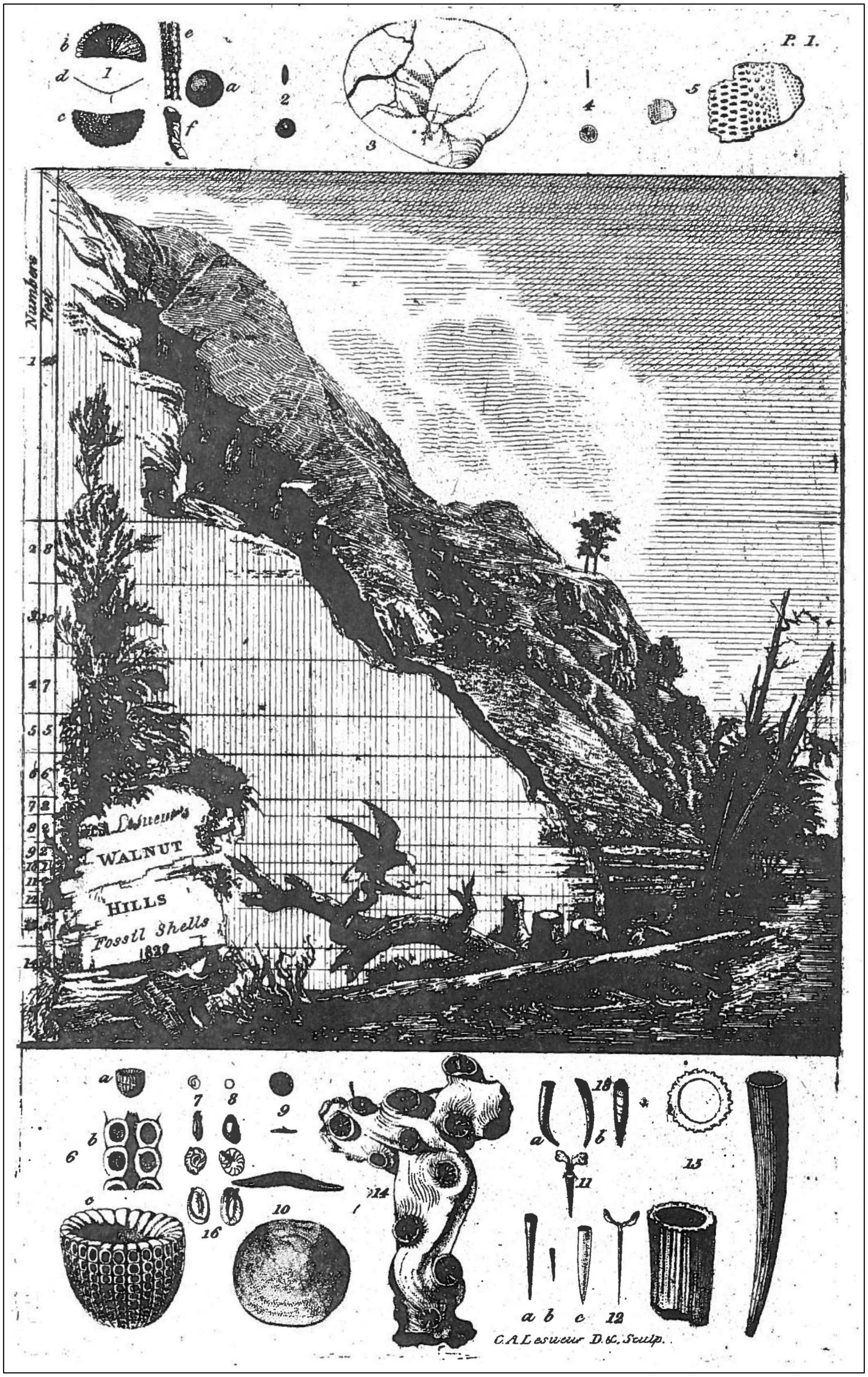

Figure 3. Plate 1 of 12 of Lesueur's fossil collections from Walnut Hills (Dockery 1982a: 239; Mississippi State Geological Bulletin 123).

Before Lyell's trip to Vicksburg, Timothy Abbott Conrad traveled to the area via the Mississippi River to collect marine fossil shells. Conrad had previously contributed to the geological survey of New York in 1836. He spent two weeks near Vicksburg in the spring of 1845 and subsequently published on his observations (Conrad 1846a, 1846b, 1848a, 1848b). Conrad's work at Vicksburg and his publication of fossils found there were later mentioned in Wailes' "Report of the Agriculture and Geology of Mississippi" in 1854 (p. 237–274). Conrad correctly correlated the section in Mississippi with that of Alabama and his report constitutes the first monograph on the fossils of the Vicksburg Group. After the naming of the Oligocene epoch by German paleontologist Heinrich Ernst Beyrich in 1854, Conrad published additional articles in which he placed the Vicksburg fossils in the Oligocene (Conrad 1865a, 1865b, 1866). Reproductions of Conrad's plates from Vicksburg can be seen in Dockery (1982a).

One of the most notable historical anecdotes about VICK geology involves John Wesley Powell, the famed explorer of the West and second director of the U.S. Geological Survey. Before his adventures in the Grand Canyon, Powell served in the Union army during the 1863 siege of Vicksburg. His unit Battery F, later known as Battery Powell, the 2nd Illinois Light Artillery Regiment, was part of the Sixth Division of the Seventeenth Army Corps during the campaign (Worster 2001). Battery F was involved in all five encounters leading up to the siege, occurring at Port Gibson, Raymond, Jackson, Champion Hill, and Big Black River Bridge. General Ulysses S. Grant and his army had surrounded the Confederate stronghold of Vicksburg, and he ordered the construction of thirteen zones where men would tunnel through the loess and up to the walls. Battery F took position at Ransom's Approach (currently near the Wisconsin Monument), and Powell, with his knowledge of geology and engineering, quickly took a leading role (Figure 4), proving himself so capable that Grant would regularly visit the approach and seek out Powell's opinions (Worster 2001).

There are many accounts of Powell collecting fossils, likely Pleistocene gastropods, from the loess trenches (Stegner 1954; Worster 2001), though the whereabouts of his collections from this time are unknown. One source reports that Powell sent fossil mollusks he collected with his wife on the frontline to Wheaton, Illinois for safekeeping before the battle intensified (Darrah 1951). The collection was ostensibly donated to Powell's alma mater, Wheaton College, though there is no trace of it at the university (Stephen O. Moshier, pers. comm., 2022). After leaving the Army, Powell became a professor at Illinois Wesleyan University (IWU). In 1943, a fire at IWU's Hedding Hall destroyed the collections of the Powell Museum of Natural Sciences, and it is possible this included Powell's Vicksburg specimens (Illinois Wesleyan University, pers. comm., 2021). He also lectured at Illinois State University in Normal, Illinois, for much of his career, at which he created the institution's first Museum of Anthropology and served as curator for its Museum of Natural History. Purportedly, there was at one point in this museum a collection from Vicksburg and the surrounding area that Powell made in the winter following the fall of the city (Lincoln et al. 1903). Powell is known to have made many donations to this museum, but no specimens from Vicksburg have been located within its collections (Beckie Dyer, Illinois State University, pers. comm., 2022).

Figure 4. "Our works before Vicksburg – Battery Powell" sketched by Theodore R. Davis (*Harper's Weekly Magazine,* July 4, 1863: 420). A man depicted in the image as having only one arm is thought to be John Wesley Powell.

Following the siege, Powell was placed on medical leave due mostly to the pain caused by the arm he had lost at Pittsburgh Landing in the Battle of Shiloh. Returning later in the year, he was stationed in Vicksburg, helping General William T. Sherman ensure the city's isolation from the rest of the Confederacy. He spent the winter in Vicksburg and spent the spring and summer of 1864 instructing a regiment of freed slaves on the manning of its garrisons (Worster 2001). Powell was in Vicksburg for roughly a year, eventually leaving in September to rejoin his unit after Battery F received heavy casualties in the Battle of Atlanta. With this length of time, it is possible and believed by some that Powell visited the Mint Springs waterfall locality and collected Oligocene fossils in addition to the plentiful Pleistocene shells he surely encountered during the siege (Ross 2018). For more information on John Wesley Powell and his time in Vicksburg, see Dellenbaugh (1902), Lincoln et al. (1903), Darrah (1951), Stegner (1954), USGS (1970), Lapham (1996), Worster (2001), Moring (2002), Lucas et al. (2006), and Ross (2018).

The first Americans around VICK to interact with the fossil organisms preserved in solid rock utilized them for a variety of purposes. The fossiliferous Glendon Limestone of the Vicksburg area in particular was used by Native Americans to create effigy pipes, chunky stones, and other such lithic items. In 1996, Vin Steponaitis, Professor of Archaeology at the University of North Carolina at

Chapel Hill, and David Dockery, Chief of the Surface Geology Division of the Mississippi Department of Environmental Quality's Office of Geology, met to study limestone effigy pipes in Mississippi's Department of Archives and History Building. It was discovered that these pipes, dating from 1100 to 1500 AD, were likely sourced near Vicksburg due to the notable presence of dime-sized wafer-like foraminifera known as *Lepidocyclina supera,* a guide fossil of the Glendon and Byram Formations (David Dockery, pers. comm., 2022) (Figure 5).

Figure 5. Human utilization of fossiliferous stone consistent with a Vicksburg origin (MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY/DAVID DOCKERY). **Left.** The Arkansas Hot Springs cat pipe in the National Museum of Natural History. **Right.** Cross-section of *Lepidocyclina supera* in the Glendon Limestone on the pipe's surface.

Other influential people who contributed to our current understanding of the area's geology and paleontology include Charles Wythe Cooke, Joseph A. Cushman, Julia Gardner, F. Stearns MacNeil, and many others. Interactions with the unique geology and paleontological resources extend back even further, before European colonization of the land. Later researchers studying the area around VICK have built off the efforts begun by those mentioned above; the contributions of these more modern scientists will be discussed in the body of this report.

Summary of 2021–2022 Paleontological Survey

Paleontology has not been a major focus of resource study, management, or interpretation at VICK during its time as a protected area. The NPS prepared a paleontological resource summary of the park for the Gulf Coast Network (GULN) Paleontological Resource Inventory and Monitoring Report (Kenworthy et al. 2007). This is the first comprehensive paleontological resource inventory created specifically for VICK. The survey commenced with communications and a preliminary literature review in August of 2021. Field work began in January 2022 under the research permit VICK-2022-SCI-0003. This work was funded through the Scientists in Parks (SIP) program, a collaborative opportunity run by the National Park Service and the Geological Society of America, after initially being conceptualized during the pilot phase of the Paleontology in the Parks Fellowship program coordinated between the Paleontological Society and National Park Service.

A total ground survey of VICK was conducted over a three-month period, utilizing a GPS to geospatially track paths. The survey began with the south loop then moved northward. Outcrops belonging to the Vicksburg Group, as well as Paleozoic fossils extruding from gravels of the ancestral Mississippi River, were found. Specimens were collected mostly ex situ, meaning they were not embedded in the matrix, and VICK's Natural Resource Program Manager determined minimal specimens per species to be collected per locality.

The fossils, which had been given tags and placed in bags when collected, were cleaned by hand and organized in preparation for accessioning. Specimens were sorted, counted, photographed, and given initial identifications. All of these fossils will remain in VICK's museum collections, which did not previously have any paleontological resources stored. Further research was done to gain a better understanding of taxa that occurred more rarely, and research into certain aspects such as the history of paleontological research around Vicksburg was ongoing throughout the project's duration. This inventory was written in the months following completion of field work.

Methods

This paleontological inventory focused on surveying approximately 445 hectares (1,100 acres) within VICK (out of ~730 hectares [~1,800 acres]), excluding the park's newly acquired satellite units at Port Gibson, Raymond, and Champion Hill. The survey consisted primarily of the Vicksburg Group (Oligocene Epoch; 33.9 to 23 million years ago) (see Appendix G for a geologic time scale) and to a lesser extent the overlying loess and pre-loess gravel deposits (Pleistocene Epoch; roughly 1 million years ago). Exposed rock and fossil locations were reached by driving VICK's roads and parking in pullouts, parking lots, and grassy areas without vulnerable resources as determined by park resource staff. After reaching these locations, surveying began. A GPS was used to track areas inventoried and mark areas of interest or notable findings. Documentation was made via photography of specimens and locations, recording coordinates both on paper and digitally, and other written notes.

When significant fossils or geologic specimens were found, appropriate park staff were contacted to ensure that collection was safe and warranted. Instances of collection followed VICK's specific protocols once approval was given. Fossil specimens were collected for the purposes of establishing an interpretative collection for public education, as well as a potential comparative collection for future research. This was necessary as VICK previously had no paleontological resources curated in its collections. However, due to the abundance of recurring taxa, most fossils remained in situ. Collections were limited to surface collection with little to no ground disturbance during collection consisted of light digging (no greater than 5 cm/2 in into the surface) and only took place after receiving authorization from VICK staff.

Fossils often required only minimal preparation before being added to collections due to a general lack of indurated sediments adhering to specimens. Light, gentle cleaning occasionally took place by hand using warm water and baking soda, small dental tools and/or soft bristled baby toothbrushes. These approaches were used following collection of specimens from harder substrates as well as from loess localities. Some specimens were extremely fragile and were at times already fragmented, requiring delicate handling. At the Mint Spring type section and upstream along Mint Spring Bayou, strikes and dips were taken on various exposed Glendon Limestone outcrops using the Brunton pocket transit and measurements of stratigraphy were taken with a Jacobs staff.

In the creation of this report, various publications were used for the purposes of formation and specimen identification. These resources are included below in the "Geologic Formations" and "Taxonomy" sections, respectively, as well as in Appendix A. Vicksburg Group or Oligocene fossils were primarily identified using Dockery (1982a) and MacNeil and Dockery (1984), while Peorian loess or Pleistocene fossils were primarily identified using Shimek (1902, 1930), Hubricht (1963), and Williams (1999). Some preliminary identification of pre-loess gravel deposits follow Dockery et al. (2008), but identification to genus or species level will require a more in-depth study that is outside the scope of this report.

Geology

Geologic History

VICK and the local area have undergone a myriad of geologic events spanning approximately the last 750 million years (from the Late Proterozoic through the Phanerozoic) that influenced geology and paleontology. Briefly, faulting from the break-up of two supercontinents laid the foundation for the depositional trough known as the Mississippi Embayment, a structure that influenced the Gulf Coast to embay northward as well as the geographic placement of the Mississippi River. The deposition of sediment in this trough gradually formed Vicksburg's bedrock under the influence of coastal sea level rise and fall, and the fluvial deposits that followed and were lain via the Mississippi River make up the modern Quaternary alluvium sediments seen today.

The Mississippi Embayment is one of the major features upon which the city of Vicksburg and the historic battlefield reside and has greatly influenced the area's geology and geomorphology. Initially, the supercontinent of Rodinia broke apart about 750 million years ago (Mya) during the Precambrian (Bogdanova et al. 2009). This rifting was associated with the activity of mantle plumes and characterized by north-south normal faulting (pull-apart faulting) in the area paralleling what would later become the Mississippi River. This complexly faulted bedrock, including the failed rift known as the Mississippi Valley Graben, continued to subside, weighed down as sediments were continually deposited overtop, setting the stage for the Mississippi Embayment and reinvigorating the trough (Galicki and Schmitz 2016).

The embayment and its influence on the geology of the area around Vicksburg were heavily influenced by the formation of the Gulf of Mexico. The breakup of Earth's most recent supercontinent Pangea during the Mesozoic led to the Gulf's establishment (Bird and Burke 2006). Lakes accumulated in large grabens (linear valleys between two normal faults), turning the Vicksburg area into a deltaic environment as sediment was deposited by the rivers which flowed toward it (Thomas 1988). During the Cretaceous Period (143 to 66 Mya), the Mississippi Embayment divided what was once a single mountain range into two, the Appalachian and Ouachita, and extended from the present-day Gulf of Mexico up to what is now Cairo, Illinois (Salvador 1991). This path would eventually become the modern Mississippi River.

Much of the underlying bedrock within VICK was influenced by the Mississippi Embayment and changing of ocean depths and Gulf Coast geography. The embayment was low enough that when glacial ice melted following the Oligocene (34 to 23 Mya) it allowed the rising Gulf of Mexico to encroach north beyond present-day Vicksburg (Hart et al. 2008). Erosion and transportation from the Gulf of Mexico and Appalachian Mountains deposited sediment in the trough during periods of higher sea level (Stearns 1975). Over time, sea level transgressed and regressed, and these sediments were compacted, forming the rock units we see today. Of the Oligocene Vicksburg Group strata, the Forest Hill Formation was deposited first and is composed of deltaic sediments deposited just before a major marine transgression (Cooke 1918). During the following sea level rise, the sands of the Mint Spring Formation and the Marianna and Glendon limestones were deposited, followed by another regression. Byram Formation sands and overlying Bucatunna Formation clays represent this last phase of change. What resulted was the preservation of the most complete sequence of successive marine faunas worldwide for the early Oligocene (Dockery 1986).

The formation of the Mississippi River led to the transportation of sediment down the Mississippi Embayment and the deposition of more recent units around Vicksburg. Lying atop the marine strata of the Vicksburg Group are the deltaic sediments, sands, and clays of the late Oligocene–early Miocene-age Catahoula Formation (Dockery and Thompson 2016). As the Embayment filled from north to south during the Neogene, fluvial deposition and terrestrial fauna became common. The southern segment of the Mississippi River, including Vicksburg, receives sediments from the entire Mississippi drainage basin. During the Pleistocene ice ages (2.58 to 0.012 Mya), this supply included Paleozoic gravels (539 to 252 Mya) ground by northern glaciers (Dockery et al. 2008). The youngest sediments found in the region are fine-grained, wind-blown loess soils dating to the last Ice Age that cover the Miocene and Oligocene bedrock below. The flat Great Plains allowed easterly winds to transport silts that were then deposited on the east side of the river from Cairo, Illinois, down to New Orleans. This light, nutrient-rich soil was deposited along the river's banks, creating ideal agricultural conditions as well as providing structural integrity for earthworks and caves during the Civil War period for which VICK is known. More on the impacts of the loess during the siege of Vicksburg is discussed in Myers et al. (2005).

Studies relating to the age and origin of the loess around Vicksburg date back more than one hundred years. The state geologist of Mississippi during the Civil War, Eugene W. Hilgard, published one of the earliest papers considering the possibility of the loess being eolian in origin (Hilgard 1879). When determining the age of such younger deposits, charcoal and plant fossils rich in carbon-14 are ideal but rarely found in loess. Radiocarbon dating of terrestrial fossil gastropod shells recovered from the loess near Vicksburg confirmed the estimated age as roughly 26,000 to 18,000 years (Snowden and Priddy 1968). The use of gastropods in radiocarbon dating is reliable due to the taxa living briefly and travelling very little, meaning their estimates are likely temporally equivalent to the deposits in which they are found. Later studies improved on previous estimates by accounting for the "limestone problem" which refers to the fact that many gastropods consume "old carbon" from the carbonate rocks they are surrounded by, thus resulting in a slight overestimate in age. Most recently, Pigati et al. (2014) dated shells from Vicksburg of the land snail genera *Anguispira*, *Inflectarius*, and *Neohelix*, and the results were similar with a range of around 24,000 to 19,000 years.

Millions of years of geologic history set the stage for the terrain of our modern era, including the unique topography that made Vicksburg a strategic Civil War site. Before turning his sights to understanding the loess, Hilgard was the first to codify the Vicksburg Group as a mappable lithologic unit (Figure 6) (Hilgard 1860). By comparison, the most recent geologic map of the state of Mississippi was developed by the Department of Geosciences at Mississippi State University in 2016. Provided in this report is a geologic map of VICK derived from 1969 geologic data collected by Alvin R. Bicker Jr. of the Mississippi Geological Survey (Figure 7). This version is missing the full extent of ancestral pre-loess terrace deposits. A more complete and up-to-date geologic map of VICK is in progress as of the publication of this report. For more information on the geologic history of Vicksburg and Mississippi, see Dockery and Thompson (2016). VICK is underlain by a combination of the early Oligocene Vicksburg Group, the Oligocene–Miocene Catahoula Formation, and younger terrace, loess, and fluvial deposits (Figure 7; Table 1).

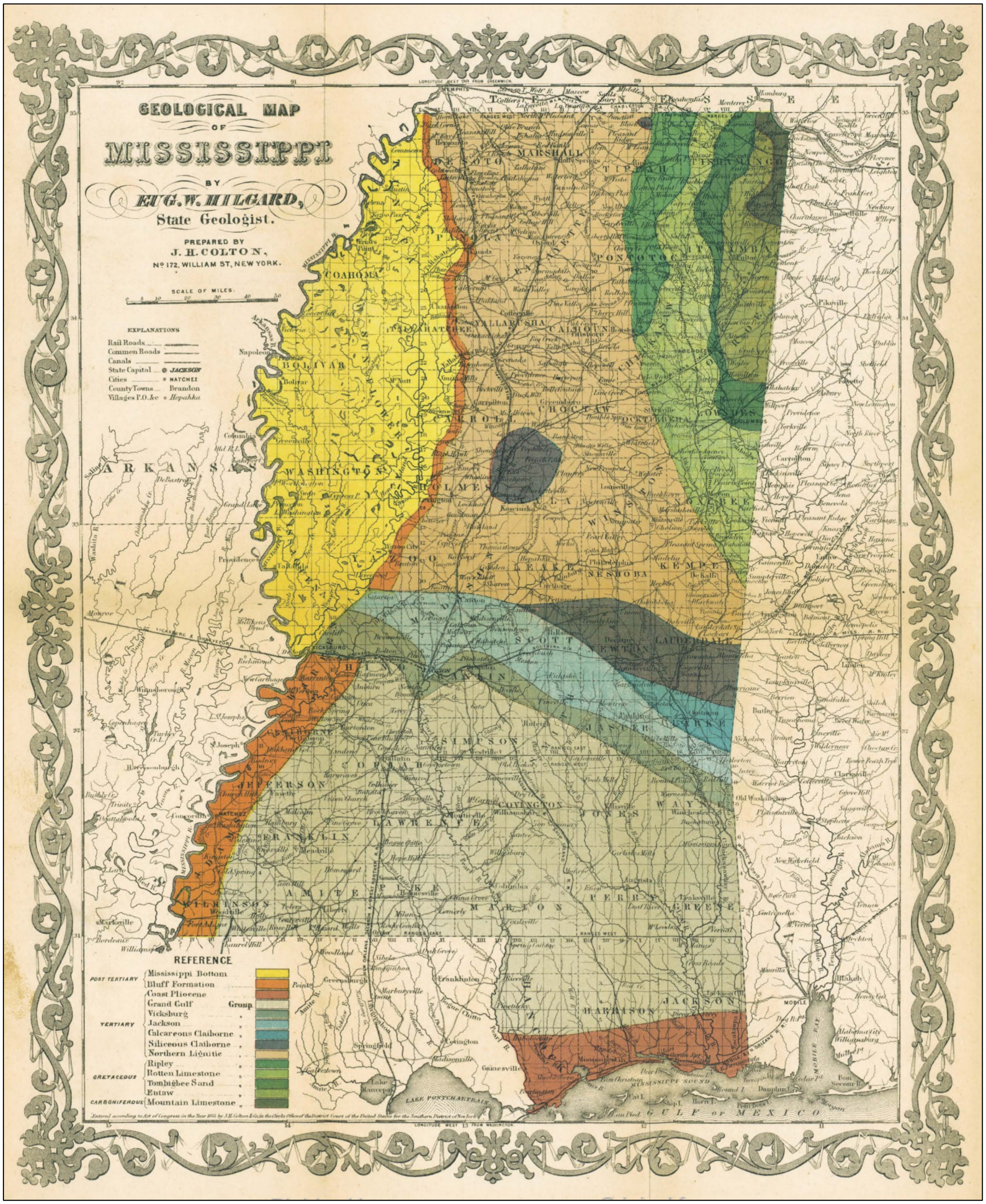

Figure 6. Geologic map of Mississippi from Hilgard's *Geology and Agriculture of the State of Mississippi* (1860). This book is the first publication to map the Vicksburg Group.

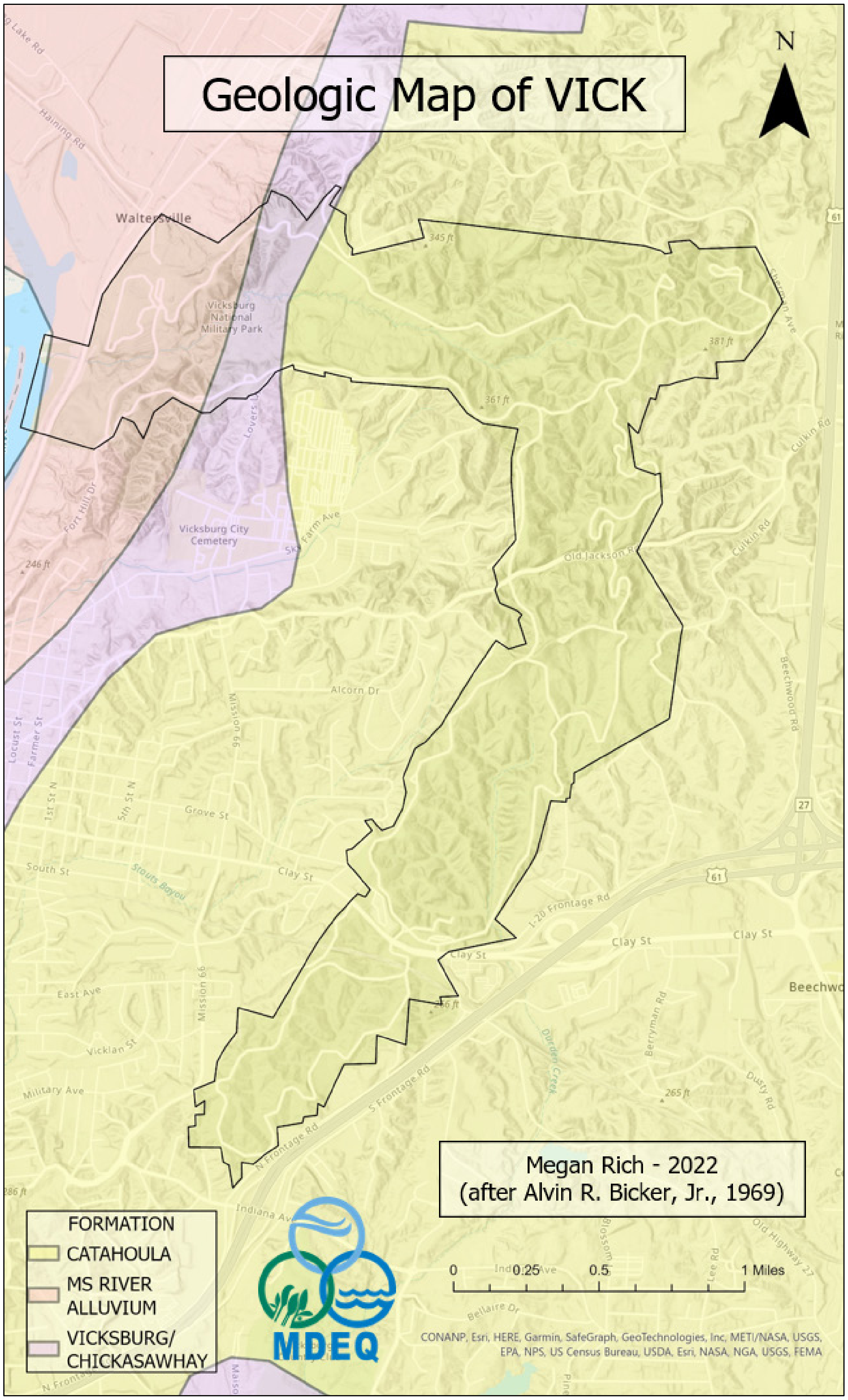

Figure 7. Geologic map of VICK, derived from 1969 geologic map data provided by the Mississippi Department of Environmental Quality. Each formation represented is overlain by Quaternary loess throughout much of the park. Pre-loess terrace deposits are not included. An updated geologic map of VICK with much more precise bedrock geology is in progress as of the publication of this report.

Table 1. Summary of VICK stratigraphy, fossils, and depositional settings in descending order of age, from youngest to oldest. Details and references can be found in the text and in Kenworthy et al. (2007). Lists of the fossil taxa which may occur in each formation can be found in Appendix A.

Formation	Age	Fossils Within VICK	Depositional Environment
Quaternary sediments	late Pleistocene loess and Holocene sediments	Pleistocene bivalves and gastropods, possible vertebrate bones	Eolian silt accumulated along eastern banks of Mississippi River
Paleozoic gravel in more recent deposits	Paleozoic origin in Cenozoic deposits	Corals, bryozoans, brachiopods, gastropods, trilobites, crinoids	Glacially deposited sediments from far up the Mississippi River drainage basin, transported downstream
Catahoula Formation	late Oligocene–Miocene	Invertebrate ichnofossils	Sand and clay deposited in coastal and delta environments
Vicksburg Group: Bucatunna Formation	early Oligocene	Plant material (near park at Keyes Scrap Metal Yard)	Marine regression
Vicksburg Group: Byram Formation	early Oligocene	Corals, bivalves, gastropods, scaphopods, echinoids, an otolith, foraminifera	Marine regression
Vicksburg Group: Glendon Limestone	early Oligocene	Shell material, foraminifera, nannoplankton	Marine transgression
Vicksburg Group: Marianna Limestone	early Oligocene	Shell material, foraminifera, nannoplankton	Marine transgression
Vicksburg Group: Mint Spring Formation	early Oligocene	Bryozoans, bivalves, gastropods, scaphopods, ostracods, mollusk borings, foraminifera, nannoplankton	Marine transgression, shallow, sand-marl
Vicksburg Group: Forest Hill Formation	early Oligocene	Not fossiliferous in VICK	Shallow delta, silty sands

Note: In 1828 Lesueur collected diverse fossils (including corals, bryozoans, bivalves, gastropods, scaphopods, crabs, echinoids, shark and ray teeth, fish otoliths, foraminifera, and possible marine mammal material) from the Vicksburg Group of an area including VICK, but geographic and stratigraphic provenance data are limited.

Geologic Formations

Vicksburg Group (lower Oligocene)

Description: The Vicksburg Group represents a coastal transgressive-regressive sequence, or sea level rise and fall, respectively. This environmental flux took place during the early Oligocene, known as the Rupelian age, ranging from 33.9 to 28 million years ago. The Vicksburg Group stretches across multiple southern coastal states from Texas to Florida, first acquiring its name in Conrad (1848a). In ascending order from oldest to youngest, the component formations are the Forest Hill Formation, Mint Spring Formation, Marianna Limestone, Glendon Limestone, Byram Formation, and Bucatunna Formation. Deposition of the Vicksburg Group began during a period of low sea level, then was followed by a marine transgression at the onset of the Mint Spring Formation which later regressed once more after the Glendon Limestone was lain. A disconformity, denoted by a faunal change, interrupts the transgressive-regressive sequence at the Marianna–Glendon contact (Dockery 1986). Given the lithological similarities of both limestone formations, the difference in assemblage is the primary way the two formations are differentiated. The fossil-rich Byram and the mudstones of the Bucatunna were subsequently deposited during the sea level retreat, concluding the sequence (Dockery 1986).

Vicksburg Group: Forest Hill Formation (lower Oligocene)

Description: The Forest Hill Formation, as it crops out in the Vicksburg area, is a laminated, calcareous mudstone. The formation consists of shallow-water or nonmarine facies and was given its name by C. Wythe Cooke in 1918. Also known as the Forest Hill Sand, this formation shows a disconformity with the sand of the Forest Hill channel cutting into the Yazoo Clay of the Jackson Group and Forest Hill lignites resting atop marine Yazoo Clay (Dockery and Thompson 2016: 462–467). It is estimated to be around 18 to 21 m (60 to 70 ft) thick in Warren County (Cooke 1918). The uppermost Forest Hill Formation in exposures near Vicksburg may contain Mint Spring Formation fauna (MacNeil 1944). Mellen (1941) excavated a vertical face below the limestone ledges at the Mint Spring waterfall locality in VICK to show the contact of the Forest Hill and Mint Spring Formations. It was revealed that mollusk borings penetrated the Forest Hill sediments and filled the spaces with Mint Spring material. The name “Forest Hill Formation” was recommended to supersede “Forest Hill Sand” in Ainsworth (1967) given the composition of the formation at the type locality as 51% silt, 32% sand, and 17% clay. Lignite, varying from low-grade peat-like material to high-grade hard and shiny material, is useful in differentiating the Forest Hill Formation from younger terrace deposits (Ainsworth 1967). The only known outcrop of the Forest Hill Formation in VICK is at the lower Mint Spring Falls locality.

Fossils found within VICK: No fossils from the Forest Hill Formation were recovered in the 2022 survey, though microfossils and lignitic wood may potentially be found.

Fossils found elsewhere: Plant remains have been found in the Forest Hill Formation, such as petrified wood and leaves (Cooke 1918). The formation is particularly known for lignite (derived from plant matter), but animal remains at localities of the Forest Hill Formation are rare.

Vicksburg Group: Mint Spring Formation (lower Oligocene)

Description: The Mint Spring Formation disconformably overlies the Forest Hill Formation. It was first named in Cooke (1918) in which it was described as a member of the Marianna Limestone. The formation is composed of a calcareous marl (Figure 8). The grains of the Mint Spring Formation are larger in size and more rounded than those of the underlying Forest Hill Formation (Mellen 1941). The unit can be differentiated from the neighboring formations by its abundant shell fossils (Figure 9). Deposited after the Forest Hill deltaic environment, the Mint Spring Formation marks the start of a marine transgression with the sea moving inward and bringing with it an abundance of marine organisms. The water at this time was shallow as indicated by the presence of lignitic wood, which also occurs in the Forest Hill Formation. The abundant fossils are water-worn and soft from the movement of groundwater and leaching of calcium carbonate (Mellen 1941). Because of this, the fossil specimens within this formation are fragile and collection is difficult.

Figure 8. Megan Rich collects fossils from the Mint Spring Formation (NPS/CHARLES BEIGHTOL). The light sand receives regular sun exposure, which also bleaches the numerous fossils that can be seen exposed as white specks in the image.

Figure 9. A closer view of the Mint Spring Formation matrix. A dense layer of fossils, mostly bivalves, can be seen in the center of the image. Photo taken March 2022 (NPS/MEGAN RICH).

Fossils found within VICK: The Mint Spring Formation is the most paleontologically diverse unit of the Vicksburg Group and the fourth most diverse formation of the Gulf Coastal Plain, featuring 325 documented molluscan taxa (Dockery 1986; Dockery and Thompson 2016). Within VICK, bivalves, gastropods, and scaphopods have been recovered over the course of this survey. Bivalves and gastropods were reported in Dockery (1982a) and MacNeil and Dockery (1984), as listed in Appendix A-3. Hazel et al. (1980) conducted a study on ostracod ("seed shrimp") biostratigraphy in the Vicksburg Group, collecting 21 fossil samples from VICK. From these samples, the species *Ghardaglaia obovata* was described from the park. Cheetham (1968) mentioned the presence of the bryozoan *Metrarabdotos* (*Rhabdotometra*) *micropora micropora* in the Mint Spring Formation at VICK. The coral *Turbinolia vicksburgensis* was also reported from VICK in Monsour (1944). Hall (2003) described the calcareous nannoplankton in the Mint Spring Formation from VICK. Cushman (1922, 1923) and Todd (1952) described foraminifera samples from the Mint Spring Formation in VICK, describing 12 new foram species from the park. The 2022 survey did not look for microfossils, and the macrofauna recovered often had poor preservation quality. Of the mollusk specimens collected, most are awaiting dedicated identification efforts, while many are likely too fragmentary to identify with confidence.

Fossils found elsewhere: Echinoids such as the sand dollar *Clypeaster rogersi* (Cooke 1959) and heart urchin *Rhyncholampas gouldii* (Carter and Beisel 1987) appear at some Mint Spring Formation localities and can range through the Byram Formation. Calcareous nannoplankton, a kind of microscopic algae, have been studied at other Mint Spring Formation localities (Bybell 1982; Siesser 1983). A tooth from the giant white shark species *Otodus angustidens* was found at MGS locality 99 in Rankin County, and the genus was first recorded in the Vicksburg Group by Lesueur's collections from Walnut Hills (Dockery and Manning 1986). Other shark teeth and ray teeth were illustrated by Lesueur after his 1828 visit (Dockery 1982a, 1982b). The fish fauna of the Mint Spring Formation as described by Stringer and Miller (2001) from MGS localities 99–101 (Lime Creek) included 12 shark species, one sawfish species, two ray species, and 21 otolith-based fish taxa. The Mint Spring Formation section at the Lime Creek locality has also provided substantial molluscan collections which may serve as a comparison for the assemblage at VICK, as well as Dockery (1982a) and MacNeil and Dockery (1984).

Vicksburg Group: Marianna Limestone (lower Oligocene)

Description: The Marianna Limestone is conformable with the underlying Mint Spring Formation, and disconformable with the Glendon Limestone above (Hazel et al. 1980). The formation is a soft, light tan to white colored marine limestone originally named for its type locality in Marianna, Florida (Matson and Clapp 1909). The Marianna Limestone formed during a continuation of a marine transgression as the waters of the depositional environment deepened (Dockery 1986). Calcium carbonate precipitated from this inundated region to form a limestone with markedly different marine fauna from the preceding Mint Spring Formation (Figure 10). More specifically, the transition between the two units is determined by the appearance of the large foraminifera *Lepidocyclina mantelli* and the scallop *Pecten poulsoni* (Matson and Clapp 1909; Gravell and Hanna 1938). The Marianna and Glendon Limestones have been quarried for agricultural lime and building stones (Wailes 1854; Dockery and Thompson 2016). Given the Marianna's softness, it was sawed into blocks very easily (Cooke 1923) and was used for chimneys so often that it acquired the nickname "chimney rock". The Marianna Limestone at VICK is roughly 2 m (6.5 ft) thick, thin compared to its neighbors, especially the thick Glendon Limestone.

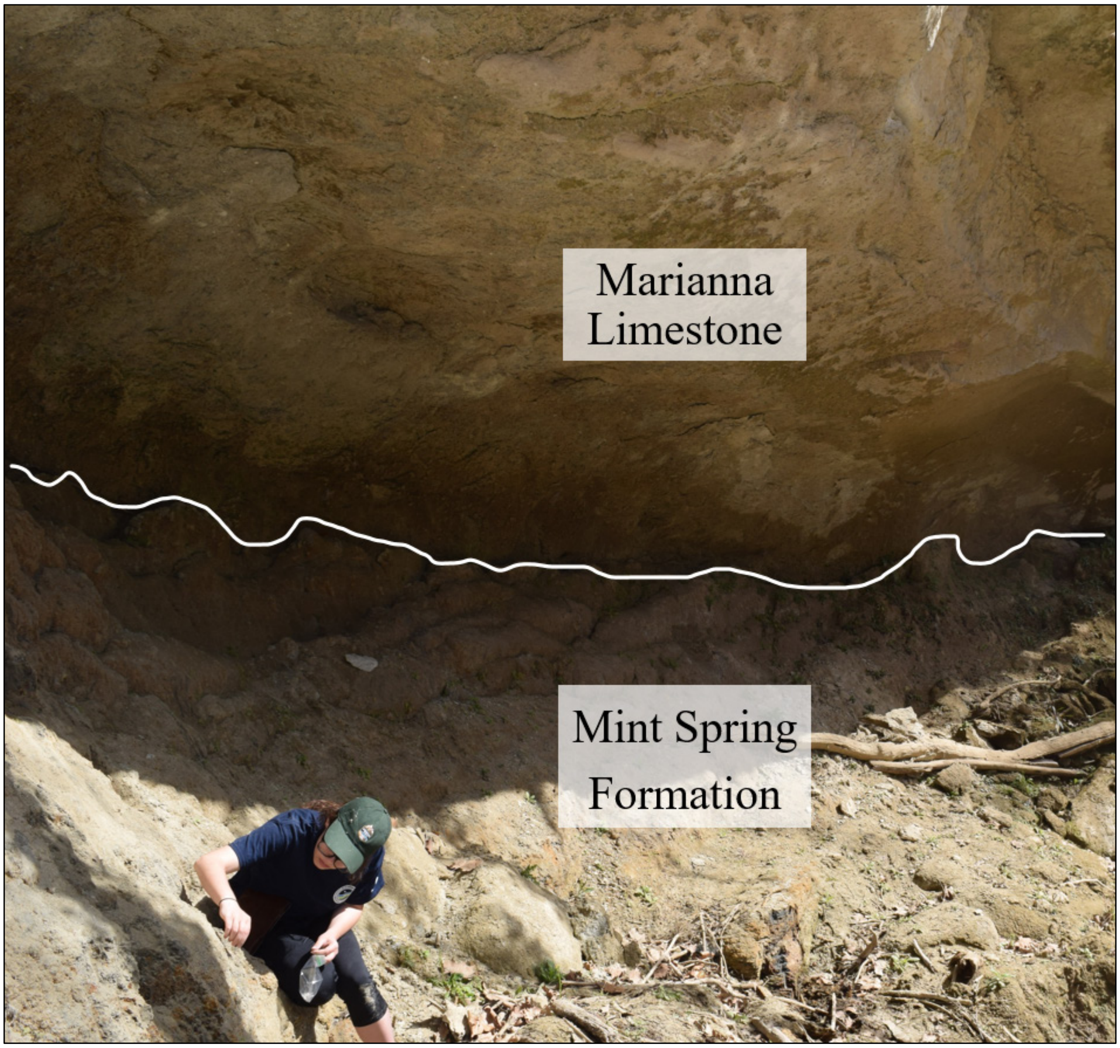

Figure 10. Megan Rich collecting fossils below the Marianna Limestone overhang. The difference in lithology between the hard limestone and softer marl of the Mint Spring Formation can be noted. Photo taken March 2022 (NPS/CHARLES BEIGHTOL).

Fossils found within VICK: No fossils were recovered in this survey from the Marianna Limestone, due in part to the solidified matrix making extraction difficult. However, bivalves from the genus *Pecten* and the foraminifera of the genus *Lepidocyclina* were observed embedded in the rock. More specifically, the fossils *Lepidocyclina mantelli* and *Pecten poulsoni* are the species most useful for identifying the Marianna Limestone relative to other formations (Monroe 1954). Hall (2003) also collected calcareous nannoplankton from this unit in VICK.

Fossils found elsewhere: In addition to the common *Lepidocyclina* and *Pecten*, other calcitic fossils that occur frequently in the Marianna Limestone include the oyster *Pycnodonte vicksburgensis* and the bryozoan *Metrarabdotos micropora* (Cheetham 1968). The fossil crab *Necronectes vaughani* is not uncommon in the Marianna, reported in a Florida locality by Rathbun (1935). Marianna Limestone microfossils such as calcareous nannoplankton and foraminifera were studied by Siesser (1983), Mancini and Tew (1991), and Denison et al. (1993).

Vicksburg Group: Glendon Limestone (lower Oligocene)

Description: The Glendon Limestone is a cream-colored layer with alternating beds of indurated limestone and soft, gray calcareous clay (Hazel et al. 1980). The alternating semi-crystalline nature of the Glendon Limestone in Warren County was described by Mellen (1941), with both materials being similar in composition. The contacts between the Glendon Limestone and its adjacent formations can be difficult to identify consistently, and some beds have been identified as part of the underlying Marianna Limestone (Hopkins 1917) or overlying Byram Formation (MacNeil 1944; Monroe 1954) in the past. Cooke (1918) noted the Glendon Limestone differed from the Marianna by its lithology, as it is the hardest unit of the Vicksburg Group in Mississippi, and by a few fossil species restricted to it. In VICK, the Glendon outcrops are harder than either of its neighbors, appearing slightly darker than the Marianna but lighter than the Byram. This hardness has resulted in Glendon Limestone being quarried for use as building stone elsewhere in Mississippi (Wailes 1854). Weathered exposures of the Glendon have a waterworn appearance with holes and cavities, particularly when it occurs as stream bed in Mint Spring Bayou. The depositional environment of the Glendon Limestone is the deepest of the Vicksburg Group, marking the tail-end of the marine transgression. This was determined through a study by Fisher and Ward (1984) of the Glendon's foraminiferal assemblage, which was found to be indicative of a deep inner marine shelf. In addition to the abundant foraminifera, including *Lepidocyclina*, the Glendon Limestone can also be easily recognized by bivalves of the genus *Pecten*, which appear in abundance embedded in the stone. The calcium carbonate from the limestone, as well as from the loess soils around it, often creates earthy travertine deposits where water flows. The presence of this travertine may mark sites of ancient, abandoned, or active waterfalls (Dockery and Thompson 2016).

Fossils found within VICK: Like the Marianna Limestone, fossils were not collected from the Glendon Limestone within VICK due to the indurated surfaces (Figure 11). However, fossil *Pecten* and other embedded bivalves, as well as large foraminifera, were commonly spotted within the Glendon Limestone. In 2003, Hall conducted a study of calcareous nannoplankton and documented specimens from the Glendon Limestone in VICK.

Fossils found elsewhere: The fauna of the Glendon Limestone as described from the type locality includes bryozoans, brachiopods, echinoids, mollusks, ostracods, and foraminifera (forams) (Howe 1942). The large foram *Lepidocyclina supera* is a common fossil in this unit. The presence of *L. supera* and an external mold of the bivalve *Pitar imitabilis* helped identify Native American effigy pipes as being made from Glendon Limestone (Steponaitis and Dockery 2011). A squirrelfish, *Holocentrites ovalis*, has been collected from the Glendon, as well as the Marianna and Byram (Dockery and Thompson 2016). The Glendon specimen was preserved in the three-dimensional shape of the original fish, with the bony skeleton intact on the inside and covered with imbricated scales on the outside. The fossil crab *Ranina georgiana* occurs in the Glendon Limestone in Decatur

County, Georgia. The type specimens of two other crabs, *Callianassa berryi* and *Necronectes vaughani*, were collected from Glendon Limestone around Vicksburg (Rathbun 1935). Siesser (1983) and Mancini and Tew (1991) conducted foraminiferal studies of the Glendon.

Figure 11. Close-up view of fossil material embedded in a block of Glendon Limestone. Photo taken February 2022 (NPS/MEGAN RICH).

Vicksburg Group: Byram Formation (lower Oligocene)

Description: The Byram Formation was named for its type locality at Byram Station on the Pearl River in Mississippi (Casey 1901). It is a calcareous marl near the top of the Vicksburg Group and is one of its most fossiliferous units (Cooke 1918). It is composed of clayey sands that often appear dark in color but can range from a tan-brown or yellow like the Mint Spring Formation to a dark blue-gray like much of the Glendon Limestone. This is largely dependent on exposure to the elements, such as water and air. Currently only two Byram localities are discernable and documented along the Mint Spring Bayou in VICK, and they are dark gray due to hydration from the flowing stream (Figure 12). However, other localities have been reported above the Mint Spring falls (Monsour 1944) though the current loess cover and/or cement retaining structures obscures these locations. In addition, a landslide in the Vicksburg National Cemetery revealed a long-buried layer of the Byram that was brown and lightened with continual sun exposure (Figures 13 and 14). Fossils of the Byram can often be found as float from outcrops, given the soft matrix of some of these localities that permits fossils to become easily dislodged. The Byram Formation is the first unit in the Vicksburg Group that entirely encompasses the period of a marine regression (Dockery 1986). As the waters of the Gulf receded, clastic sediments from the near-shore shelf environment were conformably lain upon the carbonate shelf of the Glendon Limestone. The well-preserved and diverse molluscan assemblage is a key factor for recognizing this formation.

Fossils found within VICK: The Byram Formation fossils are much better preserved than those of the Mint Spring Formation and include a variety of molluscan taxa representing both aragonitic and calcitic shells. The Byram Formation is known for its abundant mollusks, and while most specimens recovered in this survey and in other collections efforts are bivalves as they are more numerous, gastropods show greater diversity. Cooke (1922) published a faunal checklist of the Byram Formation including five corals, 134 mollusks, and two echinoids. The bivalve *Scapharca lesueuri*, named for Charles Alexandre Lesueur, is recognized as the diagnostic fossil of the Byram Formation (Cooke 1923). One prevalent species, *Pecten byramensis*, is a useful guide for both the Glendon Limestone and the Byram Formation. This species, as well as bivalve *Scapharca lesueuri* and the large foraminifera *Lepidocyclina supera* were listed as Byram guide fossils in Monroe (1954). The concentrically ribbed bivalve *Ervilia lamelloexteria* can also be used as a guide fossil for the Byram, while another species from the same genus, *E. exterolaevis*, appears in the Mint Spring Formation. The presence of one species or the other in the matrix can affirm whether the stratigraphic horizon belongs to the Byram Formation or Mint Spring Formation (Dockery and Thompson 2016). While *Pecten, Scapharca,* and *Ervilia* are common bivalves, turrid gastropods also occur regularly in the Byram. The large gastropod species *Turbinella wilsoni*, first collected and illustrated by Lesueur from Walnut Hills, is a rare indicator of the formation. These fossils have all been documented and collected within VICK (Appendix A). Two Byram localities were a primary focus of collection within VICK over the course of this survey, though characteristic fossils can be found elsewhere. In addition, fossils were also collected from a Byram Formation locality along the landslide scarp in the cemetery, but that outcrop will be buried in the near future, limiting future fossil collections. Scaphopods, commonly called tusk shells, in particular often provide indications of nearby Byram exposures. Microfossils were not looked for though are presumed to be present in VICK. The coral *Turbinolia vicksburgensis* was reported from VICK in Monsour (1944). A single vertebrate fossil is confirmed in the Byram Formation of VICK: an otolith from the cusk eel genus *Ariosoma* (Ivany et al. 2000).

Figure 12. The Byram Formation of VICK (NPS/CHARLES BEIGHTOL). **A.** Megan Rich points out the conformity between the Byram Formation and Bucatunna Formation overlying it. **B.** Byram fossils can be seen in situ. **C.** The exposures illustrate loess that has washed in and can be seen lying atop Byram material.

Figure 13. The Byram Formation outcrop exposure in the US National Cemetery, revealed after a landslide (NPS/MEGAN RICH). Pre-loess gravels lie in a layer under the roadbed.

Figure 14. Fragments of the bivalve *Pecten* are seen in the Byram Formation (NPS/MEGAN RICH). The calcitic shells of *Pecten* are preserved in the calcareous Marianna–Glendon–Byram sequence.

Fossils found elsewhere: While only mollusks and potentially bryozoans and corals were found in the Byram at VICK during this survey, microfossils, vertebrate fossils, echinoderms, and more have been discovered at other localities. Calcareous nannoplankton have been studied at the Byram section of Big Black River near Vicksburg (Hall 2003), as well as 105 species of foraminifera from the same locality (Mixon 2004). The ophiuran (brittle starfish) species *Amphiophiura oligocenica* (Berry 1937) was identified from the Byram type locality at Byram Station on the Pearl River in Mississippi. As many as 245 molluscan taxa are recognized to occur in the Byram Formation (Dockery 1986). Large gastropods more than 10 cm (roughly 4 in) in length appear rarely in the Byram but have been reported in outcrops nearby VICK. One such species, *Melongena crassicornuta*, has been documented at the Keyes Scrap Metal Yard locality (MGS locality 140). At these nearby locations and others, extensive collections have taken place and may be used as a useful point of reference in identifying the taxa recovered in VICK (Dockery 1982a; MacNeil and Dockery 1984). Much of Lesueur's collections from Walnut Hills came from the Byram Formation which includes corals, bryozoans, pteropod gastropods, scaphopods, echinoids, and shark teeth (Dockery 1982a, 1982b). An otolith of a conger eel (genus *Paraconger*) was described by Ivany et al. (2000) and used in isotopic studies of the Oligocene climate. Land mammal fossils have been found in the Byram at Big Black River, including a skull of the hippopotamus-like amynodont *Metamynodon planifrons* (Manning et al. 1985) and a jaw of the hornless rhino *Subhyracodon occidentalis* (Manning 1997).

Vicksburg Group: Bucatunna Formation (lower Oligocene)

Description: The Bucatunna Formation as it crops out in VICK is less fossiliferous than the preceding units. Around Vicksburg, the Bucatunna Formation consists of gray to dark or chocolate brown lignitic clays, meaning it contains traces of plant material and soft pieces of low-rank coal. The material is soft in texture and the grain size is small. An 8 m (25 ft) section of the Bucatunna Formation near the National Cemetery was described in Mellen (1941) as interlaminated silts with local deposits of black massive clay, all of which are lignitic or carbonaceous. The paper also noted an abundance of large gypsum crystals in the weathered zone at this location. Due to the presence of occasional red banding discolored from the presence of iron, it can sometimes have a similar appearance to the Catahoula Formation, though the Bucatunna Formation tends to be darker and contains no burrows (Figure 15). Elsewhere the Bucatunna Clay has been marketed for its mineral-rich content and mineral water mined from the Strite Mine in Smith County, Mississippi (Dockery and Thompson 2016: 496–497). The Bucatunna Formation was originally named as a member of the Catahoula Group (Blanpied et al. 1934), then later as a member of the Byram Formation (Cooke 1935; Wilmarth 1938; Mellen 1941; MacNeil 1944), before being recognized as the topmost unit of the Vicksburg Group, conformably overlying the Byram Formation. Laminations are common in the unit, alternating between silt and more fine-grained sands but remain dominated by clays. When weathered, the clay may appear blocky or have a conchoidal fracture. The Bucatunna Formation is the youngest unit of the Vicksburg Group and at the time it was deposited, sea level had receded significantly, and waters of the depositional environment were shallow (Dockery 1986). There are few Bucatunna outcrops within the park. The formation can be viewed overlying the Byram localities along Mint Spring Bayou and at other exposures upstream from these locations. North of the park, at Keyes Scrap Metal Yard, is a substantial exposure of the Bucatunna Formation that may serve as a reference for the formation and its lithofacies (Figure 16).

Fossils found within VICK: No fossils from the Bucatunna Formation have been collected in VICK, though fossil pollen, nannoplankton, and other microfossils may be possible.

Fossils found elsewhere: As part of the Glendon–Byram–Bucatunna regressive sequence, the Bucatunna Formation occasionally contains some marine invertebrate fossils. Fossil leaves have been found in a clay pit of the Bucatunna Formation in northern Vicksburg at MGS locality 172 on the eastern side of Business Highway 61 (Starnes 2003). Calcareous nannoplankton was reported at other Bucatunna localities such as St. Stephens Quarry in Alabama (Siesser 1983). Sporomorphs, or fossil pollen grains, have also been found at this locality as well as in the Bucatunna Formation of eastern Mississippi (Oboh and Reeves Morris 1994).

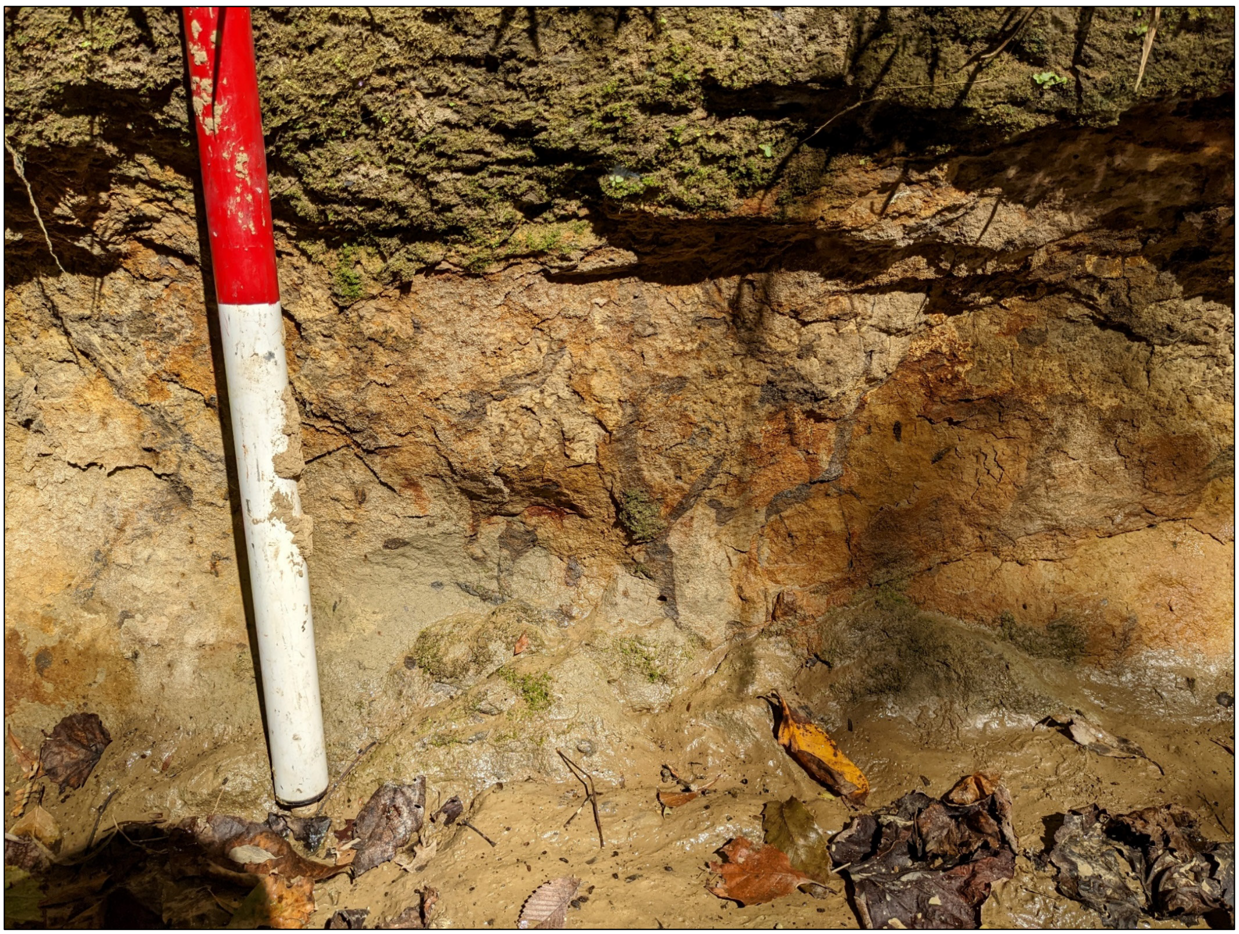

Figure 15. Laminated clays of the Bucatunna Formation at locality VPFV-CVB22-0037. Red coloration due to the presence of iron can be observed. The red and white segments on the staff each represent one foot (approximately 30.5 cm) in length (NPS/CHARLES BEIGHTOL).

Figure 16. Bucatunna Formation layers as seen at the Keyes Scrap Metal Yard locality north of VICK (NPS/MEGAN RICH).

Catahoula Formation (upper Oligocene–lower Miocene)

Description: The Catahoula Formation, often referred to in older works as the Grand Gulf sandstones, crops out prominently in Texas, Louisiana, and Mississippi. Cooke (1935) placed the formation as late Oligocene to early Miocene in age. The Catahoula Formation is a nearshore sedimentary deposit that appears within VICK as either lagoon mudstones or deltaic sandstones, to which the latter is more commonly recognized outside the park (Mellen 1941). These sands often appear loose and white with large grain sizes, underneath which is harder, light gray or tan sandstone. This can be distinguished from indurated loess due to being much lighter in appearance, cross-bedded, and having kaolinitic clay components (Mellen 1941). Laminations can be seen stretching across the face of outcrops because of the way sediments were lain and compacted, including thin red or orange layers originating from iron-rich waters (Figure 17). Some Catahoula outcrops are known for "quartzite" that forms as water percolates through the ash-rich sands and precipitates into indurated stone rather than the typical metamorphic quartzite, though this feature is not seen near VICK. Stones of the Catahoula have been used as rip-rap for levees, floors for spillways, and railroad ballast (Monroe 1954). A quarry 4.0 km (2.5 mi) east of Raymond provided Catahoula sandstone used to build the old Mississippi State Capitol between 1833 and 1839 (Monroe 1954). There are four outcrops of the Catahoula Formation in VICK, and the locality on the banks of Glass Bayou show this layering distinctly. This site, as well as others near Jackson Road, can all be recognized by their white, chalky appearance that comes from the weathering of opal cement. The Catahoula Formation is often covered by deposits of loess and may resemble either the loess or Bucatunna Formation, but it can be differentiated from the others by the presence of abundant shrimp burrows.

Figure 17. A red, iron-rich layer from the Catahoula outcrop at locality VPFV-CVB22-0020 (NPS/MEGAN RICH). Above the thin rust-colored laminations is the white, loose, sandy content making up most of the outcrop.

<u>Fossils found within VICK</u>: Trace fossils such as shrimp burrows of the ichnotaxon *Ophiomorpha* have been recorded in the Catahoula outcrops in VICK and are useful markers for identification when trying to differentiate clays of the Catahoula and Bucatunna Formations.

<u>Fossils found elsewhere</u>: The Catahoula Formation is interesting for its inclusion of both marine and terrestrial fossils. A marine lens in the lower Catahoula Formation in Wayne County, Mississippi, contains both marine and land mammal fossils (Dockery and Thompson 2016). Twenty-four species of fossil plants have been identified in the Catahoula of Texas, Louisiana, and Mississippi, and the assemblage resembles that of coastal flora (Berry 1916). For example, fossil leaves of the climbing fern *Lygodium mississippiensis* have been documented at a locality in Hinds County, Mississippi (Starnes 2003). Petrified wood of many species has been documented in localities outside of Mississippi; within the state, palm stumps of the genus *Palmoxylon* are commonly found (Blackwell

1984). Catahoula Formation sites in Louisiana have yielded pteridophyte (spore-producing plants) spores, pollen, fungal debris, rare dinoflagellate cysts (a kind of phytoplankton), and freshwater algae (Wrenn et al. 2003). Freshwater clams of the family Unionidae and one gastropod were described from the Catahoula in Texas (MacNeil 1935). The index foraminifera for the formation are *Siphonina davisi, Marginulina ascensionensis,* and *Lenticulina chambersi* (Nunn and Sen Gupta 1986). Other fossils which have been found in the Catahoula Formation of Mississippi include bryozoans, ostracods, and fish teeth (George and Bay 1935). The depositional chemistry of the Catahoula Formation was not favorable for bone preservation, but a molar of the pig-like mammal *Dinohyus hollandi*, known to live during the early Miocene, may have been found in the Catahoula of Escambia County, Alabama (Westgate 1992). The location is also home to outcrops of the Vicksburg Group and other formations of similar time periods, so the source is unconfirmed. Lastly, burrows of callianassid shrimp belonging to the ichnotaxon *Ophiomorpha* have been found elsewhere in Warren County (Dockery and Thompson 2016), which bear similarity to burrows found in VICK.

Pre-loess gravels (Paleozoic origin, Cenozoic redeposition)

Description: The streams of Mississippi contain gravels that have been transported from across the Mississippi River drainage basin by rivers draining into the Gulf of Mexico. Many of these gravel deposits contain large boulders that floated down the glacier-fed Mississippi River in blocks of ice, a process known as ice-rafting. Among the gravels are examples representing a variety of geologic formations of Paleozoic age (539 to 252 Mya), ranging mostly from the Silurian (443 Mya) to Mississippian (323 Mya) periods (Dockery et al. 2008). They were brought to the Vicksburg area just before the deposition of the loess, hence the “pre-loess” descriptor. Other sediments continue to be delivered to the area by rivers in the present day. These gravels are highly variable in size, shape, and color, and include chert, agate, jasper, quartz, and more. Among or within these pebbles are often molds, impressions, encased, or isolated fossils. Some of these rocks were used by Native Americans to craft accessories, toys, or projectile points. The deposits are mined by commercial gravel companies for use in construction, and examples of this usage can be seen in erosional areas around VICK as gravels underlying damaged or missing roadbed. For a better understanding of the Paleozoic gravels of Mississippi as well as the potential fossils within, please see Dockery et al. (2008).

Fossils found within VICK: This survey yielded a variety of Paleozoic fossils from the pre-loess gravels (Figure 18). The most abundant specimens were corals (Figure 19), bryozoans, and crinoids, but specimens of brachiopods, bivalves, gastropods, and trilobites were also found. They have yet to be more specifically identified beyond broad taxonomic groups.

Fossils found elsewhere: In addition to those listed above, Dockery et al. (2008) described the Paleozoic gravels of Mississippi as including petrified wood, stromatoporoids (reef-building sponges), ammonites, other echinoderms such as blastoids, foraminifera such as fusulinids, and more. Given the wide ranges of geologic time and geographic space, the potential diversity of Paleozoic fossils is very large, with most being marine invertebrates.

Figure 18. Co-author Christy Visaggi examines a pre-loess gravel bar. Photo taken March 2022 (NPS/MEGAN RICH).

Figure 19. An apertural cross-section of a solitary rugose coral is prominently exposed in the central piece of pre-loess gravel (NPS/MEGAN RICH).

Quaternary sediments (upper Pleistocene–Holocene)

Description: Loess deposits have a wide variety of appearances depending on the context of each location. Generally, loess in Mississippi is composed of yellow or light brown silt-dominated sediments and contain a clay content of less than 20% (Galicki and Schmitz 2016). These sediments are eolian (transported by wind) and accumulated along the eastern banks of the Mississippi River. The occurrence of the loess at Vicksburg was first described by Morse (1935) as being ground by glaciers in the north near Canada and transported south, then deposited as floodplain material and blown onto the bluffs. The loess of Vicksburg belongs to a type called the Peorian loess and is stratigraphically correlated with loess stretching as far north as Peoria, Illinois (Pigati et al. 2014). Loess bluffs are common around VICK and much of the Mississippi River Valley, appearing many dozens of meters or feet tall in some locations and giving the city its characteristic fortified topography (Figure 20). The soft matrix has allowed for art to be carved into loess cuts, such as those on Interstate 20 near Vicksburg, though some have vanished due to weathering and kudzu cover. According to Bettis et al. (2003) the average thickness of the loess in Vicksburg and along much of the Mississippi River is around 5 to 10 m (16 to 33 ft), but it can reach much higher. Many cliffs or landslides can be seen in the more densely vegetated parts of the park, as well as smaller erosional exposures occurring throughout. Exposure to water gives the loess a darker, hydrated appearance, and mineral content in the water can cause the sediment to soften or become blocky. However, most loess exposures are light-colored and are metastable when conditions keep the loess dry. When disturbed, the structural integrity of the loess is lost easily and earthworks erode rapidly, which is a concern for environmental stability at VICK. Calcium carbonate nodules tend to solidify, creating "loess dolls" which are concretions that take rounded, irregular, often rootlike shapes. The presence of calcareous constituents within the loess often leads to the formation of freshwater travertine, especially when combined with tannic acid leached from surrounding plants, which was observed in VICK during this survey. Such deposits of freshwater-derived limestone are often associated with waterfalls and other steep gradients (Autin 1993), including examples in Warren County (Logan 1916). Sediments from the loess were deposited approximately 26,000 to 18,000 years ago, spanning both sides of the last glacial maximum, and were dated using fossil gastropod shells recovered from various localities, including the nearby Highway 61 Bypass locality in Vicksburg (Snowden and Priddy 1968) and about mile marker 7 off Interstate 20 just outside of Vicksburg (Pigati et al. 2014). Loess localities were the most common localities documented in the surveying efforts of this report.

Figure 20. Megan Rich stands in front of tall loess scarps. Similar embankments can be found throughout VICK and the city of Vicksburg (NPS/CHARLES BEIGHTOL).

Fossils found within VICK: This survey produced an abundance of terrestrial land snails added to VICK's collections. Some of the most common genera collected include *Anguispira, Helicodiscus, Stenotrema, Succinea*, and *Triodopsis* (Figure 21). Most of the specimens recovered belonged to taxa outlined in Hubricht (1963), which documented shells among the loess in western Mississippi, including Warren County (outside VICK). Shimek (1902) conducted an early investigation of the loess of the Vicksburg–Natchez area, describing 21 species of snails from within the park. Additionally, there were also anomalous loess localities that deviated from this trend by yielding freshwater mollusks. Among these shells were tiny bivalves known as pea clams of the family Sphaeriidae. These were often found alongside the plentiful ramshorn snail of the family Planorbidae. There was one locality of loess from a toppled block now situated adjacent to an outcrop of the Catahoula Formation at which both of these freshwater taxa were present. An additional taxon that was eventually identified as potentially belonging to the species *Pomatiopsis lapidaria* (Shimek 1930) was also found at this locality. This snail was extremely uncommon, and only three specimens were collected. Other aquatic taxa also appeared at this locality (see Appendix A-Table 1). The diversity of taxa recovered from this survey was greater than expected, and future research is necessary to clarify the identification of these snails. As for vertebrates, Lowe (1919) stated that "mammal bones may be collected in the bluffs at Vicksburg." Wailes (1854) indicated a mastodon tooth was discovered in a deep railroad cut at Vicksburg, but it is unclear if it was within park boundaries. Hay (1923) also describes an upper right molar fragment of a mastodon from a nonspecific Vicksburg locality. While Quaternary mammal bones belonging mainly to horses or bovine were collected in this survey, it is suspected that most were Holocene or potentially from the Civil War, and therefore not fossilized despite their appearance. Only one vertebrate fossil believed to be Pleistocene was recovered, but it is a fragmentary and incomplete bone, making identification impossible without further context or analysis. More information on the Pleistocene taxa recovered in this survey can be found in Appendix A-Table 1.

Figure 21. Fossil gastropod specimens found in situ in loess exposures at VICK. **A.** The shell in the center belongs to the genus *Anguispira.* **B.** *Stenotrema* sp. **C.** *Triodopsis* sp. **D.** *Succinea* sp. (NPS/MEGAN RICH).

<u>Fossils found elsewhere</u>: A little less than 1 km (0.5 mi) west of Halls Ferry Road in Vicksburg, at Pemberton Mall and Interstate 20, a nearly complete Pleistocene mastodon (*Mammut americanum*) was excavated from the loess (Knox and Pitts 1984). According to the map provided in Knox and Pitts (1984) the specimen comes from approximately where Popeye's is situated currently. The remains appeared after major erosion took place in the 1950s, and the then-superintendent of VICK, James R. McConaghie, was asked by a citizen to assist in providing information on the exposed bones. It was not until the 1980s that the skeleton was eventually removed, led by Dr. Eleanor Daly, the vertebrate paleontologist of the Mississippi Museum of Natural Science, and aided by the Mississippi Gem and Mineral Society, the Mississippi Bureau of Geology, and volunteers from around Vicksburg (Figure 22). A separate occurrence of mastodon bones in the loess roadcuts along Highway 61 were used for radiocarbon dating (Priddy et al. 1966). Kolb et al. (1976) described these

and other instances of mastodon remains recovered near VICK. Other vertebrate fossils and megafauna have been recovered in abundance from loess of much greater geographic distances relative to VICK. Daly (1992) also recorded a list of occurrences of fossil vertebrates in Mississippi, many of which come from the loess. There have been numerous surveys of the loess to understand its assemblage of fossil mollusks in Mississippi and elsewhere. The papers which included samples collected from near Vicksburg (Shimek 1902, 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999) were referenced when identifying taxa collected in this survey. Other papers regarding the loess which may be useful when searching taxonomic lists or understanding its physical characteristics include Baker (1931), Richards (1938), Vestal (1942), Leonard and Frye (1960), and Krinitzsky and Turnbull (1967).

Figure 22. Paul Hartfield at the mastodon excavation site in loess at Pemberton Mall and Interstate 20 at Vicksburg, Mississippi. Paired tusks are covered in a plaster jacket on the excavation floor. Picture taken on April 14, 1984 (David Dockery, pers. comm., 2022) (MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY).

Taxonomy

Fossils found in the 2022 survey in VICK, as well as potential taxa which may be found upon further investigation, are recorded here. See Appendix A for full lists of taxa.

Fossil Plants

Modern leaf impressions within the buff-colored freshwater travertine deposits near or within streams can be observed within VICK, such as at locality VPFV-CVB22-0018, and mistaken for true fossils. While no plant fossils were collected from VICK in the course of this survey, the possibility of recovering microfossils such as pollen is high. This is particularly true of the Bucatunna Formation, which is rich in plant matter, though plant palynomorphs are widely distributed in the Vicksburg Group in general: six stratigraphic units of the group have been used in palynology studies (Oboh and Reeves Morris 1994; Oboh and Reeves 1995). These studies have been used to understand the paleoclimate conditions of the early Oligocene. Studies have incorporated Vicksburg Group localities in Wayne County in southern Mississippi (site of the Bucatunna Formation type locality) and St. Stephens Quarry in Alabama (Oboh and Reeves Morris 1994), but palynomorph assemblages have not been examined in depth near Vicksburg and could constitute a future research avenue.

Fossil Invertebrates

The fossil assemblages at VICK are dominated by marine invertebrates. The majority of fossils from the Vicksburg Group belong to the phylum Mollusca, as do the fossils within the Pleistocene loess. While bivalves and gastropods were found in abundance in this survey and are documented in previous publications, corals, bryozoans, scaphopods, and other invertebrates also occur among the Vicksburg assemblage.

Phylum Cnidaria (jellyfish and corals)

Organisms of the phylum Cnidaria are aquatic animals that share an ability to sting and capture prey using cells called cnidocytes. They appear either as free-swimming medusae like jellyfish or sessile polyps like corals. Species of coral described from the Vicksburg Group include *Archohelia* (originally *Madrepora*) *vicksburgensis*, *Archohelia* (originally *Madrepora*) *mississippiensis*, and *Balanophyllia caulifera* (Conrad 1848a). Lesueur also illustrated the coral *Oculina virginea* which he found at the Walnut Hills locality (Dockery 1982a). Monsour (1944) reported *Turbinolia vicksburgensis* from the Mint Spring Formation. From this survey, various Paleozoic corals have been collected in gravels and other pre-loess deposits. These specimens have yet to be more closely identified; many are colonial tabulate corals, while horn-shaped rugose corals are also common. Small coral fragments from the Vicksburg Group were also recovered less frequently, such as the species *Archohelia vicksburgensis* (Figure 23).

Figure 23. Coral fossils of the species *Archohelia vicksburgensis* (Conrad 1848a) recovered from the Vicksburg Group at an exposure of the Byram Formation (NPS/CHARLES BEIGHTOL).

Phylum Bryozoa (moss animals)

Bryozoans, literally meaning moss animals, are aquatic, microscopic invertebrates that typically live in colonies. Similar to specimens of the phylum Cnidaria, bryozoans are not very common in the Vicksburg Group, though some species have been reported, including *Lunulites vicksburgensis* (Conrad 1848a), *Reptocelleporaria glomerata* (Gabb and Horn 1862), and *Membrendoecium lowei* (Canu and Bassler 1920). Lesueur noted a handful of bryozoan species during his collections at Walnut Hills, such as "*Cellepora incideus*", "*Cupuloporites digitalis*", and "*Cupuloporites discoides*" (Dockery 1982a). Cheetham (1968) reported the bryozoan *Metrarabdotos* (*Rhabdotometra*) *micropora micropora* from the Mint Spring Formation at VICK. While no Oligocene bryozoans were recovered in this survey, Paleozoic specimens were collected from pre-loess gravels such as bryozoans of the Order Fenestrata (Figure 24). They, like the corals, are in need of greater investigation and identification in VICK and commonly appear in rocks in the streams.

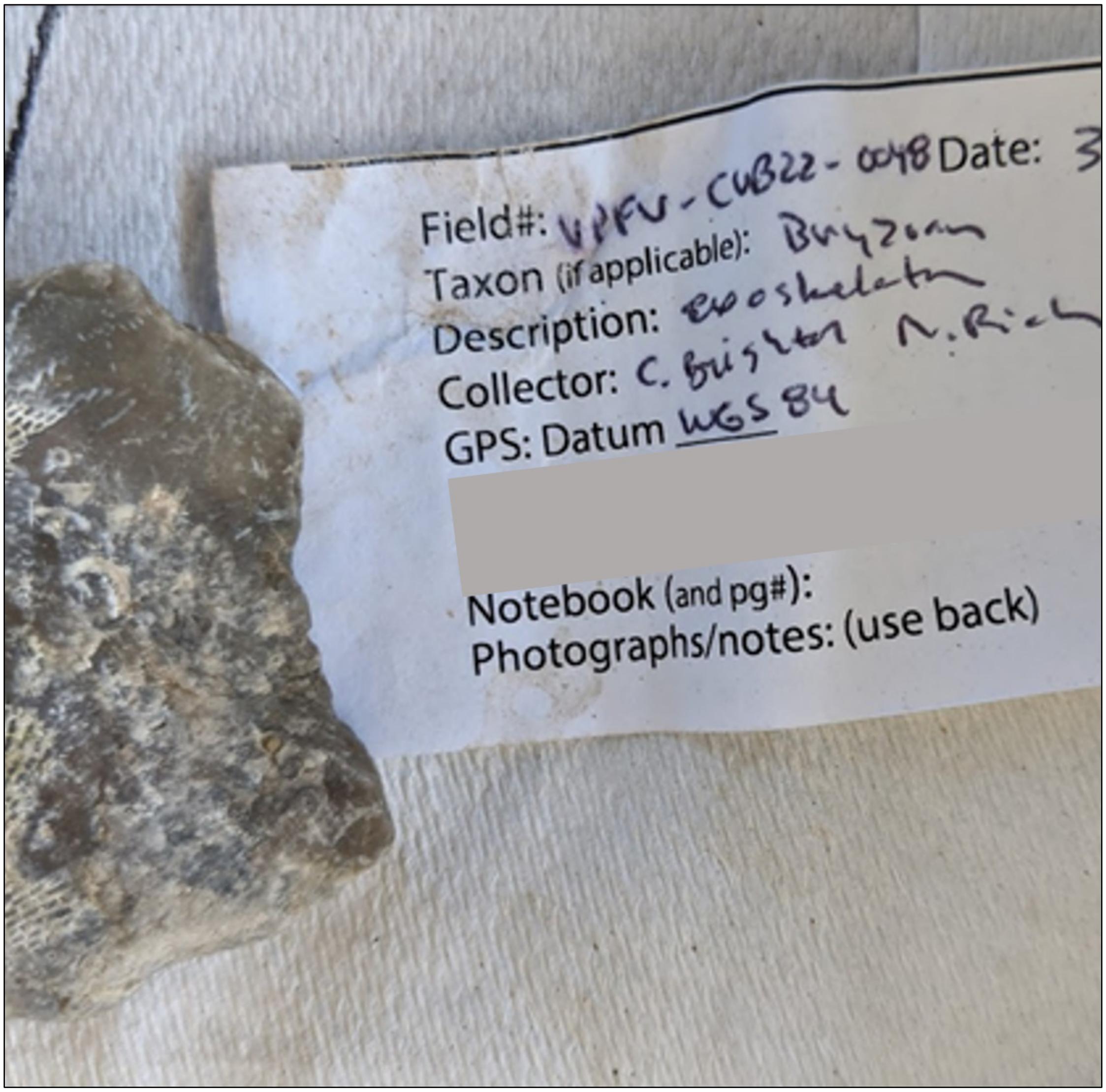

Figure 24. Paleozoic fenestrate bryozoan fossil collected from a pre-loess gravel bar. Photo taken March 2022 (NPS/MEGAN RICH).

Phylum Mollusca: Class Bivalvia (clams, oysters, etc.)

Bivalves are mollusks which consist of two shells that have lateral symmetry, meaning the shells mirror each other. This is the most plentiful class of organisms found within VICK and occur in the Pleistocene and Oligocene bedrock, and potentially even Paleozoic gravel. The bivalves belonging to the Vicksburg Group have been described in a number of publications, most notably Dockery (1982a). One of the most common bivalves in the Vicksburg Group is the genus *Pecten* (Figure 14), which appears in the Mint Spring, Marianna, Glendon, and Byram Formations, and different species have often been used as index fossils of respective formations. Common taxa that appear within the Byram Formation include *Callista, Corbula, Crassatella, Pitar, Scapharca,* and *Tellina* (Figure 25).

Bivalves are also recorded in the Pleistocene loess in buried beds of small ponds (Shimek 1902, 1930; Williams 1999). Examples of the pea clam *Pisidium* were recovered in this survey and are reported in the loess from other localities near Vicksburg (Richards 1938; Williams 1999). These tiny clams range from 1 to 10 mm (0.04 to 0.4 in) and are very useful for bioindicator studies (Figure 26). Watercourses produced various bivalves in the stream that did not belong to the Pleistocene; many may be float material from the Byram or Mint Spring Formations, but there is the possibility of recovering Paleozoic bivalves in gravel as well.

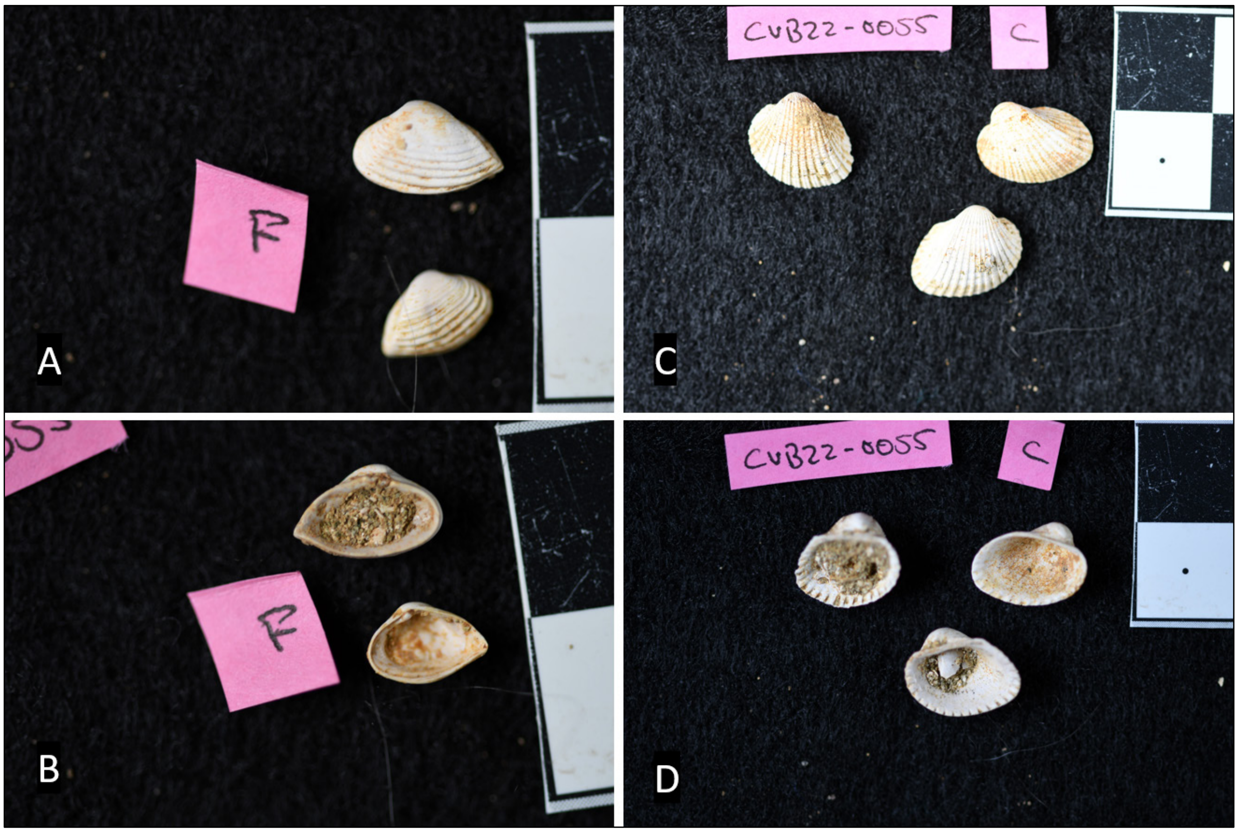

Figure 25. Specimens of *Corbula engonata* (A and B) and *Scapharca lesueuri* (C and D) collected from an exposure of the Byram Formation (NPS/CHARLES BEIGHTOL).

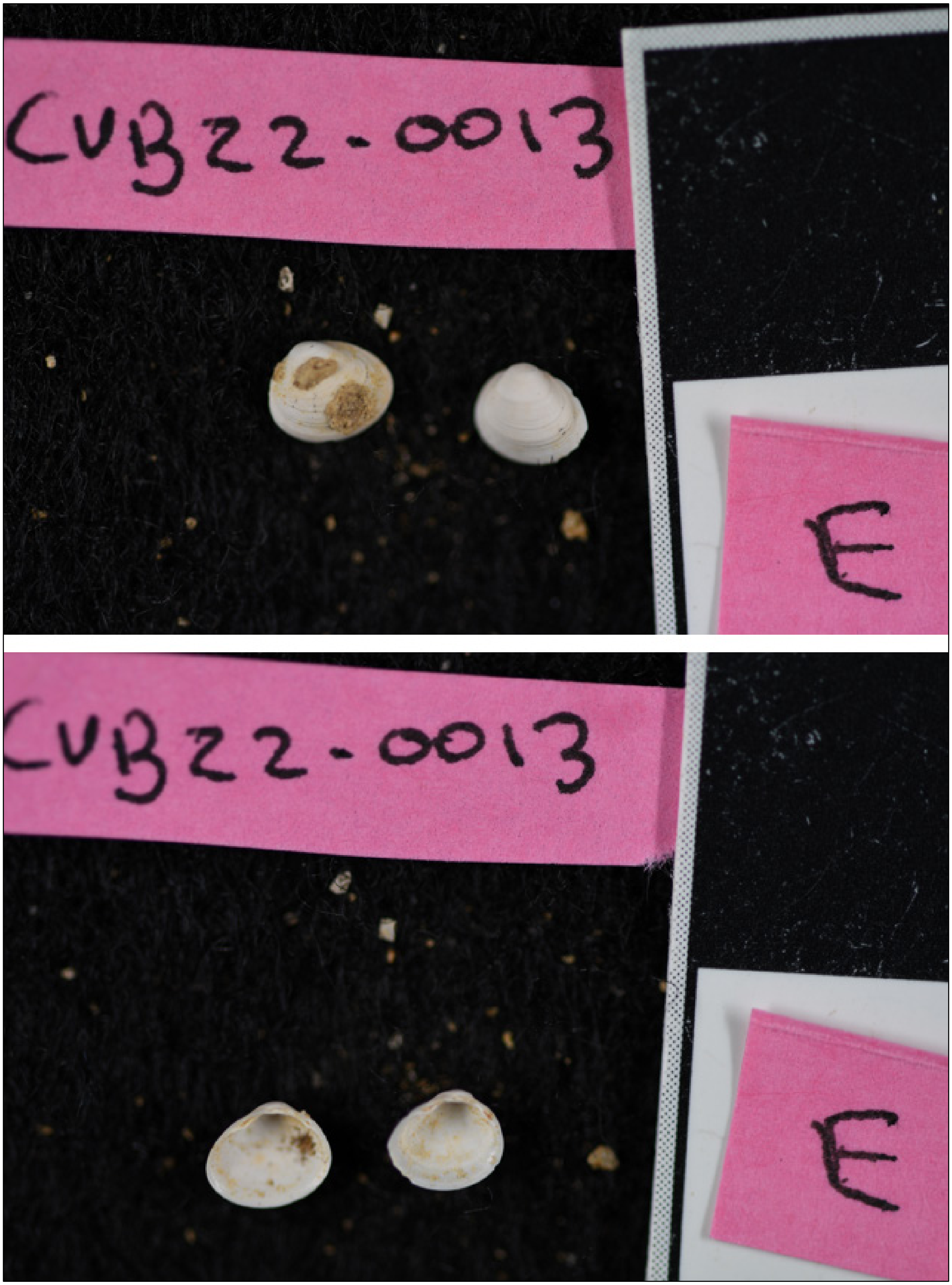

Figure 26. Exterior (top) and interior (bottom) views of the Pleistocene fossil pea clams collected from a loess locality adjacent to an outcrop of the Catahoula Formation (NPS/CHARLES BEIGHTOL).

Phylum Mollusca: Class Cephalopoda (octopuses, nautiloids, squids, etc.)

Cephalopods are marine mollusks characterized by having bilateral body symmetry and a set of arms or tentacles. They have not been confirmed from within VICK, though nautiloids have been described from previous publications on the Vicksburg Group (MacNeil and Dockery 1984). The species *Aturia berryi*, described in Stenzel (1940), may potentially have been described from VICK fossils. The only other cephalopod described from the Vicksburg Group in Mississippi is *Aturia alabamensis*, a nautiloid described in Morton (1834). Ammonites, which are similar in appearance to nautiloids, have been discovered in Paleozoic gravels elsewhere in Mississippi (Dockery et al. 2008) and have the potential to be found at VICK.

Phylum Mollusca: Class Gastropoda (snails)

The class Gastropoda, literally meaning "stomach foot", is comprised of snails and slugs and contains more named species than any other animal class besides insects. While bivalves are most abundant in the Vicksburg Group, gastropods have a greater species richness and occur often in the loess as well. Within the Vicksburg Group, gastropods are most likely to be found in the Byram Formation, though they also occur in the Mint Spring Formation and sparingly in the Glendon and Marianna Limestones. Most taxa occur across most or all of these fossiliferous horizons. Common taxa that appear within the Byram Formation in VICK include *Calyptraea, Conus, Natica, Euspira, Oliva, Terebra,* and *Turritella* (Figure 27). These small gastropod shells generally range in width from less than 1 to 5 mm (0.04 to 0.2 in). Very few Byram species, belonging to only three genera (*Turbinella, Melongena,* and *Volema*), exceed the typical size range (MacNeil and Dockery 1984). These are the largest and rarest known gastropods from the Oligocene of the Gulf Coast. The species *Turbinella wilsoni* is among the first reported large-bodied gastropod specimens from around Vicksburg, first observed by Lesueur at Walnut Hills in 1829, later published in Dockery (1982a). It has been recovered from various localities surrounding Vicksburg and was confirmed to be within the park in this survey (Figure 28). See MacNeil and Dockery (1984) for descriptions and illustrations of 397 gastropod taxa of the Vicksburg Group.

An abundance of gastropods found in VICK occur in the Pleistocene loess. Hubricht (1963) conducted a survey of land snails from 15 loess localities in Mississippi, including two locations in Warren County. Some of the common genera in Hubricht (1963) that were also observed during this survey include *Anguispira, Helicodiscus, Stenotrema,* and *Triodopsis*, the last two of which belong to the family Polygyridae (Figure 29). In addition to the terrestrial snails, this survey also turned up at least two freshwater snail types, the most common of which were of the family Planorbidae (Figure 30). These ramshorn snails, identified by their planispiral (flat-coiled) shells, occur in loess deposits near modern streams, and further investigation might reveal these deposits are fluvially reworked loess during the time of deposition. Very few specimens of one species, thought to be the aquatic species *Pomatiopsis lapidaria*, were also found at the same reworked loess locality as most of the ramshorn snails collected in this survey (Figure 31). There also exists the potential to find Paleozoic gastropods within and among the Paleozoic gravels in VICK's streams.

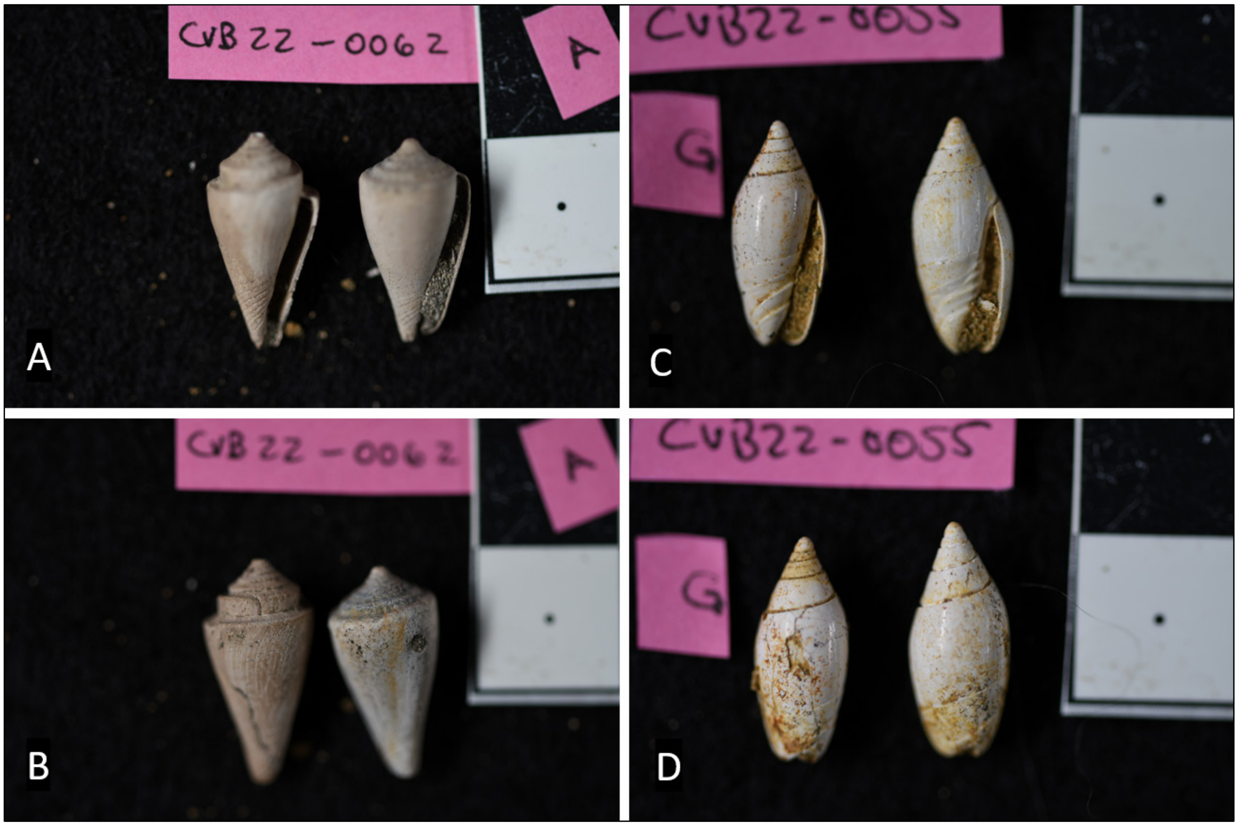

Figure 27. *Conus* (A and B) and *Oliva* (C and D) specimens collected from the Byram Formation (NPS/CHARLES BEIGHTOL).

Figure 28. Specimens of *Turbinella wilsoni* collected from the Byram Formation (NPS/CHARLES BEIGHTOL).

Figure 29. “Giant land snails” of the family Polygyridae, which are very common in the loess. The specimens in this figure, collected from locality VPFV-CVB22-0046, are believed to be the species *Allogona profunda* (NPS/CHARLES BEIGHTOL).

Figure 30. Fossil ramshorn snails found at locality VPFV-CVB22-0013 (NPS/CHARLES BEIGHTOL).

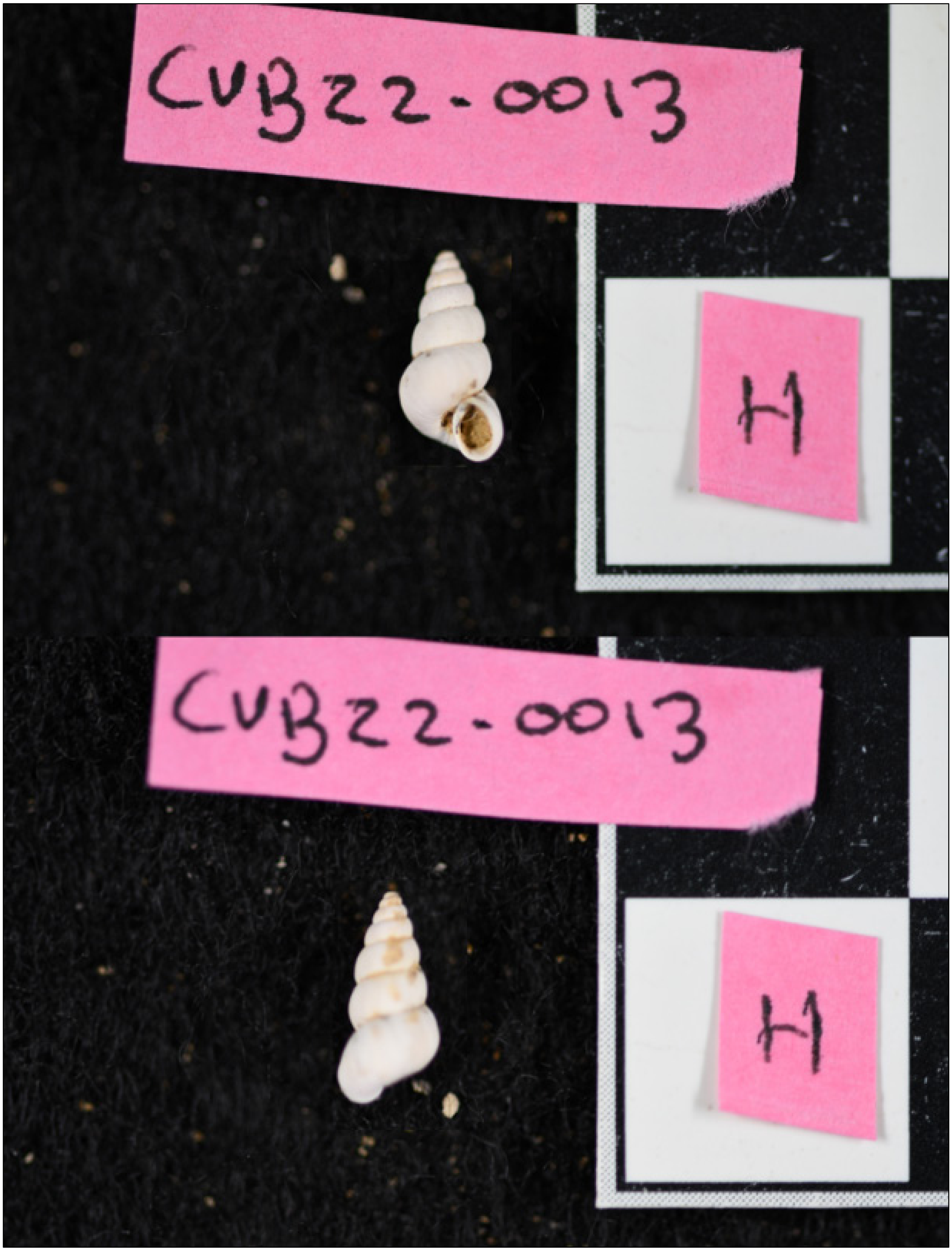

Figure 31. The small, uncommon amphibious snail *Pomatiopsis lapidaria* found at a loess locality (VPFV-CVB22-0013) adjacent to an exposure of Catahoula Formation (NPS/CHARLES BEIGHTOL).

Phylum Mollusca: Class Scaphopoda (tusk shells)

Scaphopods are infaunal marine mollusks with curved shells in the shape of a tooth or tusk. They are known for their strong, elongated shell material and are a sister group to cephalopods. All scaphopods recorded in VICK occur in Oligocene strata. In this survey, the genus *Dentalium* was collected most often (Figure 32), and the species *Dentalium mississippiensis*, *D. opaculum*, and *D. strenuum* were described from Vicksburg collections (Casey 1903). Scaphopods of the genera *Fustiaria* and *Cadulus* have also been reported from the Vicksburg Group at other localities (MacNeil and Dockery 1984). In VICK, the presence of scaphopods in streams or reworked sediments can serve as an indicator for a nearby Byram or Mint Spring Formation outcrop.

Figure 32. *Dentalium* specimens collected from the Byram Formation (NPS/CHARLES BEIGHTOL).

Phylum Arthropoda: (insects, arachnids, crustaceans, etc.)

Arthropods are united by their jointed limbs and chitinous exoskeletons. No arthropod fossils from the Oligocene were collected in this survey, but they are known to be present within VICK. Many species of crustaceans, in particular, have appeared in assemblages of the Vicksburg Group and were collected in or near the park. One such example are ostracods, which are small crustaceans around 1 mm (0.04 in) in size and often referred to as seed shrimp. Hazel et al. (1980) collected ostracod samples from the Vicksburg Group across Mississippi, including six localities in Warren County. The samples were used to correlate the stratigraphic units across space and provide context for the depositional environments of the layers. From this publication, the species *Ghardaglaia obovata* was first described, having been collected from within VICK (Mumma in Hazel et al. 1980). One of the earliest ostracods collected from around Vicksburg was the genus *Eucythere* of the Byram Formation (Howe 1936). In Rathbun (1935), two fossil crabs were reported from the Vicksburg Group, including *Necronectes vaughani* from the Marianna Limestone (Figure 33) and the mud shrimp *Callianassa berryi*. Fossil arthropods from the loess or Catahoula Formation are unlikely, though the pre-loess has a potential for certain arthropods possibly ranging different eras. During this survey, a trilobite pygidium, or hind section, was recovered in gravel; trilobites are notable index fossils spanning the Paleozoic Era.

Figure 33. Fossil crab *Necronectes vaughani* found in the Marianna Limestone of Smith County, Mississippi (MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY).

Phylum Echinodermata (sea stars, brittle stars, sea lilies, sea urchins, etc.)

Echinoderms are marine organisms known for their radial five-fold symmetry, hard spiny skins, and water vascular systems. Common types of echinoderms include sand dollars, sea urchins, and sea stars, and they live in every ocean, including the Antarctic. Only one kind of echinoderm was found in VICK over the course of the survey. Crinoids, also known as sea lilies, were recovered in the Paleozoic pre-loess gravels (Figure 34). More specific classifications have yet to be undertaken, though various types of columnals, or stems, have been found both as impressions in the gravels and as individual pieces that have eroded out.

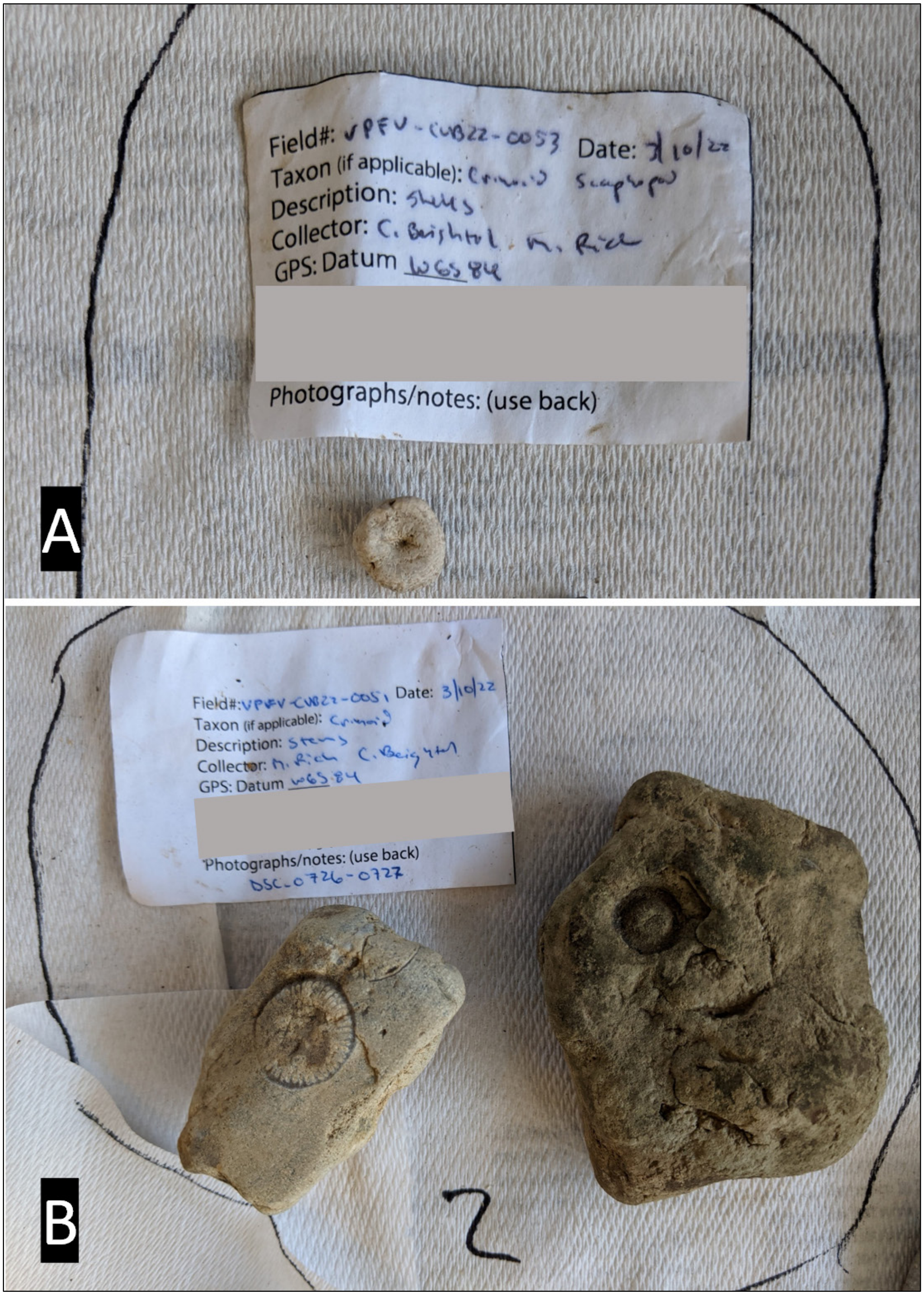

Figure 34. An eroded crinoid (A) and a crinoid impression (right specimen in B) found in pre-loess gravels. The left specimen in B is a solitary rugose coral collected from the same locality (NPS).

Regarding the Oligocene, no echinoderms were recovered from the Vicksburg Group during this survey, but Cooke (1942) documented echinoids in VICK. The sea urchin *Schizaster (Paraster) americanus* was found in VICK at station 6450 (Cooke 1942). The sand dollar *Clypeaster rogersi* was reported from VICK (Cooke 1942) and was discovered elsewhere in the Mint Spring and Byram Formations beyond VICK (Carter and Beisel 1987). The same paper also reported the dome-shaped heart urchin *Rhyncholampas gouldii* as occurring in the Mint Spring and Marianna Formations.

Fossil Vertebrates

Vertebrate fossils within VICK are uncommon, particularly from the Oligocene, though there are occasional occurrences of vertebrates recovered from the Vicksburg Group such as shark teeth or fish fossils. The limited variety of vertebrate fossils recovered from the Vicksburg Group is summarized in Daly (1992). There were numerous vertebrate remains found over the course of the survey within loess or streams. Due to a number of factors such as exposure to mineralized water, the bones often quickly turn a darker color and can be coated or infilled with freshwater travertine, giving the specimens an older appearance which may be mistaken for fossilization but are actually modern. However, the possibility of finding fossils from Pleistocene vertebrates or megafauna is significant as indicated by discoveries in loess elsewhere near Vicksburg. A fragmentary piece of bone presumed to be Pleistocene was recovered in this survey, so further investigation of the loess may reveal more identifiable vertebrate remains.

Class Chondrichthyes (cartilaginous fishes)

Organisms of the class Chondrichthyes are composed mostly of cartilage rather than bone tissue. Sharks and rays are the most common examples of these cartilaginous fishes. Ray teeth were found and illustrated by Lesueur as "*Raia quadrilobata*" in his early plates of fossils from Walnut Hills (Dockery 1982a). No shark teeth were recovered in the 2022 survey. However, teeth of the large species *Carcharodon auriculatus* (Figure 35), were first recorded in the Vicksburg Group when Lesueur visited Walnut Hills in 1828 (Dockery and Manning 1986). The identity of this lamniform shark was recently updated to *Otodus angustidens* (Hodnett et al. 2022). The genus has been reported sporadically in the Oligocene rocks of Mississippi since then, particularly the Byram Formation. Lesueur also illustrated several other taxa of fossil shark teeth from his visit to Walnut Hills, mostly attributed to the spiny dogfish shark genus *Squalus* (Dockery 1982a).

Figure 35. Left anterior lower tooth of *Otodus angustidens* (*Carcharodon auriculatus* of previous usage) collected from the Byram Formation of Vicksburg. It is one of the largest documented shark teeth from Mississippi and is on display at Millsaps College Geology Department (Figures 2A and 2B from Plate 3, Dockery and Manning 1986; Mississippi Geology 7[1]).

Class Actinopterygii (ray-finned fishes)

More than half of living vertebrate species belong to class Actinopterygii, which encompasses ray-finned fishes, a clade of bony fishes. Many fossils of this class are identified by otoliths, or ear bones. At VICK, Frizzell and Dante (1965) documented otoliths of the species *Corvina gemma* and *Corvina pseudoradians.* Although no otoliths were recovered in this survey, they have often been found in the Vicksburg Group elsewhere and may be collected again in VICK through future studies. For example, a cusk eel otolith of the genus *Ariosoma* was found at MGS locality 113, a roadcut exposure of Glendon Limestone and Byram Formation across from the International Paper plant in Warren County, and was used in paleoclimate estimations (Ivany et al. 2000). More complete skeletons of bony fish have been found in the Marianna, Glendon, and Byram Formations, such as *Holocentrites ovalis* (Dockery and Thompson 2016).

Class Mammalia

While many Quaternary mammal bones were collected over the course of this survey, nearly all are expected to be modern despite their aged appearance from exposure in the streams. Other pieces of older bones are too fragmentary for identification, though the possibility of finding more complete specimens is significant (Lowe 1919). Ice Age megafauna have been recovered from the loess in many locations beyond Vicksburg. A nearly complete skeleton of the Pleistocene mastodon *Mammut americanum* was found very close to the park at Pemberton Mall and Interstate 20 (Knox and Pitts 1984). Other mastodon remains have been recovered in areas around the park and possibly within, though the locations are unclear (Wailes 1854; Hay 1923; Priddy et al. 1966; Kolb et al. 1976). Ground sloths, ungulates, and other characteristic Pleistocene mammals of North America may also be discovered.

The Vicksburg Group has also yielded occasional mammal fossils outside of the park. An early Oligocene rhinoceros skull of the genus *Metamynodon* was recovered from the Byram Formation (Manning et al. 1985). Later, a nearly complete lower jaw of *Subhyracodon occidentalis,* another rhino, was recovered from the same locality in Manning (1997). This site, MGS locality 106, lies on the Big Black River near Edwards, which is near a recently acquired VICK satellite unit. These discoveries indicate the potential for more Oligocene mammal fossils to be found within VICK, though the likelihood is low.

Ichnofossils

Ichnofossils, or trace fossils, show evidence of the behavior of organisms without preserving the organism itself. These behaviors may include movement, diet, predation, or other actions. One common type of trace fossil are tubular sedimentary structures known as root casts, which formed in soils of plants long ago. These may be found in plant-rich formations like the Bucatunna Formation, especially at sites such as Keyes Scrap Metal Yard which had abundant charcoalified plant material. However, despite the proximity of Keyes Scrap Metal Yard to the park, no charcoalified plant material was observed within the laminated outcrops of Bucatunna Formation within VICK. Burrows are another remnant of animal activity, such as that of tunneling or burrowing animals like shrimp or crayfish that create spaces suitable to inhabit. Shrimp burrows are often preserved in the Catahoula Formation and can be used to distinguish it from lithologically similar horizons. The burrows belong to the ichnotaxon *Ophiomorpha* and are formed from shrimp of the genus *Callianassa* (Dockery and Thompson 2016). None of these burrows were collected but were observable within Catahoula Formation outcrops. Lastly, a gastrolith belonging to a Pleistocene crayfish was discovered in the loess along Ballground Creek in Warren County (Williams 1999). Gastroliths, such as this specimen identified as belonging to the crayfish *Cambarus*, are literally “stomach stones”, smooth rocks held within an animal’s digestive tract to help grind food. Because of this, they can provide insight into an organism’s diet. None of these ichnofossils were collected in this survey, though similar features of both ancient and modern organisms can be seen all throughout VICK.

Other Fossils

Foraminifera

Foraminifera, or forams, are microscopic, single-celled organisms that are primarily marine and have a fossil record exceeding 500 million years. The phylum Foraminifera, having been previously classified as protists along with many other unicellular organisms, are now instead assigned to the kingdom Chromista (Ruggiero et al. 2015). This study did not look for or document foraminifera within VICK with the exception of the very large foram *Lepidocyclina*. Forams of this genus are common in the Vicksburg Group, particularly the Byram, Glendon, and Marianna Formations. They are dime-sized and wafer-shaped, often dark in color and sticking out on the light-colored surfaces of the limestones or Byram marl (Figure 36). The presence of microscopic foraminifera is expected within VICK and could be the subject of future research. Planktonic foraminifera have been used in the correlation and paleogeographic reconstruction of Vicksburg Group strata (Tew and Mancini 1995). See the "Geologic Formations" section for more information on studies which have collected forams for dating Oligocene formations. Taxa from these studies, particularly Conrad (1865b), Cushman (1922, 1923), and Todd (1952), which documented species within VICK, can be found in Appendix A-Table 3.

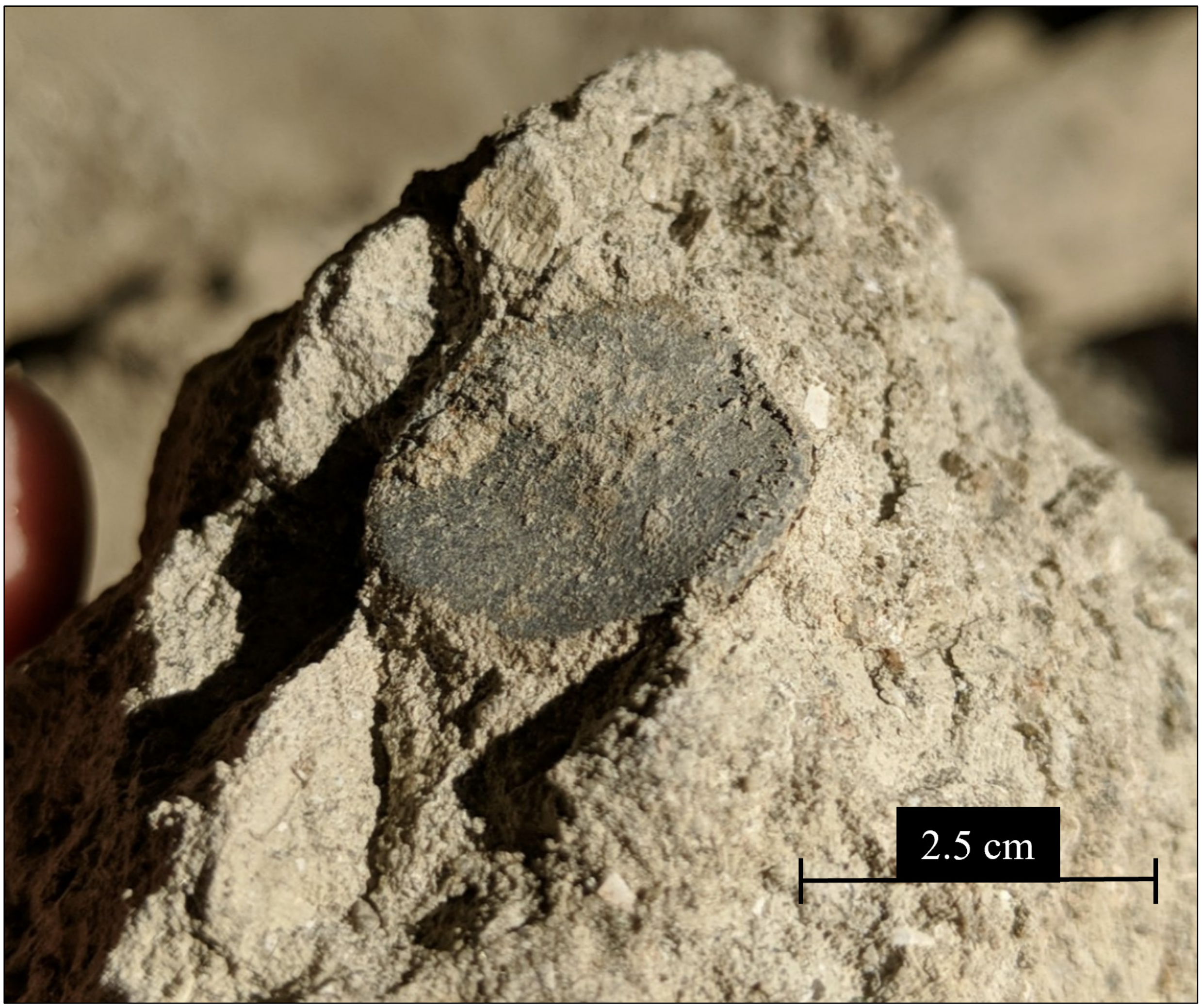

Figure 36. A specimen of the foram genus *Lepidocyclina* found embedded in a chunk of Glendon Limestone. Photo taken February 2022 (NPS/MEGAN RICH).

Fossil Localities

Paleontological Localities Within VICK

Fossil localities within VICK are limited to four notable outcrop types. The first type of fossil locality is the various outcrops of the Oligocene Vicksburg Group. These localities are separated by formation and include the well-known Mint Spring Formation type section (a geological reference locality upon which a formation is based). Though locations of any early Miocene outcrops were unknown before this survey, one locality of the Catahoula Formation was recorded and other exposures observed. No fossils were collected from the Catahoula at these sites. The locality type most common in this survey were the exposed loess localities which can be found throughout the park and are often revealed by natural weathering processes. These were initially thought to be dominated by a single type of giant land snails of the family Polygyridae, but further inspection during this survey revealed a greater diversity of Pleistocene mollusks. The instances in which the fossils differed from the abundant terrestrial gastropods were labeled as "Anomalous Exposed Loess Localities". One of these lies adjacent to an outcrop of the Catahoula Formation. The final locality type includes instances of stream-wash in which the fossils are ex situ and provenance is unable to be definitively determined. See Appendix F for a list of localities. Further information is available to qualified researchers.

Oligocene Units

Lower Mint Spring Waterfall Locality

The lower Mint Spring Bayou waterfall is the type section for the Mint Spring Formation (Henderson et al. 2022). Because several formations are visible here it is useful for geological studies. The Mint Spring Formation, overlying the Forest Hill Formation, is a sandy marl representing a portion of a major marine transgression. At this locality, it is well-compacted and contains marine fossils that are less durable than those of the Byram Formation. The outcrop appears light in color on the surface, but below the parent material, the Mint Spring Formation is a dark gray laminated sandy mudstone. It stretches across and underneath the waterfall, and the stratigraphy of each of the neighboring units is easily identifiable (Figures 37 and 38). Chunks of the unit, as well as chunks of Marianna, Glendon, and Byram Formations, have been collected at the waterfall's base.

Figure 37. The Mint Spring waterfall locality labeled for identification. The lower lines do not correspond to contacts but to where the units can be visually distinguished, which varies due to erosion and rock falls. Photo taken February 2022 (NPS/MEGAN RICH).

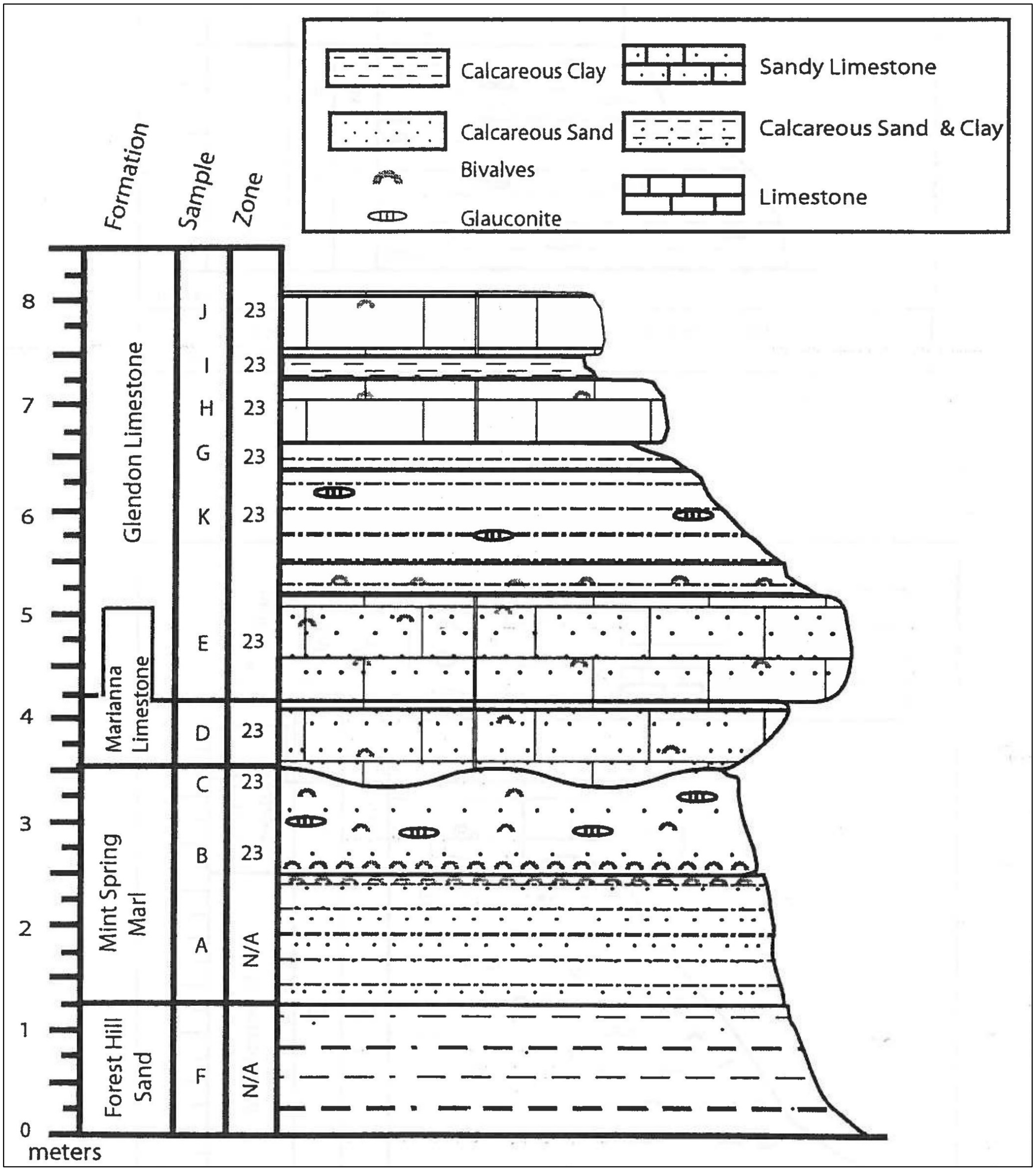

Figure 38. The measured section of the lower Mint Spring Bayou waterfall, the type locality for the Mint Spring Formation (Hall 2003: 89). Reused with permission of Christopher Hall.

Glendon and Marianna Limestones

The Glendon and Marianna Limestones, while lithologically similar, are differentiated by a disconformity and faunal change occurring at the contact. When hydrated the limestone takes on a darker gray coloration, and with greater sun exposure, it appears lighter; this difference can be observed in Figure 39. No Glendon or Marianna localities in this survey were specifically marked or collected from. The Glendon Limestone can be seen making up the upper Mint Spring waterfall as well as the lower. Embedded shell material can be observed in this matrix, but due to the indurated rock material, collection of individual specimens is difficult.

Figure 39. The top of the Mint Spring Bayou waterfall, which is composed of Glendon Limestone as the streambed. The Glendon layer also stretches around the falls as seen by the light-colored, exposed scarp in the background. Photo taken March 2022 (NPS/CHARLES BEIGHTOL).

Byram Formation Outcrops

The Byram Formation is a highly fossiliferous unit of the Vicksburg Group. Representative of a regressive sequence, the Byram is a buff to dark-gray-colored marl with an abundance of marine invertebrate fossils. Before this survey, there was not a known locality of the Byram Formation in VICK. However, many older publications, such as Cooke (1942) or Monsour (1944), report collecting Byram fossils in the park. These researchers are thought to have had access to exposures of the Byram Formation in and near Vicksburg National Cemetery, but over the years the topography has changed and covered these exposures. The cliff near the cemetery and lower Mint Spring Bayou waterfall has a history of instability, so park staff grouted the surface and put in soil nails to prevent future erosion, which may have resulted in a loss of the exposures. This effect was compounded by the growth of trees since the 1930s, as well as topsoil and loess covering much of the original bedrock.

In the process of this inventory, Byram fossils were collected from six locations; three of these were float, two were definitive new localities with fossils in situ, and the last was from a temporary locality (VPFV-CVB22-0055). Due to recent landslides in the National Cemetery, Byram fossils were seen in situ near gravesites in the park. Given the absence of any fossils in VICK's museum collections, collection took place at this site with the approval of park staff and significant distance was given between the site and the burials. The two new exposed localities are not easily accessible. One (VPFV-CVB22-0054) is much smaller and contains shell hash that would be difficult to extract for collection. The other locality (VPFV-CVB22-0062) is long and segmented. On one side here, the bedding material is very soft as seen in Figure 40. Across the way the matrix is much harder, and it is difficult to remove specimens without risk of damage (Figure 41). The stratigraphy of this locality is also readily visible, with the visible contact between the Byram outcrop and the overlying Bucatunna Formation, pre-loess gravels, and loess above (Figure 42).

Figure 40. A large outcrop of the Byram Formation (NPS/CHARLES BEIGHTOL). This locality, VPFV-CVB22-0062, is the best exposure of Byram in the park. The Bucatunna Formation can be seen overlying it with orange, iron-rich laminations and is pointed out by Megan Rich in the upper lefthand corner of the image.

Figure 41. An outcrop of the Byram Formation near the outcrop in Figure 40 from which collection was comparatively more difficult (NPS/MEGAN RICH). **A.** This area is much more compacted and elevated from the stream. **B.** A scaphopod can be seen embedded in the material. **C.** A dense, coquina-like section of the outcrop.

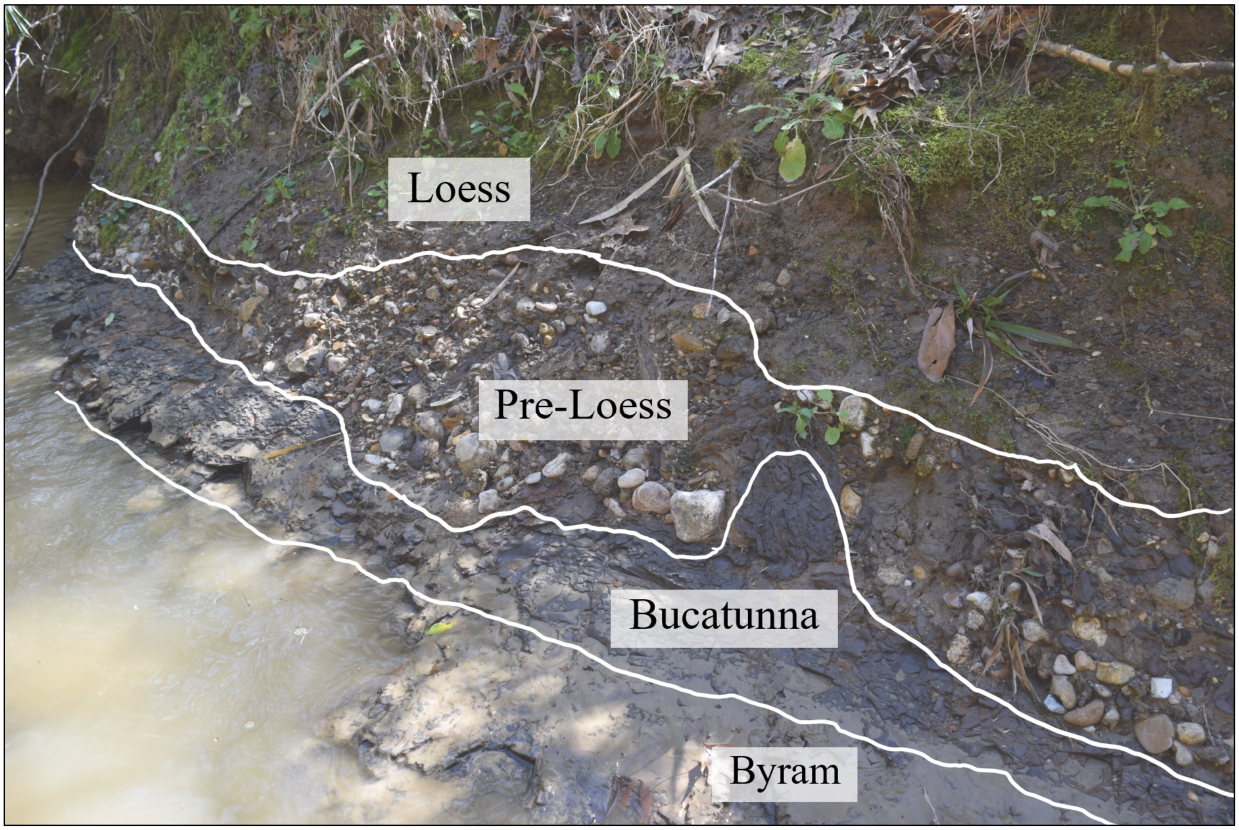

Figure 42. Sediment layers at the Byram Formation outcrop at locality VPFV-CVB22-0062, labeled for ease of identification (NPS/MEGAN RICH).

Bucatunna Formation

The Bucatunna Formation is characterized by its carbonaceous clays which range from similar coloration as the Catahoula Formation to a chocolatey-brown. The dark color is consistent with the abundance of plant material, charcoal pieces, and petrified wood. Petrified wood, root casts, and an abundance of charcoalified plant material were found at the Keyes Scrap Metal Yard near VICK, though the fossils were less common in the park. Fossil leaves were found in the Bucatunna Formation in northern Vicksburg, and the Bucatunna clays have often been sampled in palynological studies (Oboh and Reeves Morris 1994), indicating potential for future work in VICK. Two localities from this survey (VPFV-CVB22-0037 and VPFV-CVB22-0042) are marked as the Bucatunna Formation (Figure 43), though more outcrops likely exist throughout the park along stream banks. No Bucatunna Formation fossils were collected from within VICK, though future research may yield pollen, spores, or other noteworthy paleontological resources.

Figure 43. An outcrop of the Bucatunna Formation in VICK at locality VPFV-CVB22-0042 (NPS/CHARLES BEIGHTOL). Each color band on the survey rod represents an interval of one foot (approximately 30.5 cm).

Oligocene–Miocene Units

Catahoula Formation Outcrop

Before this survey, the early Miocene-age Catahoula Formation was not previously confirmed to crop out within VICK. In other locations, the Catahoula Formation contains plant fossils, pollen, fungal debris, dinoflagellate cysts, freshwater algae, foraminifera, and many ichnofossils. In VICK, there are numerous Catahoula exposures (Figure 44). Four sandstone outcrops are found within the park and are almost entirely white, with a chalky habit from the weathering of opal cement. One prominent outcrop (VPFV-CVB22-0020) consists of five strata of cross-bedded arenaceous sandstones which are mostly white with thin layers of orange from iron-rich waters (Figure 45). Catahoula clays crop out broadly within a few locations in VICK. These clays are heavily carbonaceous, like both the loess and Bucatunna clays, and can be differentiated from the two in having burrows from burrowing shrimp.

Figure 44. Exposure of the Catahoula Formation at locality VPFV-CVB22-0020 (NPS/CHARLES BEIGHTOL). Each color band on the survey rod represents an interval of one foot (approximately 30.5 cm).

Figure 45. Close-up image of the lithology of the Catahoula Formation at locality VPFV-CVB22-0020 (NPS/CHARLES BEIGHTOL).

Typical Exposed Loess Localities

Pleistocene loess forms a ubiquitous blanket throughout much of VICK. Erosional damage and landslides often result in exposures of bluffs that were previously covered by topsoil, moss, or other vegetation cover (Figure 46). Within these tan-colored, often weakly consolidated scarps are an abundance of giant land snails of varying sizes, roughly 5 to 30 mm (0.2 to 1.2 in) wide, distinguishable from morphologically similar modern taxa by their opaque white coloration (Figure 47). The gastropods found in this survey were identified with the aid of previous studies of loess in and near Vicksburg (Shimek 1930; Hubricht 1963; Williams 1999). The vast majority of these taxa were terrestrial land snails, and they are plentiful throughout park grounds, hence why typical loess localities such as these were the most numerous in this survey.

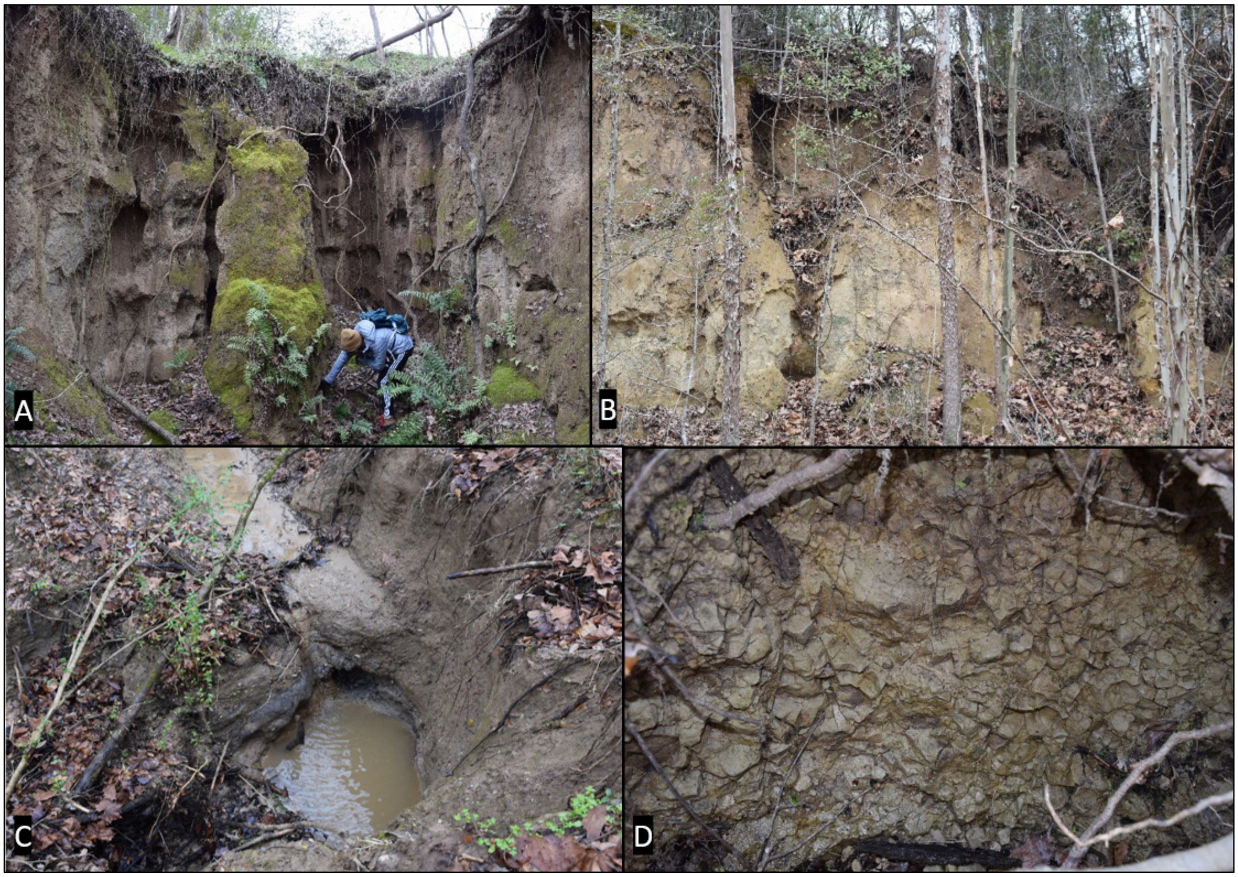

Figure 46. Various examples of exposed loess (NPS/CHARLES BEIGHTOL). **A**. Cave-like loess structure, some sections with heavy moss. **B.** Loess scarp showing structural integrity and a slight gradient. **C.** Hydrated loess on the banks and bed of a pool, which is darker in color than that which has more sun exposure. **D.** Blocky loess exposed to spring water.

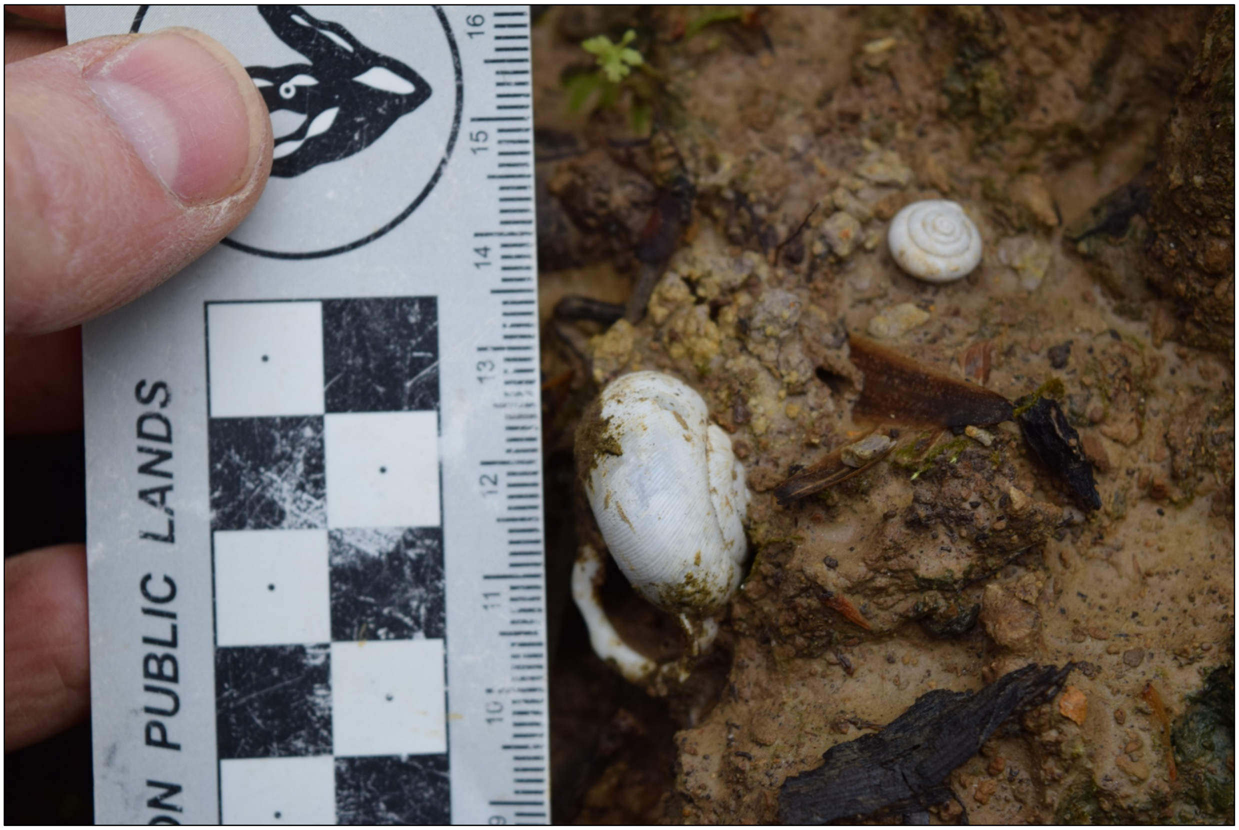

Figure 47. A large land snail embedded in loess from locality VPFV-CVB22-0027. Photo taken February 2022 (NPS/CHARLES BEIGHTOL).

Anomalous Exposed Loess Localities

The loess in VICK is exposed in a variety of textures, from typical dry buff-colored loess that holds steep angles, to higher concentrations of clay or saturation, or being well indurated (Figure 46). Paleontological resources can be found in any kind of loess exposure, and there were a number of localities in this survey at which the fossils deviated from the typical terrestrial Pleistocene gastropods. At the first locality discovered, VPFV-CVB22-0001, a Quaternary oyster shell was found (Figure 48). This specimen, as well as approximately ten similar shells found at VPFV-CVB22-0006, were thought to be fossils upon initial inspection but were later determined to be modern oyster shells, likely derived from historical human activities. Another example of modern life potentially being mistaken for fossils may include leaf impressions found in the layers of freshwater travertine (Figure 49). This mineralization process consolidates the loess and often occurs in streams, and the stark change in lithology results in the anomalous loess classification.

Peculiarities in identification extended to other anomalous loess locations. The loess most commonly yielded terrestrial gastropods representing a known list of taxa, though, as mentioned before, the fossils found in this survey occasionally deviated from this expectation. The first instance of this was at the Catahoula outcrop at VPFV-CVB22-0020. Above the white sands of the Catahoula are a pebble conglomerate and overlying redoxic mudstone which are layers of pre-loess and loess, respectively. The loess was strongly consolidated, and may have fallen in blocks that can be found adjacent to the Catahoula sands. Another possibility is that the material is in fact in situ and is composed of reworked loess deposited by running water as it down-cut the current valley. This muddy sediment contained pulmonate gastropods that were not known elsewhere in VICK until similar taxa were later found. Interestingly, these gastropods did not appear in the loess above the Catahoula exposure and were only found in the unconformable loess sediments nearby. The most common taxon at this locality is the freshwater ramshorn snail of the family Planorbidae, identified by their planispiral shells (Figure 50). Among them were tiny pea clams of the family Sphaeriidae. This was also the only locality at which the presumed species *Pomatiopsis lapidaria* occurred, an amphibious snail documented in the loess in other counties in Mississippi (Shimek 1930; Hubricht 1963). While this species is found on floodplains in more northern locations, it often appears on the slopes of ravines or talus slopes in the southern Appalachians, which is comparable to the locality at which these specimens were found.

Figure 48. Clam shell of the order Ostreida from VPFV-CVB22-0001. It was originally thought to be float from an ephemeral stream but later determined to have more modern origins, likely as a part of an anthropogenic midden. Photo taken January 2022 (NPS/CHARLES BEIGHTOL).

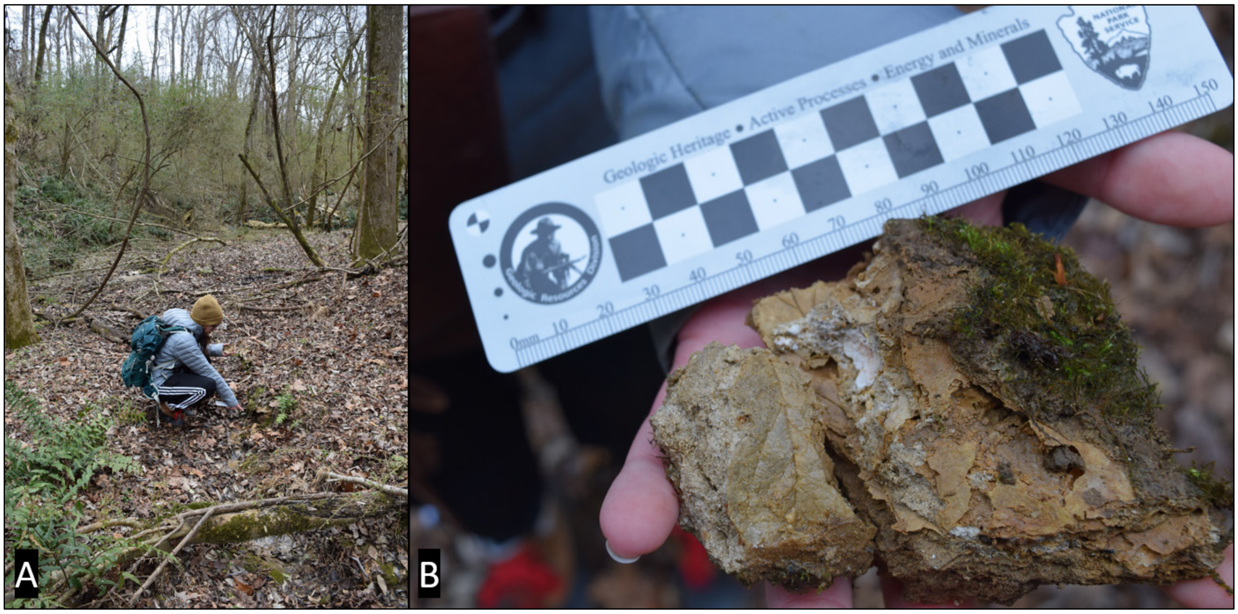

Figure 49. Locality VPFV-CVB22-0018. **A.** Small stream with consolidated, hard loess and calcium carbonate deposits from the stream. **B.** Breaking open the travertine deposits yielded numerous copper-colored leaf impressions. Photo taken February 2022 (NPS/MEGAN RICH).

Figure 50. A planispiral gastropod belonging to the family Planorbidae lying ex situ on the surface of compact loess (NPS/MEGAN RICH). The common name is “ramshorn snail”, and it is the fossil most indicative of this anomalous loess locality.

Ex Situ Stream Localities

Pre-loess gravels found in VICK are frequently a colorful mix of smooth sedimentary rocks carried down the ancestral Mississippi River (Figure 51) and were the focal interest of this part of the survey, though metamorphic and igneous gravels are likely present. Among these pebbles were fossils such as corals, bryozoans, gastropods, trilobites, crinoid stems, and likely bivalves and brachiopods, many of which were casts or impressions, though some have eroded out of the matrix (Figure 52). Other fossil finds include petrified wood and root casts, with the potential for other ichnofossils. Dockery et al. (2008) provides great detail on the rocks and fossils found in Mississippi's gravel. Exotic fossils may include a great range of taxa due to the wide area drained by the Mississippi River system.

In addition to the fossil specimens found in VICK's gravels, many small streams within VICK are fed by natural springs, and this mineral-rich freshwater tends to form travertine, a calcareous deposit encrusting or indurating other substrates. Quaternary remains include mollusks which have presumably washed in from loess but are found as float in the streams, as well as vertebrate bones which may be Pleistocene or Holocene in age (Figure 53).

While it is unsurprising to find terrestrial giant land snails from the loess, there were also a number of freshwater mollusks (Figure 54). The presence of this group in the loess is not as well understood. They occur more infrequently and are spatially limited. Given that the provenance of specimens recovered from streams may be hard to determine, they are potentially younger than the terrestrial snail fossil taxa typical of the loess.

Not only was this the first attempt to identify the paleontological resources in VICK's streams, but this survey also resulted in the first archeological resources in VICK's collections relating to indigenous communities. Woodland-age pottery sherds and potential projectile points were recovered, as well as Civil War era artifacts such as horseshoes, bullets, a cannonball, a Union solider belt buckle, and more.

Figure 51. Example of a pre-loess gravel bar. Photo taken March 2022 (NPS/CHARLES BEIGHTOL).

Figure 52. Crinoid columnal within and surrounded by pre-loess gravel. Photo taken March 2022 (NPS/MEGAN RICH).

Figure 53. Quaternary vertebrate cannon bone found at locality VPFV-MMR22-0002. Photo taken February 2022 (NPS/MEGAN RICH).

Figure 54. Freshwater and terrestrial mollusks collected from locality VPFV-MMR22-0001 (NPS/MEGAN RICH). **A.** View of a creek with shells embedded in the banks. **B.** Small bivalves belonging to the family Sphaeriidae. **C.** Gastropod belonging to the family Succineidae.

Paleontological Localities Near VICK

Listed below are notable localities of the Vicksburg Group near VICK, though more localities exist within or near Warren County. See Dockery and Thompson (2016) for a comprehensive list of Mississippi Geological Survey localities and their particular locations.

Highway 61 Exposures Northeast of Vicksburg

Located 7.2 km (4.5 mi) northeast of Vicksburg is a beautiful outcrop of the Byram Formation. The Vicksburg Group exposures on Highway 61 stand 11 m (35 ft) tall, exposing highly fossiliferous clay marls and thin coquinas (Mellen 1941). Collections from this locality are housed at the Mississippi Office of Geology, and famous paleontologists such as Katherine Palmer are reported to have made collections from this area for the Paleontological Research Institution of Ithaca, New York in 1938 (Dockery 1995).

The Big Black River Bluffs at Edwards

The Big Black River, a notable location in the Vicksburg campaign as the Union army marched west from Jackson, is among the best exposures of the Byram Formation. Hilgard (1860) was the first to describe the presence of outcrops of the Vicksburg Group at the bluffs. This location, MGS locality 106, has yielded fossils of the Oligocene land mammals *Metamynodon planifrons* (Manning et al. 1985) and *Subhyracodon occidentalis* (Manning 1997). The exposure along the bluffs is approximately 0.4 km (0.25 mi) long and displays the contact between the Byram and Bucatunna Formations above (Figure 55).

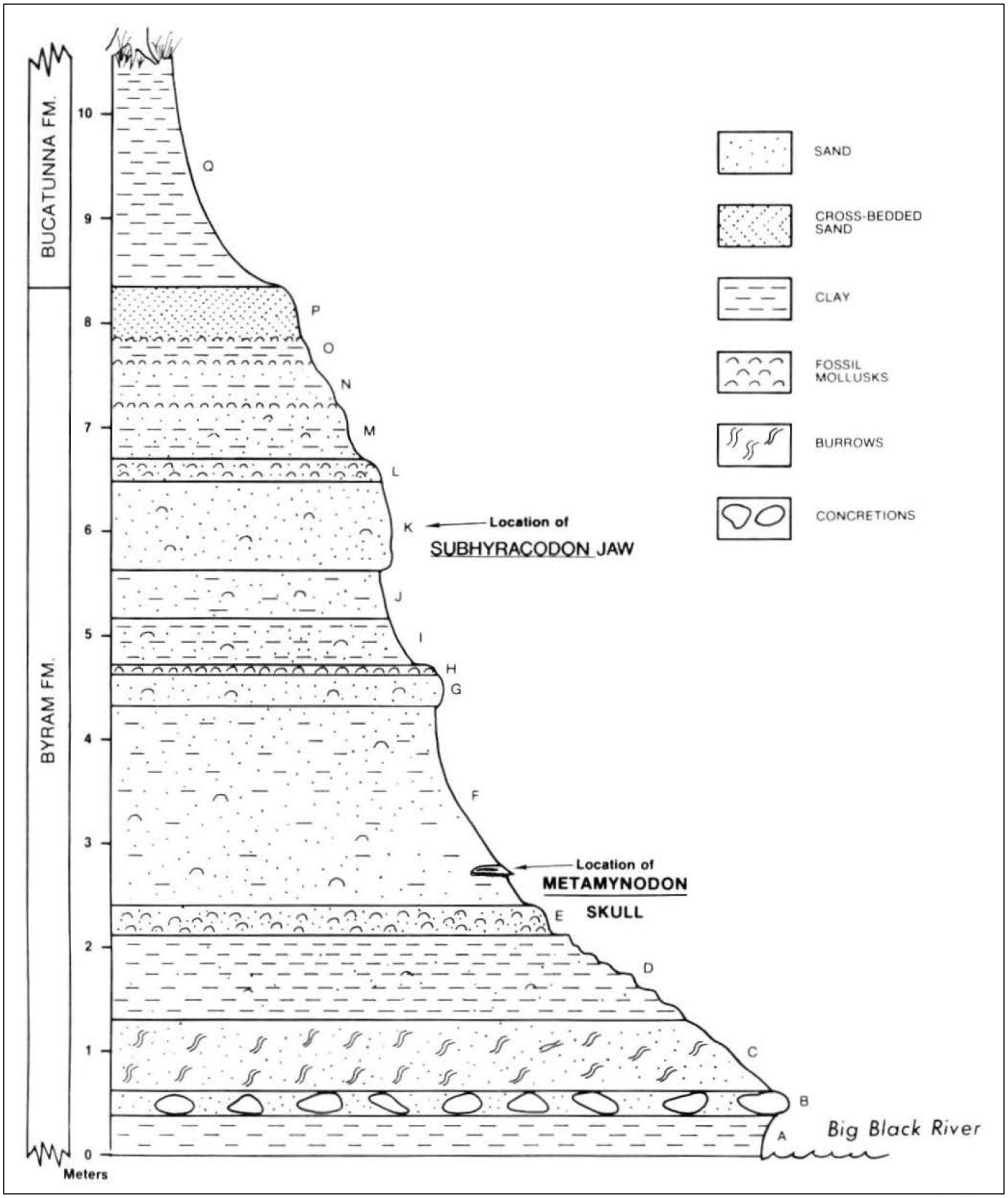

Figure 55. Measured section of the Byram–Bucatunna beds from MGS locality 106, the site of two Oligocene mammal fossil discoveries in the Byram Formation (Figure 4 from Manning 1997; Mississippi Geology 18[2]).

Keyes Scrap Metal Yard

Near the Highway 61 locality is Keyes Scrap Metal Yard (MGS locality 140). This site is a short drive from the park and currently is a useful reference for Bucatunna Formation lithofacies (Figure 16). The outcrop here is a highly laminated chocolate brown with petrified wood, root casts, and other plant or trace fossils. The Byram Formation was once beautifully exposed at this locality, measuring 8.2 m (27 ft) in thickness and extending 34 m (112 ft) wide (Figure 56; Visaggi 2004; Visaggi and Ivany 2010). This section is now covered. Fossil samples collected contained 95 molluscan species with a ratio of bivalves to gastropods numbering 7:1 (Visaggi 2004; Visaggi and Ivany 2010). Despite totaling fewer individuals, gastropods showed greater diversity. The Byram Formation here showed upwardly shallowing parasequences indicative of the marine regression of its depositional environment. The most dominant taxa were *Scapharca lesueuri* and *Corbula laqueata*, both of which are found in VICK.

Figure 56. Christy Visaggi working on her master's thesis at the Keyes Scrap Metal Yard locality (MGS locality 140) in May 2003 (DEVIN BUICK). The abundance of compacted shell material and lithology of the Byram Formation can be seen in the exposure.

VICK's Satellite Units at Port Gibson, Raymond, and Champion Hill

This inventory did not include the three newly acquired satellite units of Port Gibson, Raymond, and Champion Hill, seen in Figure 57, due to the timing of the transfer to VICK's management. Any exposures of fossiliferous rocks at these locations are expected to resemble the outcrops described herein. Future surveying efforts of these satellites are necessary to more accurately and comprehensively describe VICK's paleontological resources. Currently, Mississippi Department of Environmental Quality geologists are mapping geologic stratigraphy and paleontological resources for the Port Gibson and Champion Hill sections as part of a larger Natchez Trace Parkway project looking at geology along the trace (a parkway based on a historic corridor used by Native Americans for travel). These locations were included in that project due to their proximity to Natchez Trace.

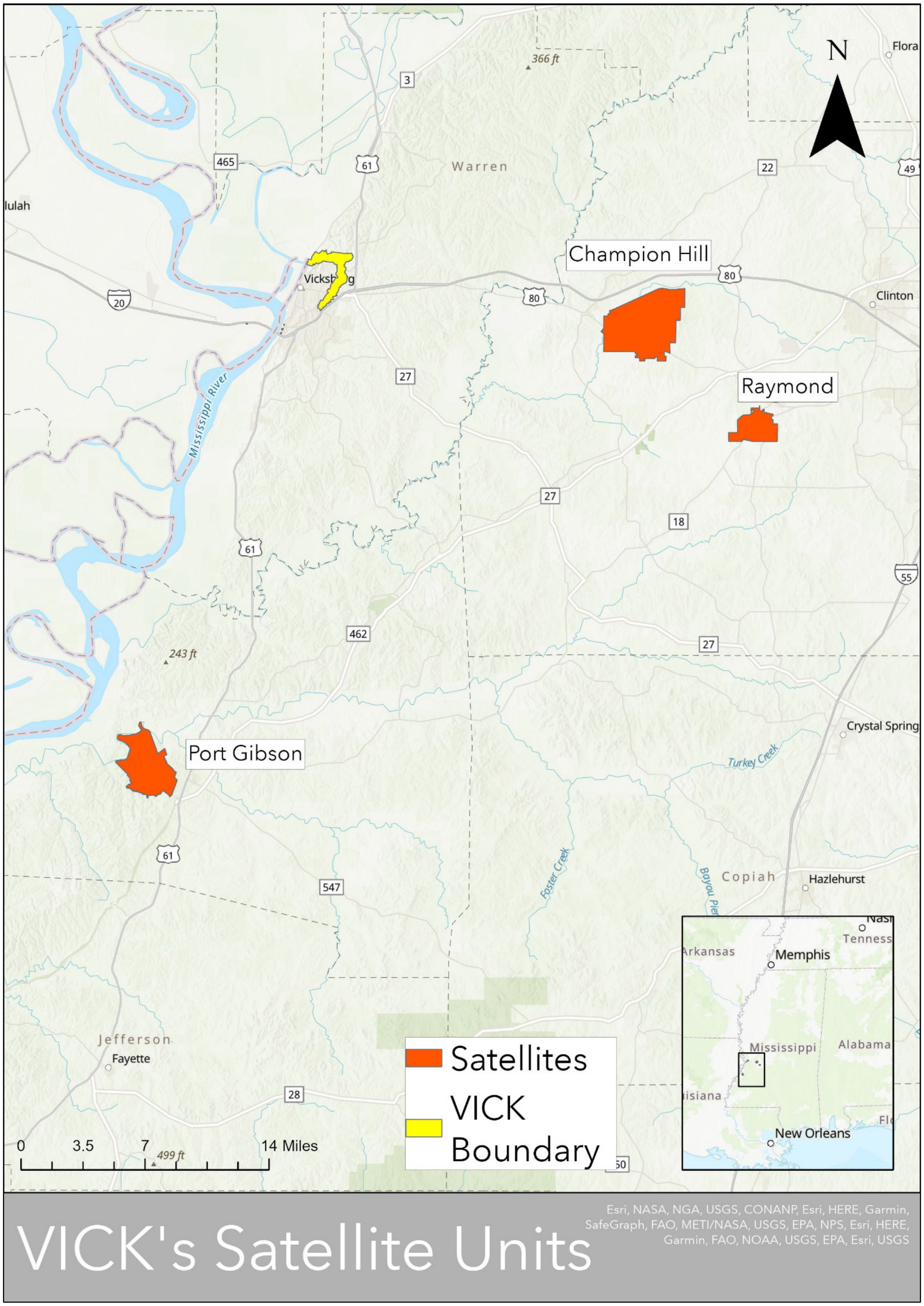

Figure 57. Map of the satellite units acquired by VICK in relation to the main park boundaries (NPS/MEGAN RICH). Regarding the boundaries of Port Gibson, Raymond, and Champion Hill, these are legislative boundaries that may contain parcels not currently owned by Vicksburg National Military Park.

Cultural Resource Connections

There are many ways for paleontological resources to have connections to cultural resources. Examples of paleontological resources in cultural contexts include, but are not limited to: fossils used by people for various purposes, such as petrified wood used for tools, projectile points, and other artifacts, or fossil shells picked up as charms or simply because they looked interesting; associations of prehistoric humans with paleontological resources, such as kill sites of mammoths, prehistoric bison, and other extinct animals; incorporation of fossils into cultural records, such as fossils in Native American lore, "tall tales" of mountain men, and emigrant journals; and fossils in building stone. Kenworthy and Santucci (2006) presented an overview and cited selected examples of National Park Service fossils found in cultural resource contexts.

Little is known of the prehistoric archeological context around Vicksburg because the historical focus within the park has prioritized the area's significance to the American Civil War. However, discoveries within Mississippi's gravel deposits can be extrapolated to the area of Vicksburg. Paleozoic gravels that have been "ice rafted" down the Mississippi River have significant cultural connections, with beautiful cherts, agates, and other rocks being utilized elsewhere by Native American tribes for beads and arrowheads (Dockery et al. 2008). Projectile points carved from gravels were found in our survey of VICK's streams, the first pre-Civil War archeological resource of its kind found at VICK (Figure 58). Often protruding from these stream gravels were Paleozoic fossils, making these resources the oldest geological and cultural crossover within the park.

Cultural resources are also known to be modified from Oligocene-age rocks. Mississippian cultural sites across much of the South, which contain artifacts of the Native American culture dated between the years 800 to 1600, have yielded large effigy pipes made out of Glendon Limestone of the Vicksburg Group (Steponaitis and Dockery 2011). This was determined nondestructively through the identification of characteristic fossils in the limestone such as pectinid bivalves, gastropods, and foraminifera, particularly the dime-sized species *Lepidocyclina supera* (Figure 59). There is a strong possibility that the material was sourced from Vicksburg, and potentially the park itself.

> *[Professor of Archeology at the University of North Carolina at Chapel Hill] Vin Steponaitis recognized the Glendon pipes as examples of the Bellaire style that is native to the lower Mississippi Valley and dates from 1100 to 1500 AD. It also seems that master carvers set up their workshop at Vicksburg where the Glendon Limestone outcrops by the navigable waters of the Mississippi River. There are no exposures of Glendon Limestone west of Vicksburg, but there are exposures east of Vicksburg, though not as grand as those at Vicksburg, which extend in a narrow belt through Mississippi and Alabama and into the panhandle of Florida. [Figure 60] shows the distribution on known Belaire style effigy pipes in the Mississippi Basin; Vicksburg is in the center of the distribution.* (David Dockery, pers. comm., 2022).

Figure 58. Multiple projectile points were discovered. This survey also resulted in the addition of VICK's first Native American archeological resources to its museum collections. Photo taken March 2022 (NPS/MEGAN RICH).

Figure 59. Bird-head effigy pipe in the Smithsonian collections collected from the Sycamore Landing site in Morehouse Parish, Louisiana (MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY/DAVID DOCKERY). The hole in the side is the external mold of *Pitar imitabilis.* The pipes in both the foreground and background also contain the common Glendon Formation foraminifera *Lepidocyclina supera*.

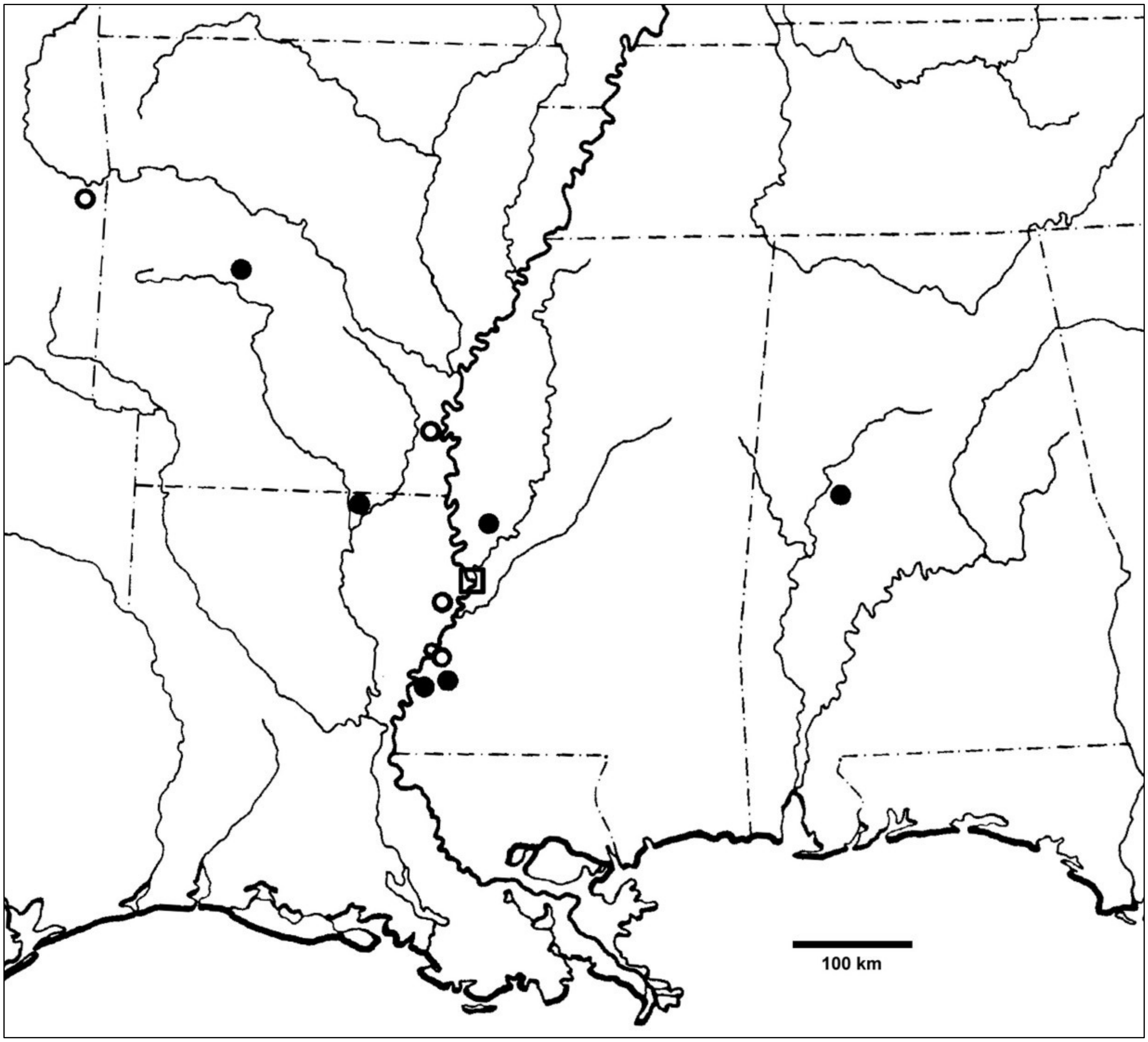

Figure 60. Geographical distribution of limestone effigy pipes of the “Bellaire group” (MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY/DAVID DOCKERY). Solid circles represent pipes made of Glendon Limestone. Open circles represent pipes not examined. The open square indicates Glendon Limestone outcrops of Vicksburg, Mississippi.

The prevalence of activity in Vicksburg during the 1863 siege, as well as the crucial role the land itself played in the conflict, inevitably led to interactions with the paleontological resources of the area. John Wesley Powell, and likely other soldiers, reportedly saw and collected fossil shells protruding from the loess in which the trenches were dug (Stegner 1954; Worster 2001). Citizens of Vicksburg also got up close to the loess during the siege as many retreated into caves for safety during the cannon fire of attacks. Given the prevalence of fossil mollusks in the loess, it is highly likely many could be found along the walls and floors of these caves.

Another geologic connection to Native American culture is the use of sherds from the Miocene Catahoula Formation for projectile points and other tools. Examples of this, as well as Native

American pottery, have been found through the field methods used while conducting this survey (Figure 61). Similar discoveries emerged from this approach, such as a site of an abundance of modern oyster shells originally mistaken for Pleistocene-age specimens. In other studies near Vicksburg, similar refuse was found near Native American mound sites, which were thought to be middens, or domestic waste (Shimek 1930). Also found via the survey were several Civil War-era relics such as a bayonet, cannonball, and belt buckle, as well as more recent historic waste dating from the 20th century (Figure 62). In streams, this refuse would often be encrusted with travertine accumulating from freshwater deposits, undergoing its own unique process of preservation. Mineral encrustation may make objects appear older than they actually are. Though not paleontological resources, these finds still yield noteworthy cultural connections to the history of the land.

Figure 61. A sherd of Native American pottery. Photo taken March 2022 (NPS/MEGAN RICH).

Figure 62. A Union soldier belt buckle was discovered near a cache of a dozen Civil War-era bullets. Photo taken March 2022 (NPS/MEGAN RICH).

Museum Collections and Paleontological Archives

Museum Collections and Curation

Park Collections

Before this paleontological survey, there were no fossil specimens within VICK's museum collections. Very few, if any, cultural resources in VICK's collections were collected in the field. Given the infrequency of field collections efforts at VICK, there is little information with regard to collections from VICK in holdings at other institutions in either a paleontological or archeological context.

Collections in Other Repositories

Fossil specimens definitively collected from within VICK can be found at the following museums (see Appendix D for contact information):

- Academy of Natural Sciences of Drexel University (ANSP; formerly the Academy of Natural Sciences of Philadelphia) in Philadelphia, Pennsylvania (Conrad 1848a, 1848b, 1849, 1865a, 1871; Gabb 1861; Gabb and Horn 1862; Casey 1903; MacNeil and Dockery 1984)
- Le Havre Museum of Natural History in Le Havre, France (Dockery 1982a)
- Louisiana State University/Louisiana Museum of Natural History (LSU/LMNH) in Baton Rouge, Louisiana (Hazel et al. 1980)
- Paleontological Research Institution (PRI; including former Tulane University collections) in Ithaca, New York (de Gregorio 1890)
- Smithsonian Institution, National Museum of Natural History (USNM) in Washington, D.C. (Aldrich 1885; Meyer 1885, 1886; Dall 1892, 1900, 1903; Casey 1903; Canu and Bassler 1920; Cushman 1922, 1935, 1945; Cooke 1928; Rathbun 1935; Stenzel 1940; Todd 1952; Vokes 1963; Dockery 1982a; MacNeil and Dockery 1984)
- University of California Museum of Paleontology (UCMP) in Berkeley, California

Based on searches of digital collections, specimens listed as collected in the "Vicksburg" area, which may potentially be within VICK, can be found at the following museums: Cincinnati Museum Center (CMC) in Cincinnati, Ohio (including former University of Minnesota collections); the University of Kansas (KU) in Lawrence, Kansas; and the Peabody Museum of Natural History, Yale University (YPM), New Haven, Connecticut.

Type Specimens

At least 27 species have been named and described from specimens collected from lands now within VICK. A complete list of these species can be found in Appendix B. Many others, at least 203, are based on specimens with limited provenance information, such as "Vicksburg", that may plausibly have been discovered within VICK boundaries. A list of these species can be found in Appendix C.

Archives

NPS Paleontology Archives

All data, references, images, maps and other information used in the development of this report are maintained in the NPS Paleontology Archives and Library. These records consist of both park-specific and servicewide information pertaining to paleontological resources documented throughout the NPS. If any resources are needed by NPS staff at VICK, or additional questions arise regarding paleontological resources, contact the NPS Senior Paleontologist & Paleontology Program Coordinator Vincent Santucci, vincent_santucci@nps.gov. Park staff are also encouraged to communicate new discoveries to the NPS Paleontology Program, not only when support is desired, but in general, so that this information can be incorporated into the archives. A description of the Archives and Library can be found in Santucci et al. (2018).

E&R Files

E&R files (from "Examination and Report on Referred Fossils") are unpublished internal USGS documents. For more than a century, USGS paleontologists identified and prepared informal reports on fossils sent to the survey by other geologists, for example to establish the relative age of a formation or to help correlate beds. The system was eventually formalized as a two-part process including a form sent by the transmitting geologist and a reply by the survey geologist. Sometimes the fossil identifications were incorporated into publications, but in many cases this information is unpublished. These E&R files include documentation of numerous fossil localities within current NPS areas, usually predating the establishment of the NPS unit in question and were frequently unpublished or previously unrecognized. Extensive access to the original files was granted to the NPS by the USGS beginning in 2014 (Santucci et al. 2014). At this time, no E&R files have been located for VICK.

Photographic Archives

There are no images of paleontological resources within VICK's archives, though there are historic photographs of loess earthworks and its unique geology. One such example is the trenches excavated by Major General John A. Logan's troops near Shirley House (Figure 63). This image is a vivid example of the loess's structural integrity and of the exposures from which fossil mollusks may be uncovered. Other historic photographs, such as research at the Mint Spring waterfall (Morse 1935), can be found in publications outside of VICK.

Figure 63. “Quarters of Logan’s Division in the trenches in front of Vicksburg”. Shirley House can be seen in the background from the vantage near today’s Union Road. Photographed 1863 and printed between 1880 and 1889 (NPS).

Park Paleontological Research

Current and Recent Research

Since the 1990s, three permits have been issued for research at VICK that was either paleontological in focus, or a geological project with paleontological significance.

VICK-2014-SCI-0001, principal investigator Daniel Schmitz of Mississippi State University, project "*Geologic Mapping in Vicksburg National Military Park and Natchez Trace Parkway and National Scenic Trail*", issued for 2014–2015; this project was continued in 2016 under permit VICK-2016-SCI-0001.

VICK-2022-SCI-0003, principal investigator Megan Rich of Georgia State University, project "*Vicksburg National Military Park Paleontological Resource Inventory*", issued for 2022. This report was supported by this permit.

Paleontological Research Permits

See the National Park Service Natural Resource Management Reference Manual DO-77 section on Paleontological Resource Management, subsection on Scientific Research and Collection (https://irma.nps.gov/DataStore/Reference/Profile/572379). NPS Management Policies 2006, section 4.8.2.1 on Paleontological Resources, states that

> The Service will encourage and help the academic community to conduct paleontological field research in accordance with the terms of a scientific research and collecting permit.

Any collection of paleontological resources from an NPS area must be made under an approved research and collecting permit. The NPS maintains an online Research Permit and Reporting System (RPRS) database for researchers to submit applications for research in NPS areas. Applications are reviewed at the park level and either approved or rejected. Current and past paleontological research and collecting permits and the associated Investigator's Annual Reports (IARs) are available on the RPRS website (https://irma.nps.gov/rprs/). Additional information on NPS law and policy can be found in Appendix E.

Suggested Future Inventories, Research or Other Projects

Given the paucity of information on fossils from VICK, there are a number of potential research avenues that have emerged during the completion of this inventory.

- The streams within VICK contain remnants of the ancestral Mississippi River in the form of pre-loess gravel. Underlying many loess localities are gravels deposited by former streams. Since these were not traditional geologic outcroppings nor were they an initial focus alongside the known Pleistocene and Oligocene fauna, little attention was given to the Paleozoic fossils of the pre-loess in this inventory. A more comprehensive examination of the resources found in these gravels is much needed.
- The fauna of the Pleistocene loess is generally understudied, particularly in Mississippi. This survey produced collections of numerous fossil gastropod specimens from the loess. Identification of these taxa relied on older publications, and names or classifications have

varied over time. Knowledge of the diversity of Pleistocene mollusks found within VICK is sparse, and a more detailed study could remedy this information gap.

- Although this survey did not produce any confirmed, identifiable vertebrate fossils from the loess, the potential for finding such specimens within park boundaries is considerable. Areas of the park which show evidence of erosion may reveal other Pleistocene fossils in the future, or a more focused survey of the loess exposures cursorily studied in this inventory could reveal unique finds.
- No fossils were collected from the Bucatunna Formation in this survey, though the plant-rich outcrops documented could prove useful in further studies of microfossils like sporomorphs. Pollen from the Bucatunna elsewhere has been used in paleoclimate studies, and VICK has the potential to contribute to this understanding.
- This survey documented outcrops of the Catahoula Formation and Byram Formation from which little if any collection has taken place before. While Byram outcrops near the park and around Vicksburg have served as the basis for other in-depth studies, outcrops within park boundaries were not previously well-known. Future research could work toward identifying more taxa found within VICK's Byram and Catahoula outcrops more specifically and comparing these assemblages to that of localities beyond the park.
- Since VICK did not previously have representative paleontological resources in its museum collections, future collection and more focused identification efforts for VICK's own collections may be a worthwhile effort.
- Documenting paleontological resources in building stones and historic structures is a recent endeavor taking place across units of the National Park Service (Santucci et al. 2020). While the monuments at VICK are largely composed of granite or marble, there exists a possibility of limestone or other fossiliferous materials being used as the source material for newer park structures. A future study dedicated to understanding paleontological resources in this context could add new insights to this inventory.
- VICK has recently acquired three new satellite units which represent key locations of the Vicksburg campaign at Port Gibson, Raymond, and Champion Hill. This inventory did not include a survey of these new sites, but a contemporaneous geologic inventory is being conducted by the Mississippi Department of Environmental Quality as part of an effort out of Natchez Trace Parkway. The results of these findings as well as any other surveying at these locations may be included as an addendum to this report.
- The most recent geologic map of the state of Mississippi comes from a publication by Alvin R. Bicker Jr. (1969). While this has been revised in years since, most notably in Dockery and Thompson (2016), geologic maps are still limited only to the state-level. The geologic map of VICK provided here was based on GIS data from Bicker Jr. provided by MDEQ. Focused efforts of localized geologic mapping would aid in future paleontological or geologic work at the park and its surrounding area.

Interpretation

The existing interpretive planning at VICK has included very little about the park's fossils (https://www.nps.gov/vick/learn/nature/fossils.htm). Staff are encouraged to interpret the park's paleontological resources and convey their value to visitors. There is interest in creating more interpretive media regarding VICK's natural resources and geologic history. Expanding tangible information such as a short paleontology summary on the park's website, informational brochures, site bulletins, or an exhibit in the Visitor Center may be a good early step off which to build programs and attract interest. The content of this communication can be the local geology of Vicksburg, a summary of the fossil types found in VICK, and descriptions of the paleoenvironments, particularly the Oligocene and Pleistocene. Programming may be created around National Fossil Day, Earth Science Week, or other notable days to inform visitors of the resources which may be found in VICK. The building of an interpretive collection of fossils could prove valuable for programming in the future, as well as other hands-on activities such as mineral or soil lessons for children. The primary objective in discussing VICK's paleontological resources is to make the knowledge accessible and digestible for all while also preserving and protecting these non-renewable resources.

Recommended Interpretive Themes

I. General Paleontological Information

All of the following interpretation topics include a section focused on emphasizing to visitors how to be paleontologically aware while in the park. The ranger will need to provide the visitor with advice on why fossils are important, how paleontologists look for fossils, what to do if fossils are found, and reminders to be aware that fossils exist and should be respected within park boundaries.

- Fossils are non-renewable resources that possess scientific and educational information and provide insight into what Earth was like thousands and even hundreds of millions of years ago.
- When paleontologists survey for paleontological resources, the most important tool for planning is a geologic map. Paleontological resources are more common in certain geologic units, so knowing where those units are exposed is important for a successful search. Other tools that a paleontologist takes into the field include a field notebook for recording data and observations, small picks and brushes, consolidants to stabilize fossils, GPS, camera, topographic maps, and appropriate First Aid and safety equipment. It might be helpful to provide examples of these items for visitors when giving an interpretive talk.
- If fossils are found in the park by a visitor, the visitor should photograph it and notify a ranger of where the resource was found, but most importantly, they should leave the fossil where they found it. It is extremely important for scientific and resource management purposes for locational information to be preserved. Visitors should be informed that park fossils are protected by law.

II. Fossils of VICK

A program could be developed to educate the public on what types of fossils are present in VICK and what they tell scientists about Earth's dynamic history. The goal of this program is to increase visitors' understanding of local geology and paleontology. Therefore, information regarding fossils from the vicinity of VICK can be included.

- Programs conveying general paleontology information may be in-person in the forms of interpretive collections, displays, or replicas, or may be a virtual program utilizing interactive maps, 3-D modeling, or other images online representative of VICK's fossils.
- Programs centered around the geology indicative of Vicksburg and depositional environments of its fossils may be developed. Artwork depicting the VICK area during the Oligocene or Pleistocene could be commissioned and displayed for visitors. Activities that teach young visitors about the rocks, minerals, or soils of the park may also be created.
- The loess cave exhibit in the Visitor Center could serve as an example not only of how the Civil War battle affected citizens of Vicksburg, but also of the prevalence of loess exposures, many of which may contain fossil shells. This detail could be incorporated into the display to illustrate the loess's structural integrity and fossiliferous tendencies.
- Telling the story of the notable historical figures who have studied Vicksburg's geology and paleontology would be a valuable interpretive theme. Posting and printing information about Charles Alexandre Lesueur, Charles Lyell, John Wesley Powell, or others could be a way to pull in visitors interested in history. A timeline could also be created of when they studied in the areas and how knowledge of Vicksburg's geology has grown over time.

III. Further Interpretation Themes

VICK should be sure to promote their paleontological resources and provide additional opportunities or programs for visitors to learn about fossils on National Fossil Day, celebrated annually on Wednesday of the second full week in October (National Earth Science Week). For more information on this event visit: https://www.nps.gov/subjects/fossilday/index.htm. The NPS coordinates the National Fossil Day partnership and hosts fossil-focused events across the country. Conducting one of the suggested paleontology-focused talks on this day would be a perfect opportunity to not only increase public awareness about paleontological resources in VICK but also connect with other parks and museums who are participating in this national event. The NPS Geologic Resources Division can assist with planning for National Fossil Day activities and provide Junior Paleontologist Program supplies including activity booklets, badges, posters and other fossil-related educational resources (https://www.nps.gov/subjects/fossils/junior-paleontologist.htm).

Paleontological Resource Management and Protection

National Park Service Policy

Paleontological resources are non-renewable remains of past life preserved in a geologic context. At present, there are 424 official units of the National Park System, plus national rivers, national trails, and affiliated units that are not included in the official number. Of these, 286 are known to have some form of paleontological resources, and paleontological resources are mentioned in the enabling legislation of 18 units. Fossils possess scientific and educational values and are of great interest to the public; therefore, it is exceedingly important that appropriate management attention be placed on protecting, monitoring, collecting, and curating these non-renewable paleontological specimens from federal lands. In March 2009, the Paleontological Resources Preservation Act (PRPA) was signed into law as part of the Omnibus Public Land Management Act of 2009. The new paleontology-focused legislation includes provisions related to inventory, monitoring, public education, research and collecting permits, curation, and criminal/civil prosecution associated with fossils from designated Department of Interior (DOI) lands. More information on laws, policies, and authorities governing NPS management of paleontological resources is detailed in Appendix E. Paleontological resource protection training is available for NPS staff through the NPS Paleontology Program. The Paleontology Program is also available to provide support in investigations involving paleontological resource theft or vandalism.

Between 2009 and 2022 an interagency coordination team including representatives from the Bureau of Land Management (BLM), Bureau of Reclamation (BOR), National Park Service (NPS) and U.S. Fish & Wildlife Service (FWS) developed the DOI final regulations for PRPA. The draft DOI regulations were published in the Federal Register in December 2016 and were available for 60 days to allow for public comment. The interagency team has reviewed public comments provided for the draft regulation and have incorporated these into the final regulation. The final regulation was surnamed by the DOI Solicitor's Office and each of the four bureau directors. On August 2, 2022, the DOI Paleontological Resources Preservation Act final regulation was published in the Federal Register. After 30 days the Office of Management and Budget approved the final DOI PRPA regulation, which is available at the following website: https://www.federalregister.gov/documents/2022/08/02/2022-16405/paleontological-resources-preservation. For more information regarding this act, visit https://www.nps.gov/subjects/fossils/fossil-protection.htm.

2006 National Park Service Management Policies (section 4.8.2.1) state

> *… Paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and managed for public education, interpretation, and scientific research. The Service will study and manage paleontological resources in their paleoecological context (that is, in terms of the geologic data associated with a particular fossil that provides information about the ancient environment).*

Superintendents will establish programs to inventory paleontological resources and systematically monitor for newly exposed fossils, especially in areas of rapid erosion. Scientifically significant resources will be protected by collection or by on-site protection and stabilization. The Service will encourage and help the academic community to conduct paleontological field research in accordance with the terms of a scientific research and collecting permit. Fossil localities and associated geologic data will be adequately documented when specimens are collected. Paleontological resources found in an archeological context are also subject to the policies for archeological resources. Paleontological specimens that are to be retained permanently are subject to the policies for museum objects.

The Service will take appropriate action to prevent damage to and unauthorized collection of fossils. To protect paleontological resources from harm, theft, or destruction, the Service will ensure, where necessary, that information about the nature and specific location of these resources remains confidential, in accordance with the National Parks Omnibus Management Act of 1998.

All NPS construction projects in areas with potential paleontological resources must be preceded by a preconstruction surface assessment prior to disturbance. For any occurrences noted, or when the site may yield paleontological resources, the site will be avoided or the resources will, if necessary, be collected and properly cared for before construction begins. Areas with potential paleontological resources must also be monitored during construction projects.

Fossils have scientific, aesthetic, cultural, educational, and tourism value, and impacts to any of these values impairs their usefulness. Effective paleontological resource management protects fossil resources by implementing strategies that mitigate, reduce, or eliminate loss of fossilized materials and their relevant data. Because fossils are representatives of adaptation, evolution, and diversity of life through deep time, they have intrinsic scientific values beyond just the physical objects themselves. Their geological and geospatial contexts provide additional critical data concerning paleoenvironmental, paleogeographic, paleoecologic, and a number of other conditions that together allow for a more complete interpretation of the physical and biological history of the earth. Therefore, paleontological resource management must act to protect not only the fossils themselves, but to collect and maintain other contextual data as well.

In general, losses of paleontological resources result from naturally occurring physical processes, by direct or indirect human activities, or by a combination of both. These processes or activities influence the stability and condition of in situ paleontological resources (Santucci and Koch 2003; Santucci et al. 2009). The greatest loss of associated contextual data occurs when fossils are removed from their original geological context without appropriate documentation. Thus, when a fossil weathers and erodes from its surrounding sediments and geologic context, it begins to lose significant ancillary data until, at some point, it becomes more a scientific curiosity than a useful piece of scientific data. A piece of loose fossil "float" can still be of scientific value. However, when a fossil has been completely removed from its original context, such as an unlabeled personal souvenir or a specimen with no provenance information in a collection, it is of very limited scientific utility. Similarly, inadvertent exhumation of fossils during roadway construction or a building excavation may result in the loss or impairment of the scientific and educational values associated with those fossils. It is not necessary to list here all of the natural and anthropogenic factors that can lead to the loss of paleontological resources; rather it is sufficient to acknowledge that anything that disturbs native sediment or original bedrock has potential to result in the loss of the paleontological resources that occur there, or the loss of associated paleontological resource data.

Cave localities are in a distinct class for management due to the close connection with archeological resources and unique issues affecting cave resources. See Santucci et al. (2001) for additional discussion of paleontological resources in cave settings.

Management strategies to address any of these conditions and factors could also incorporate the assistance of qualified specialists to collect and document resources rather than relying solely on staff to accomplish such a large task at VICK. Active recruitment of paleontological research scientists should also be used as a management strategy.

Baseline Paleontology Resource Data Inventories

A baseline inventory of paleontological resources is critical for implementing effective management strategies, as it provides information for decision-making. This inventory report has compiled information on previous paleontological research done in and near VICK, taxonomic groups that have been reported within VICK boundaries, and localities that were previously reported. This report can serve as a baseline source of information for future research, inventory reports, monitoring, and paleontological decisions. The Paleontological Resource Inventory and Monitoring report for the Gulf Coast I&M Network completed by Kenworthy et al. (2007) and the references cited within were important baseline paleontological resource data sources for this VICK-specific report.

Paleontological Resource Monitoring

Paleontological resource monitoring is a significant part of paleontological resource management, and one which usually requires little to implement beyond time and equipment already on hand, such as cameras and GPS units. Monitoring enables the evaluation of the condition and stability of in situ paleontological resources (Santucci and Koch 2003; Santucci et al. 2009). A monitoring program revolves around periodic site visits to assess conditions compared to a baseline for that site, with the periodicity depending on factors such as site productivity, accessibility, and significance of management issues. For example, a highly productive site which is strongly affected by erosion or unauthorized collection, and which can be easily visited by park staff, would be scheduled for more frequent visits than a less productive or less threatened site.

A monitoring program is generally implemented after an inventory has been prepared for a park and sites of concern have been identified, with additional sites added as necessary. Because each park is different, with different geology and paleontology among other factors, ideally each park which has in situ fossils or significant accumulations of reworked fossils would have its own monitoring protocol to define its monitoring program. Data accumulated via monitoring is used to inform further management decisions, such as the following questions: Is the site suitable for interpretation and education? Does the site require stabilization from the elements? Is collection warranted? Is there a need for some form of law enforcement presence?

Collection is recommended to be reserved for fossils possessing exceptional value (e.g., rare or high scientific significance) or at immediate risk of major degradation or destruction by human activity and natural processes. Therefore, paleontological resource monitoring is a more feasible potential management tool. The first step in establishment of a monitoring program is identification of localities to be monitored, as discussed previously. Locality condition forms are then used to evaluate factors that could cause loss of paleontological resources, with various conditions at each locality rated as good, fair, or poor. Risks and conditions are categorized as Disturbance, Fragility, Abundance, and Site Access. "Disturbance" evaluates conditions that promote accelerated erosion or mass wasting resulting from human activities. "Fragility" evaluates natural conditions that may influence the degree to which fossil transportation is occurring. Sites with elevated fragility exhibit inherently soft rapidly eroding sediment or mass wasting on steep hillsides. A bedrock outcrop that is strongly lithified has low fragility. "Abundance" judges both the natural condition and number of specimens preserved at the locality as well as the probability of being recognized as a fossil-rich area by non-paleontologists, which could lead to unpermitted collecting. "Site Access" assesses the risk of a locality being visited by large numbers of visitors or the potential for easy removal of large quantities of fossils or fossil-bearing sediments. A locality with high access would be in close proximity to public use areas or other access (along trails, at roadcuts, at beach or river access points, and so on).

Each of the factors noted above may be mitigated by management actions. Localities exhibiting a significant degree of disturbance may require either active intervention to slow accelerated erosion, periodic collection and documentation of fossil materials, or both. Localities developed on sediments of high fragility naturally erode at a relatively rapid rate and would require frequent visits to document and/or collect exposed fossils in order to prevent or reduce losses. Localities with abundant or rare fossils, or high rates of erosion, may be considered for periodic monitoring in order to assess the stability and condition of the locality and resources, in regard to both natural processes and human-related activities. Localities that are easily accessible by road or trail would benefit from the same management strategies as those with abundant fossils and by occasional visits by park staff, documentation of in situ specimens, and/or frequent law enforcement patrols. Further information on paleontological resource monitoring can be found in Santucci and Koch (2003) and Santucci et al. (2009).

Foundation Documents and Resource Stewardship Strategies

Foundation documents and Resource Stewardship Strategies are two types of park planning documents that may contain and reference paleontological resource information. A foundation document is intended to provide basic guidance about a park for planning and management. It briefly describes a given park and its purpose, significance, fundamental resources and values, other importance resources and values, and interpretive themes. Mandates and commitments are also identified, and the state of planning is assessed. Foundation documents may include paleontological information and are also useful as a preliminary assessment of what a park's staff know about their paleontological resources, the importance they place on these resources, and the present state of these non-renewable resources. A foundation document for VICK has been published and includes a brief reference to the importance of Mint Spring Falls and Bayou (National Park Service 2014: 35).

A Resource Stewardship Strategy (RSS) is a strategic plan intended to help park managers achieve and maintain desired resource conditions over time. It offers specific information on the current state of resources and planning, management priorities, and management goals over various time frames. An RSS for VICK has not yet been published.

Geologic Maps

A geologic map is the fundamental tool for depicting the geology of an area. Geologic maps are two-dimensional representations of the three-dimensional geometry of rock and sediment at or beneath the land surface (Evans 2016). Colors and symbols on geologic maps correspond to geologic map units. The unit symbols consist of an uppercase letter indicating the age and lowercase letters indicating the formation's name. The American Geosciences Institute website (https://www.americangeosciences.org/environment/publications/mapping) provides more information about geologic maps and their uses. The NPS Geologic Resources Inventory (GRI) has been digitizing existing maps of NPS units and making them available to parks for resource management.

Geologic maps are one of the foundational elements of a paleontological resource management program. Knowing which sedimentary rocks and deposits underlie a park and where they are exposed are essential for understanding the distribution of known or potential paleontological resources. The ideal scale for resource management in the 48 contiguous states is 1:24,000 (maps for areas in Alaska tend to be coarser). Whenever possible, page-sized geologic maps derived from GRI files are included in paleontological resource inventory reports for reference, but it is recommended that GRI source files be downloaded from IRMA for use. The source files can be explored in much greater detail and incorporated into the park GIS database. Links to the maps digitized by the GRI for VICK can be found in IRMA at https://irma.nps.gov/DataStore/Reference/Profile/2231845. In addition to a digital GIS geologic map, the GRI program also produces a park-specific report discussing the geologic setting, distinctive geologic features and processes within the park, highlighting geologic issues facing resource managers, and describing the geologic history leading to the present-day landscape of the park. A GRI report has not yet been published for VICK, but VICK's new satellite units of Port Gibson, Raymond, and Champion Hill are undergoing a contemporaneous survey as part of a larger inventory for Natchez Trace Parkway, and a scoping summary has been produced for the park (KellerLynn 2010).

Paleontological Resource Potential Maps

Essentially every geologic unit exposed within VICK is fossiliferous within the park or in the immediate area. Because of this and the level of detail of existing geologic maps, it was decided not to include a paleontological resource potential map showing the distribution of geologic units which have yielded fossils. While different formations have varying fossiliferous tendencies, this distinction would be lost on a map of this scale. A map showing the depths to VICK's bedrock geology would be a useful focus for future projects but was beyond the scope of this inventory.

Paleontological Resource Management Recommendations

The paleontological resource inventory at VICK has documented rich and previously unrecognized paleontological resources. This report captures the scope, significance, and distribution of fossils at VICK as well as provides recommendations to support the management and protection of the park's non-renewable paleontological resources.

- VICK staff should be encouraged to observe exposed rocks and sedimentary deposits for fossil material while conducting their usual duties. To promote this, staff should receive guidance regarding how to recognize common local fossils. When opportunities arise to observe paleontological resources in the field and take part in paleontological field studies with trained paleontologists, staff should take advantage of them, if funding and time permit.
- VICK staff should photo-document and monitor any occurrences of paleontological resources that may be observed in situ. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation. A Geologic Resource Monitoring Manual published by the Geological Society of America and NPS Geologic Resources Division (GRD) includes a chapter on paleontological resource monitoring (Santucci et al. 2009). Santucci and Koch (2003) also present information on paleontological resource monitoring.
- Fossil theft is one of the greatest threats to the preservation of paleontological resources and any methods to minimize these activities should be utilized by staff. Any occurrence of paleontological resource theft or vandalism should be investigated by a law enforcement ranger. When possible, incidents should be fully documented and the information submitted for inclusion in the annual law enforcement statistics.
- Fossils found in a cultural context should be documented like other fossils but will also require the input of an archeologist or a cultural resource specialist. Any fossil which has a cultural context may be culturally sensitive as well (e.g., subject to NAGPRA) and should be regarded as such until otherwise established. The Geologic Resources Division can coordinate additional documentation/research of such material.
- Staff should recognize the importance of preserving the type locality of the Mint Spring Formation found in the park. An increase in paleontological awareness may indirectly encourage visitors to approach the waterfall and disturb the locality. This area may need additional attention from law enforcement, and staff may benefit from becoming familiar with the fossils.
- In addition to the Oligocene fossils found at the type locality and other exposures at the park, staff should also be able to recognize Pleistocene snails and Paleozoic gravels. These are important paleontological resources which are property of the park, so it is imperative that staff can spot anyone in possession of these otherwise inconspicuous items.
- The park may fund and recruit paleontology interns as a cost-effective means of enabling some level of paleontological resource support. The Scientists in Parks Program is an established program for recruitment of geology and paleontology interns and was integral in

the development of this inventory. The Paleontology in the Parks Fellowship program coordinated between the Paleontological Society and National Park Service also provides funding for students and mentors completing paleontology projects in national parks.

- Contact the NPS Paleontology Program for technical assistance with paleontological resource management issues.

If fossil specimens are found by VICK staff, it is recommended they follow the steps outlined below to ensure proper paleontological resource management.

- Photo-document the specimen without moving it from its location. Include a common item, such as a coin, pen, or pencil, for scale if a ruler or scale bar is not available.
- If a GPS unit is available, record the location of the specimen. If GPS is not available, record the general location within VICK and height within the outcrop, if applicable. If possible, revisit the site when a GPS unit is available. Most smartphones also have the ability to record coordinates; if no GPS unit is available, attempt to record the coordinates with a phone.
- Write down associated data, such as rock type, general description of the fossil, type of fossil if identifiable, general location in VICK, sketch of the fossil, position within the outcrop or if it is loose on the ground, any associated fossils, and any other additional information.
- Do not remove the fossil unless it is loose in an area of heavy traffic, such as a public trail, and is at risk of being taken or destroyed. If the fossil is removed, be sure to wrap in soft material, such as tissue paper, and place in a labeled plastic bag with associated notes. Because VICK has many culturally important sites, simply documenting the fossil and leaving it in place is often the best course of action until natural resource staff is contacted.
- If fossil resources are found, alert staff at VICK to allow for proper documentation.

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Appendix A: Paleontological Taxa

The following tables document the fossil taxa found at or near VICK in stratigraphic context, as reported in the literature, in museum collections, and through personal observations. The first table (Appendix A-Table 1) documents specimens reported in the loess near Vicksburg (and as relevant if observed in this survey). The second table (Appendix A-Table 2) lists specimens found in pre-loess gravels during this survey. The third table (Appendix A-Table 3) lists taxa of the Vicksburg Group (and as relevant if observed in this survey). The fourth table (Appendix A-Table 4) lists the fossil genera identified in this survey in the Byram Formation of VICK. The fifth and last table (Appendix A-Table 5) lists the almost entirely informal manuscript names used by Charles Alexandre Lesueur.

Fossil taxonomy may change significantly over time, especially for fossils from locations with a long history of study such as Vicksburg. It is beyond the scope of this document to make a comprehensive and exhaustive account of changes, or to identify the best, most accurate names (a task that can prove fraught with unexpected controversy). Most of the Vicksburg Group fossil taxa are mollusks, which were detailed in two major publications that include significant historical information such as evaluations of previous taxonomy (Dockery [1982a] on bivalves; MacNeil and Dockery [1984] on other mollusk groups). These two publications are considered the publications of record for these groups for the purposes of this report. (Note that subgenera are frequently omitted in the literature; they are included here after Dockery [1982a] and Dockery and MacNeil [1984] for completeness.)

Appendix A-Table 1. Fossil taxa reported from the Pleistocene loess near Vicksburg. This is an inexhaustive list referencing only the most geographically relevant publications (Shimek 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999; Pigati et al. 2014) which may provide the best indication of potential VICK taxa. Taxa observed in this survey based on preliminary identification are noted where appropriate. Future identification of specimens now in park collections and/or additional field research may expand this list.

Group	Taxon	Locality (if observed)	Reference
Mollusca: Bivalvia (clams, oysters, etc.)	*Megalonaias nervosa*	–	Shimek 1930; Williams 1999
	Pisidium sp.	VPFV-CVB22-0013	Shimek 1930; Williams 1999
Mollusca: Gastropoda (snails)	*Allogona profunda*	VPFV-CVB22-0028; VPFV-CVB22-0046	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Anguispira alternata	VPFV-CVB22-0031	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Anguispira kochi	–	Shimek 1930
	Campeloma decisum	–	Shimek 1930; Williams 1999
	Carychium exile	–	Shimek 1930; Hubricht 1963
	Catinella vermata	–	Shimek 1930
	Cionella morseana	–	Hubricht 1963; Snowden and Priddy 1968
	Cochlicopa lubrica	–	Shimek 1930
	Columella edentula	–	Shimek 1930; Hubricht 1963
	Discus patulus	VPFV-CVB22-0046	Hubricht 1963; Snowden and Priddy 1968
	Discus perspectivus	–	Shimek 1930
	Discus shimekii	–	Shimek 1930
	Discus whitneyii	VPFV-MMR22-0001	Shimek 1930
	Euchemotrema leai (*Polygyra monodon*)	VPFV-CVB22-0028; VPFV-CVB22-0031; VPFV-MMR22-0001	Shimek 1930
	Euconulus fulvus	–	Shimek 1930; Hubricht 1963
	Gastrocopta armifera	–	Shimek 1930
	Gastrocopta contracta	–	Shimek 1930; Hubricht 1963
	Gastrocopta holzingeri	–	Shimek 1930

Appendix A-Table 1 (continued). Fossil taxa reported from the Pleistocene loess near Vicksburg. This is an inexhaustive list referencing only the most geographically relevant publications (Shimek 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999; Pigati et al. 2014) which may provide the best indication of potential VICK taxa. Taxa observed in this survey based on preliminary identification are noted where appropriate. Future identification of specimens now in park collections and/or additional field research may expand this list.

Group	Taxon	Locality (if observed)	Reference
Mollusca: Gastropoda (snails) (continued)	*Gastrocopta pentodon*	–	Shimek 1930; Hubricht 1963
	Gastrocopta corticaria	–	Shimek 1930; Hubricht 1963
	Glyphyalinia lewisiana	–	Hubricht 1963
	Guppya sterkii	–	Hubricht 1963
	Gyraulus sp.	VPFV-CVB22-0013	–
	Haplotrema concavum	VPFV-CVB22-0028; VPFV-CVB22-0046	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Helicina orbiculata	VPFV-CVB22-0046	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Helicodiscus sp.	–	–
	Helicodiscus parallelus	–	Shimek 1930; Hubricht 1963
	Helicodiscus intermedius	–	Hubricht 1963
	Helicodiscus jacksoni	–	Hubricht 1963
	Helicodiscus notius	–	Hubricht 1963
	Helisoma anceps	VPFV-CVB22-0013	–
	Hendersonia occulta	–	Shimek 1930; Snowden and Priddy 1968
	Inflectarius inflectus	–	Pigati et al. 2014
	Mesodon sp.	VPFV-CVB22-0028; VPFV-CVB22-0046	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Mesodon clausus	–	Snowden and Priddy 1968
	Mesodon thyroidus	–	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968

Appendix A-Table 1 (continued). Fossil taxa reported from the Pleistocene loess near Vicksburg. This is an inexhaustive list referencing only the most geographically relevant publications (Shimek 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999; Pigati et al. 2014) which may provide the best indication of potential VICK taxa. Taxa observed in this survey based on preliminary identification are noted where appropriate. Future identification of specimens now in park collections and/or additional field research may expand this list.

Group	Taxon	Locality (if observed)	Reference
Mollusca: Gastropoda (snails) (continued)	*Mesodon zaletus*	–	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Mesodon inflectus	–	Hubricht 1963; Snowden and Priddy 1968
	Mesomphix capnodes	VPFV-CVB22-0028	Shimek 1930; Snowden and Priddy 1968
	Neohelix albolabris	–	Shimek 1930; Pigati et al. 2014
	Oreohelix strigosi cooperi	–	Shimek 1930
	Paravitrea multidentata	–	Hubricht 1963
	Paravitrea significans	–	Hubricht 1963
	Paravitrea placentula	–	Shimek 1930
	Physa sp.	VPFV-CVB22-0013	–
	Pleurocera sp.	–	Shimek 1930; Williams 1999
	Polygyra appressa	–	Shimek 1930
	Polygyra elevata	–	Shimek 1930
	Polygyra hirsuta	–	Shimek 1930
	Pomatiopsis lapidaria	VPFV-CVB22-0013	Shimek 1930
	Punctum minutissimum	–	Hubricht 1963
	Punctum pygmaeum	–	Shimek 1930
	Pupilla blandii	–	Shimek 1930
	Pupilla muscorum	–	Shimek 1930
	Pupoides albilabris	–	Shimek 1930
	Retinella indentata	–	Shimek 1930; Hubricht 1963
	Somatogyrus sp.	VPFV-MMR22-0001	–

Appendix A-Table 1 (continued). Fossil taxa reported from the Pleistocene loess near Vicksburg. This is an inexhaustive list referencing only the most geographically relevant publications (Shimek 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999; Pigati et al. 2014) which may provide the best indication of potential VICK taxa. Taxa observed in this survey based on preliminary identification are noted where appropriate. Future identification of specimens now in park collections and/or additional field research may expand this list.

Group	Taxon	Locality (if observed)	Reference
Mollusca: Gastropoda (snails) (continued)	*Stagnicola* sp.	VPFV-CVB22-0013	–
	Stenotrema barbatum	VPFV-CVB22-0031	Hubricht 1963; Snowden and Priddy 1968
	Stenotrema fraternum	–	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Stenotrema leai aliciae	–	Hubricht 1963; Snowden and Priddy 1968
	Stenotrema stenotrema	–	Hubricht 1963; Snowden and Priddy 1968
	Strobilops sp.	–	Shimek 1930
	Strobilops aeneus	–	Hubricht 1963
	Succinea ovalis	–	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Succinea gelida	–	Hubricht 1963
	Succinea grosvenorii	–	Shimek 1930
	Triodopsis fosteri	–	Hubricht 1963; Snowden and Priddy 1968
	Triodopsis tridentata	VPFV-CVB22-0046	Hubricht 1963
	Triodopsis vulgatus	–	Hubricht 1963; Snowden and Priddy 1968
	Triodopsis obstricta	–	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
	Vallonia gracilicosta	–	Shimek 1930
	Ventridens demissus	–	Snowden and Priddy 1968
	Ventridens intertextus	–	Hubricht 1963
	Ventridens ligera	VPFV-CVB22-0028	Shimek 1930; Hubricht 1963

Appendix A-Table 1 (continued). Fossil taxa reported from the Pleistocene loess near Vicksburg. This is an inexhaustive list referencing only the most geographically relevant publications (Shimek 1930; Hubricht 1963; Snowden and Priddy 1968; Williams 1999; Pigati et al. 2014) which may provide the best indication of potential VICK taxa. Taxa observed in this survey based on preliminary identification are noted where appropriate. Future identification of specimens now in park collections and/or additional field research may expand this list.

Group	Taxon	Locality (if observed)	Reference
Mollusca: Gastropoda (snails) (continued)	*Vertigo gouldii*	–	Shimek 1930; Hubricht 1963
	Vertigo milium	–	Shimek 1930
	Vertigo ovata	–	Shimek 1930
	Vertigo tridentata	–	Shimek 1930
	Vitrea hammonis	–	Shimek 1930
	Webbhelix multilineata	–	Shimek 1930
	Xolotrema denotatum (Triodopsis denotata)	VPFV-CVB22-0028; VPFV-CVB22-0046	Hubricht 1963
	Zonitoides arboreus	–	Shimek 1930; Hubricht 1963
	Zonitoides lateumbilicatus	–	Hubricht 1963
	Zonitoides minuscula	–	Shimek 1930
	Planorbidae undetermined	VPFV-CVB22-0013	–
	Succineidae undetermined	VPFV-CVB22-0031	Shimek 1930; Hubricht 1963; Snowden and Priddy 1968
Vertebrata: Mammalia	*Mammut* sp.	–	Wailes 1854; Hay 1923; Priddy et al. 1966; Kolb et al. 1976; Knox and Pitts 1984
Trace fossils	*Cambarus* sp. gastrolith	–	Shimek 1930; Williams 1999

Appendix A-Table 2. Fossil taxa reported in pre-loess gravels of Mississippi are listed as described in Dockery et al. (2008). Taxa observed in the pre-loess gravels of VICK during the 2022 survey are noted where appropriate. Further identification is necessary as this survey focused primarily on Pleistocene and Oligocene collections. See Dockery et al. (2008) for more descriptions of fossils in pre-loess gravels.

Group	Taxon	In VICK	Notes
Porifera (sponges)	Stromatoporoidea indet.	–	Mineralized layered sponges
Cnidaria: Anthozoa (corals)	*Favosites*	–	Tabulate corals
	Heliolites	x	Tabulate corals
	Hexagonaria	–	Colonial rugose corals
	Lithostrotionella	–	Colonial rugose corals
	Rugosa indet.	x	Solitary rugose corals
	Coral indet.	x	–
Bryozoa (moss animals)	*Archimedes*	–	Cryptostome bryozoans
	Fenestrata undetermined	x	–
Brachiopoda (lamp shells)	Pentamerida indet.	–	–
	Productida indet.	–	–
	Spiriferida indet.	–	–
	Brachiopod indet.	x	–
Mollusca: Bivalvia (clams, oysters, etc.)	Bivalvia indet.	–	–
Mollusca: Ammonoidea (ammonites)	*Goniatites*	–	–
Mollusca: Gastropoda (snails)	Gastropod steinkerns	–	Internal molds
	Gastropoda indet.	–	–
Arthropoda: Trilobita (trilobites)	Proetida indet.	–	–
	Trilobita indet.	x	Pygidium collected
Echinodermata: Blastoidea (sea buds)	Blastoidea indet.	–	–
Echinodermata: Crinoidea (sea lilies)	Crinoidea indet.	x	–
Foraminifera	Fusulinida indet.	x	–

Appendix A-Table 3. Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Cnidaria: Anthozoa (corals)	*Archohelia mississippiensis*	Conrad 1848a (originally *Madrepora*)
	Archohelia vicksburgensis	Conrad 1848a (originally *Madrepora*)
	Balanophyllia caulifera	Conrad 1848a (originally *Turbinolia*)
	Turbinolia vicksburgensis	Monsour 1944
Bryozoa (moss animals)	*Lunulites vicksburgensis*	Conrad 1848a
	Membrendoecium lowei	Canu and Bassler 1920
	Metrarabdotos (*Rhabdotometra*) *micropora micropora*	Cheetham 1968
	Reptocelleporaria glomerata	Gabb and Horn 1862
Mollusca: Bivalvia (clams, oysters, etc.)	*Abra pectorosa*	Dockery 1982a
	Agnocardia glebosum	Dockery 1982a
	Anodontia (*Anodontia*) *mississippiensis*	Dockery 1982a
	Anomia microstriata	Dockery 1982a
	Arca (*Arca*) *subprotracta*	Dockery 1982a
	Arcoperna linteata	Dockery 1982a
	Astarte menthifontis	Dockery 1982a
	Astarte planilamella	Dockery 1982a
	Astarte triangulata	Dockery 1982a
	Atrina argentea	Dockery 1982a
	Barbatia (*Cucullaearca*) *lima*	Dockery 1982a
	Barbatia mississippiensis	Dockery 1982a
	Barbatia paradiagona	Dockery 1982a
	Bornia tallahalaensis	Dockery 1982a
	Brachidontes mississippiensis	Dockery 1982a
	Brevinucula pseudopunctata	Dockery 1982a
	Callista (*Callista*) *goniopisthus*	Dockery 1982a
	Callista (*Callista*) *sobrina*	Dockery 1982a
	Carditella aldrichi	Dockery 1982a
	Cardium (Trachycardium) precursor	Dall 1900
	Chama (*Chama*) *pappiladerma*	Dockery 1982a
	Chama (*Psilopus*) *mississippiensis*	Dockery 1982a
	Chama sp.	Dockery 1982a

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Chamelea mississippiensis*	Dockery 1982a
	Chione (*Chione*) *bainbridgensis*	Dockery 1982a
	Chione (*Chione*) *craspedonia*	Dockery 1982a
	Chione (*Chione*) *perbrevisformis*	Dockery 1982a
	Chione (*Lirophora*) *victoria*	Dockery 1982a
	Chlamys (*Aequipecten*) *cocoana*	Dockery 1982a
	Chlamys (*Aequipecten*) *redwoodensis*	Dockery 1982a
	Chlamys (*Anatipopecten*) *anatipes*	Dockery 1982a
	Chlamys (*Lyropecten*) *duncanensis*	Dockery 1982a
	Chlamys (*Lyropecten*) *menthifontis*	Dockery 1982a
	Coralliophaga (*Coralliophaga*) *corrugata*	Dockery 1982a
	Corbula (*Caryocorbula*) *engonata*	Dockery 1982a
	Corbula (*Varicorbula*) *laqueata*	Dockery 1982a
	Corbula (*Vokesula*) *rufaripa*	Dockery 1982a
	Crassatella (*Crassatella*) *lirasculpta*	Dockery 1982a
	Crassatella (*Crassatella*) *mississippiensis*	Dockery 1982a
	Crassatella (*Crassatella*) *mississippiensis megacosta*	Dockery 1982a
	Crassinella variabilis	Dockery 1982a
	Crassostrea sp.	Dockery 1982a
	Crenella fenestra	Dockery 1982a
	Cuspidaria (*Tropidomya*?) sp.	Dockery 1982a
	Dimya rufaripa	Dockery 1982a
	Dinocardium vicksburgense	Dockery 1982a
	Diplodonta (*Diplodonta*) *eburnea*	Dockery 1982a
	Diplodonta (*Diplodonta*) *elatia*	Dockery 1982a
	Divaricella (*Divalinga*) *subrigaultiana*	Dockery 1982a

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Donax funerata*	Dockery 1982a
	Donax sp.?	Dockery 1982a
	Eburneopecten (*Eburneopecten*) *subminutus*	Dockery 1982a
	Ervilia exterolaevis	Dockery 1982a
	Ervilia lamelloexteria	Dockery 1982a
	Felaniella (*Felaniella*) *compacta*	Dockery 1982a
	Gari (*Gari*) *papyria*	Dockery 1982a
	Gari mississippiensis	Dockery 1982a
	Glycymeris arctata	Dockery 1982a
	Glycymeris intercostata	Dockery 1982a
	Glycymeris mississippiensis	Dockery 1982a
	Glycymeris suwannensis	Dockery 1982a
	Haliris (*Haliris*) *quadrangularis*	Dockery 1982a
	Jouannetia (*Pholadopsis*) *triquetra*	Dockery 1982a
	Kelliella rufaripa	Dockery 1982a
	Laevicardium leptorimum	Dockery 1982a
	Limaria sp.	Dockery 1982a
	Limaria staminea	Dockery 1982a
	Limopsis (*Limopsis*) sp.	Dockery 1982a
	Lopha vicksburgensis	Dockery 1982a
	Lucina (*Callucina*) *choctavensis*	Dockery 1982a
	Lucina (*Cavilinga*) *imbricolamella*	Dockery 1982a
	Lucina (*Cavilinga*) *triloba*	Dockery 1982a
	Lucina (*Lucina*) *fimbripellium*	Dockery 1982a
	Lucina (*Lucinisca*) *varisculpta*	Dockery 1982a
	Lucina (*Parvilucina*) *posteocurta*	Dockery 1982a
	Lucina sp.	Dockery 1982a
	Macoma sublintea	Conrad 1871
	Myrtea (*Myrtea*) *scopularis*	Dockery 1982a
	Myrtea (Myrtea) *vicksburgensis*	Dockery 1982a
	Nemocardium (*Nemocardium*) *diversum*	Dockery 1982a

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Nemocardium* (*Nemocardium*) *eocenense*	Dockery 1982a
	Nucula tallahalaensis	Dockery 1982a
	Nucula vicksburgensis	Dockery 1982a
	Nuculana akidota	Dockery 1982a
	Nuculana triangulata	Dockery 1982a
	Ostrea paroxis	Dockery 1982a
	Ostrea sp.	Dockery 1982a
	Panopea (*Panopea*) *oblongata*	Dockery 1982a
	Pecten (*Pecten*) *byramensis*	Dockery 1982a
	Pecten (*Pecten*) *perplanus*	Dockery 1982a
	Pecten (*Pecten*) *poulsoni*	Dockery 1982a
	Pecten sp.	Dockery 1982a
	Periploma macneili	Dockery 1982a
	Pholadomya sp.	Dockery 1982a
	Pitar (*Hyphantosoma*) *semipunctata*	Dockery 1982a
	Pitar (*Lamelliconcha*) *astartifomis*	Dockery 1982a
	Pitar (Lamelliconcha) calcanea	Dockery 1982a
	Pitar (*Lamelliconcha*) *imitabilis*	Dockery 1982a
	Pitar (*Lamelliconcha*) *megacostata*	Dockery 1982a
	Pitar (*Lamelliconcha*) *perbrevis*	Dockery 1982a
	Pitar (*Lamelliconcha*) *protena*	Dockery 1982a
	Pitar (*Lamelliconcha*) *silicifluvia*	Dockery 1982a
	Pitar aldrichi	Dockery 1982a
	Plectodon intastriata	Dockery 1982a
	Plicatula variplicata	Dockery 1982a
	Pteria argentea	Dockery 1982a
	Scapharca (*Scapharca*) *chordicosta*	Dockery 1982a
	Scapharca (*Scapharca*) *delicatula*	Dockery 1982a
	Scapharca (*Scapharca*) *invidiosa*	Dockery 1982a

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Scapharca* (*Scapharca*) *lesueuri*	Dockery 1982a
	Scapharca (*Scapharca*) sp.	Dockery 1982a
	Semele mississippiensis	Dockery 1982a
	Semele staminea	Dockery 1982a
	Semelina pilsbryi	Dockery 1982a
	Septifer (*Septifer*) *probolus*	Dockery 1982a
	Solecurtus vicksburgensis	Dockery 1982a
	Spheniopsis mississippiensis	Dockery 1982a
	Spisula (*Mactromeris*) *mississippiensis*	Dockery 1982a
	Spisula funerata	Dockery 1982a
	Spisula inaequilateralis	Dockery 1982a
	Spisula sp.	Dockery 1982a
	Spondylus (*Spondylus*) *dumosus*	Dockery 1982a
	Spondylus (*Spondylus*) *filiaris*	Dockery 1982a
	Spondylus (*Spondylus*) *granulocostatus*	Dockery 1982a
	Spondylus (*Spondylus*) sp.	Dockery 1982a
	Sportella oblonga	Dockery 1982a
	Tellidorella interlacinia	Dockery 1982a
	Tellina lintea	Dockery 1982a
	Tellina perovata	Dockery 1982a
	Tellina serica	Dockery 1982a
	Tellina subprotexta	Dockery 1982a
	Tellina vicksburgensis	Dockery 1982a
	Teredo sp.	Dockery 1982a
	Thracia (*Thracia*) *vicksburgensis*	Dockery 1982a
	Timothynus turgida	Dockery 1982a
	Tiza alta	Dockery 1982a
	Tiza sp.	Dockery 1982a
	Trachycardium eversum	Dockery 1982a
	Trachycardium planicostata	Dockery 1982a
	Trigoniocardia (*Americardia*) *silvacollina*	Dockery 1982a
	Trinacria menthifontis	Dockery 1982a

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Venericardia* (*Rotundicardia*) *carsonensis*	Dockery 1982a
	Ventricolaria ucuttana	Dockery 1982a
	Verticordia (*Verticordia*) *dalliana*	Dockery 1982a
	Yoldia clydoniona	Dockery 1982a
	Yoldia serica	Dockery 1982a
Mollusca: Cephalopoda (octopuses, nautiloids, squids, etc.)	*Aturia* (*Aturia*) *berryi*	MacNeil and Dockery 1984
	Aturia cf. *A. alabamensis*	MacNeil and Dockery 1984
Mollusca: Gastropoda (snails)	*Aclis matsoni*	MacNeil and Dockery 1984
	Aclis matsoni var.	MacNeil and Dockery 1984
	Aclis sp. A	MacNeil and Dockery 1984
	Aclis sp. B	MacNeil and Dockery 1984
	Acrilla (*Acrilloscala*) *palmerae*	MacNeil and Dockery 1984
	Acteocina crassiplica	MacNeil and Dockery 1984
	Acteocina crassiplica altispira	MacNeil and Dockery 1984
	Acteocina crassiplica involuta	MacNeil and Dockery 1984
	Acteon (*Acteon*) *aldrichi*	MacNeil and Dockery 1984
	Acteon (*Acteon*) *menthafons*	MacNeil and Dockery 1984
	Acteon (*Acteon*) *meyeri*	MacNeil and Dockery 1984
	Acteon (*Acteon*) *preluculi*	MacNeil and Dockery 1984
	Acteon (*Acteon*) *pretextilis*	MacNeil and Dockery 1984
	Acteon (*Acteon*) *subaldrichi*	MacNeil and Dockery 1984
	Acteon (*Acteon*) sp. A	MacNeil and Dockery 1984
	Acteon (*Acteon*) sp. B	MacNeil and Dockery 1984
	Acteon (*Kleinacteon*) *puteatus*	MacNeil and Dockery 1984
	Admetula inflata	MacNeil and Dockery 1984
	Admetula regularia	MacNeil and Dockery 1984
	Agatrix mississippiensis	MacNeil and Dockery 1984
	Alaba blakneyensis	MacNeil and Dockery 1984
	Alaba cf. *A. blakneyensis*	MacNeil and Dockery 1984
	Alaba macneili	MacNeil and Dockery 1984
	Alabina menthafontis	MacNeil and Dockery 1984
	Alabina aff. *A. menthafontis*	MacNeil and Dockery 1984
	Ampullinopsis mississippiensis	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Amyssodropa clearyensis*	MacNeil and Dockery 1984
	Anticlimax byramensis	MacNeil and Dockery 1984
	Aporrhais (*Goniocheila*) *lirata*	MacNeil and Dockery 1984
	Aporrhais (*Goniocheila*) *menthafontis*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *fuscicava*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *fuscicava* var.?	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *meliconae*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *menthafontis*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *textilina caseyi*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *trilirata*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *trilirata palmeri*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) *vicksburgensis*	MacNeil and Dockery 1984
	Architectonica (*Architectonica*) sp.	MacNeil and Dockery 1984
	Architectonica (*Granosolarium*) *hargeri*	MacNeil and Dockery 1984
	Architectonica (*Pseudotorinia*) *julia*	MacNeil and Dockery 1984
	Arene nodosa	MacNeil and Dockery 1984
	Atys (*Atys*) *pinguis*	MacNeil and Dockery 1984
	Atys (*Roxaniella*) *caseyi*	MacNeil and Dockery 1984
	Bathytoma congesta	MacNeil and Dockery 1984
	Bathytoma congesta fontis	MacNeil and Dockery 1984
	Bathytoma rhomboidea	MacNeil and Dockery 1984
	Bathytoma rhomboidea lyrata	MacNeil and Dockery 1984
	Bittium (*Argyropeza*?) *caseyi*	MacNeil and Dockery 1984
	Bittium (*Argyropeza*?) *ottoi*	MacNeil and Dockery 1984
	"*Bittium*" *acuta*	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Bovicornu eocenense*	MacNeil and Dockery 1984
	Caecum solitarium	MacNeil and Dockery 1984
	Calliostoma sp.?	MacNeil and Dockery 1984
	Calyptraea (*Trochita*) cf. *C.* (*T.*) *aperta*	MacNeil and Dockery 1984
	Calyptraea (*Trochita*) *conradi*	MacNeil and Dockery 1984
	Calyptraea (*Trochita*) sp.	MacNeil and Dockery 1984
	Capulus (*Brocchia*) *langdoni*	MacNeil and Dockery 1984
	Capulus (*Capulus*) *americanus*	MacNeil and Dockery 1984
	Capulus planus	MacNeil and Dockery 1984
	Caricella (*Atraktus*) *demissa*	MacNeil and Dockery 1984
	Caricella (*Atraktus*) *demissa* var. A	MacNeil and Dockery 1984
	Caricella (*Atraktus*) *demissa* var. B	MacNeil and Dockery 1984
	Caricella (*Atraktus*) *reticulata*	MacNeil and Dockery 1984
	Caricella (*Atraktus*) sp.	MacNeil and Dockery 1984
	Cassis flintensis	MacNeil and Dockery 1984
	Cerithiella langdoni	MacNeil and Dockery 1984
	Cerithiella langdoni var.	MacNeil and Dockery 1984
	Cerithiella leafensis	MacNeil and Dockery 1984
	Cerithiella nassuloides	MacNeil and Dockery 1984
	Cerithiella sp.	MacNeil and Dockery 1984
	Cerithioderma sp.?	MacNeil and Dockery 1984
	Chicoreus (*Phyllonotus*) *dormani*	MacNeil and Dockery 1984
	Chicoreus (*Phyllonotus*) *mississippiensis*	MacNeil and Dockery 1984
	Chicoreus (*Phyllonotus*) *stetopus*	MacNeil and Dockery 1984
	Clathurella blakneyensis	MacNeil and Dockery 1984
	Clathurella meyeri	MacNeil and Dockery 1984
	Clathurella meyeri sylvarenensis	MacNeil and Dockery 1984
	Clathurella sp.	MacNeil and Dockery 1984
	Clavidrupa anita	MacNeil and Dockery 1984
	Clavilithes lesueuri	MacNeil and Dockery 1984
	Clavilithes longiformis	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Clavilithes vicksburgensis*	MacNeil and Dockery 1984
	Clavilithes sp. A	MacNeil and Dockery 1984
	Clavilithes sp. B	MacNeil and Dockery 1984
	Cochlespira cookei	MacNeil and Dockery 1984
	Cochlespira cookei rubracollis	MacNeil and Dockery 1984
	Cochlespira cristata	MacNeil and Dockery 1984
	Confusiscala (*Funiscala*) *durhami*	MacNeil and Dockery 1984
	Conomitra crenulata	MacNeil and Dockery 1984
	Conomitra crenulata modesta	MacNeil and Dockery 1984
	Conomitra staminea	MacNeil and Dockery 1984
	Conomitra vicksburgensis	MacNeil and Dockery 1984
	Conomitra vicksburgensis laevigata	MacNeil and Dockery 1984
	Conorbis porcellana	MacNeil and Dockery 1984
	Conus alveatus	MacNeil and Dockery 1984
	Conus alveatus spiralis	MacNeil and Dockery 1984
	Conus protractus	MacNeil and Dockery 1984
	Coronia (*Coroniopsis*) *ancilla*	MacNeil and Dockery 1984
	Coronia (*Coroniopsis*) *tenella*	MacNeil and Dockery 1984
	Coronia (*Coroniopsis*) *tenella antetenella*	MacNeil and Dockery 1984
	Crassispira (*Crassispirella*) *abundans*	MacNeil and Dockery 1984
	Crassispira (*Crassispirella*) *lyopleura*	MacNeil and Dockery 1984
	Crenilabium altispira	MacNeil and Dockery 1984
	Crenilabium paucicrenulatus	MacNeil and Dockery 1984
	Creseis hastata	MacNeil and Dockery 1984
	Creseis cf. *C. corpulenta*	MacNeil and Dockery 1984
	Crucibulum (*Dispotaea*) *hyalonama*	MacNeil and Dockery 1984
	Cyclostremiscus menthafons	MacNeil and Dockery 1984
	Cyclostremiscus quadracordata	MacNeil and Dockery 1984
	"*Cyclostremiscus*" sp.	MacNeil and Dockery 1984
	Cylichna acutiscapulae	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Cylichna acutiscapulae corrugata*	MacNeil and Dockery 1984
	Cylichna nida	MacNeil and Dockery 1984
	Cylichna sp.	MacNeil and Dockery 1984
	Cymatium (*Ranularia*) *vicksburgensis*	MacNeil and Dockery 1984
	Cymatium (*Septa*) *amnicretum*	MacNeil and Dockery 1984
	Cymia (*Tritonopsis*) *subalveatum*	MacNeil and Dockery 1984
	Cymia (*Tritonopsis*) *subalveatum* subsp.?	MacNeil and Dockery 1984
	Cypraeorbis sphaeroides	MacNeil and Dockery 1984
	Cypraeorbis cf. *C. sphaeroides*	MacNeil and Dockery 1984
	Cypraeorbis aff. *C. ventripotens*	MacNeil and Dockery 1984
	Cypraeorbis sp.?	MacNeil and Dockery 1984
	Dermomurex (*Takia*) *cookei*	MacNeil and Dockery 1984
	Diodora mississippiensis	MacNeil and Dockery 1984
	Diodora postantica	MacNeil and Dockery 1984
	Discopsis pilsbryi	MacNeil and Dockery 1984
	Distorsio (*Distorsio*) *crassidens*	MacNeil and Dockery 1984
	Dolicholatirus cervicrassus	MacNeil and Dockery 1984
	Dolicholatirus exilis confertus	MacNeil and Dockery 1984
	Dolicholatirus perexilis	MacNeil and Dockery 1984
	Epitonium (*Gryoscala*) sp.	MacNeil and Dockery 1984
	Epitonium (*Sthenorytis*) *whitfieldi*	MacNeil and Dockery 1984
	Epitonium sp.?	MacNeil and Dockery 1984
	Eulimella clearyensis	MacNeil and Dockery 1984
	Eulimella sp.	MacNeil and Dockery 1984
	Eumetula vicksburgella	MacNeil and Dockery 1984
	Euspira vicksburgensis	MacNeil and Dockery 1984
	Euspira vicksburgensis cookei	MacNeil and Dockery 1984
	Euspira sp.?	MacNeil and Dockery 1984
	Ficus mississippiensis	MacNeil and Dockery 1984
	Fusiturricula ichusa	MacNeil and Dockery 1984
	Galeodaria shubutensis	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Galeodaria shubutensis gardnerae*	MacNeil and Dockery 1984
	Galeodaria tricarinata	MacNeil and Dockery 1984
	Gemmula amica	MacNeil and Dockery 1984
	Gemmula amica var. A	MacNeil and Dockery 1984
	Gemmula mediosa	MacNeil and Dockery 1984
	Gemmula rotaedens	MacNeil and Dockery 1984
	Harpa vicksburgiana	MacNeil and Dockery 1984
	Hipponix pygmaeus	MacNeil and Dockery 1984
	Kurtziella protatrostyla	MacNeil and Dockery 1984
	Latirus aldrichi	MacNeil and Dockery 1984
	Latirus indistinctus	MacNeil and Dockery 1984
	Latirus mississippiensis	MacNeil and Dockery 1984
	Latirus protractus	MacNeil and Dockery 1984
	Levifusus nodulatum	MacNeil and Dockery 1984
	Levifusus spiniger	MacNeil and Dockery 1984
	Limacina cf. *L. inflata*	MacNeil and Dockery 1984
	Limacina sp.	MacNeil and Dockery 1984
	Litiopa meyeri	MacNeil and Dockery 1984
	Lyria (*Enaeta*) *isabellae modesta*	MacNeil and Dockery 1984
	Lyria (*Lyria*) *mississippiensis*	MacNeil and Dockery 1984
	Lyria (*Lyria*) *nestor*	MacNeil and Dockery 1984
	Mambrinia brevidentata	MacNeil and Dockery 1984
	Marginella sp.?	MacNeil and Dockery 1984
	Mathilda inaequistriata	MacNeil and Dockery 1984
	Mathilda aff. *M. plexita*	MacNeil and Dockery 1984
	Mathilda regularis	MacNeil and Dockery 1984
	Melanatria serratoides	MacNeil and Dockery 1984
	Melanella amnicreta	MacNeil and Dockery 1984
	Melanella postnotata	MacNeil and Dockery 1984
	Melanella sp.	MacNeil and Dockery 1984
	Melongena (*Myristica*) *crassicornuta*	MacNeil and Dockery 1984
	Metula (*Caseyella*) *blakneyensis*	MacNeil and Dockery 1984
	Metula (*Caseyella*) *hiwanneensis*	MacNeil and Dockery 1984
	Metula (*Caseyella*) *neptuneiformis*	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Metula* (*Metula*) *fastidiosa*	MacNeil and Dockery 1984
	Metula (*Metula*) *fragilis*	MacNeil and Dockery 1984
	Metula (*Metula*) *inflata*	MacNeil and Dockery 1984
	Microdrillia brevis	MacNeil and Dockery 1984
	Microdrillia brevis allo	MacNeil and Dockery 1984
	Microdrillia brevis gemma	MacNeil and Dockery 1984
	Microdrillia infans	MacNeil and Dockery 1984
	Microdrillia vicksburgella	MacNeil and Dockery 1984
	Microsurcula intacta	MacNeil and Dockery 1984
	Microsurcula intacta jayensis	MacNeil and Dockery 1984
	Microsurcula intacta var. A	MacNeil and Dockery 1984
	Microsurcula mentha	MacNeil and Dockery 1984
	Microsurcula mentha var. A	MacNeil and Dockery 1984
	Mitodrillia harmonica	MacNeil and Dockery 1984
	Mitodrillia pharus	MacNeil and Dockery 1984
	Mitodrillia pharus crassispiropsis	MacNeil and Dockery 1984
	Mitra (*Fusimitra*) *conquisita*	MacNeil and Dockery 1984
	Mitra (*Fusimitra*) *mississippiensis*	MacNeil and Dockery 1984
	Mitrella (*Columbellopsis*) *fuscicava*	MacNeil and Dockery 1984
	Mitrella (*Columbellopsis*) *oryzoides*	MacNeil and Dockery 1984
	Mitrella (*Columbellopsis*) aff. *M.* (*C.*) *oryzoides*	MacNeil and Dockery 1984
	Murexiella (*Murexiella*) *vaughani*	MacNeil and Dockery 1984
	Natica (*Natica*) *caseyi*	MacNeil and Dockery 1984
	Natica (*Naticarius*) aff. *N.* (*N.*) *alazana*	MacNeil and Dockery 1984
	Natica (*Naticarius*) *acuticallosa*	MacNeil and Dockery 1984
	Niso fuscicava	MacNeil and Dockery 1984
	Odostomia (*Miralda*) *menthafons*	MacNeil and Dockery 1984
	Odostomia (*Odostomia*) aff. *O.* (*O.*) *angularis*	MacNeil and Dockery 1984
	Odostomia (*Odostomia*) *boettgeri*	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Odostomia* (*Odostomia*) *byramensis*	MacNeil and Dockery 1984
	Odostomia (*Odostomia*) *byramensis* var.?	MacNeil and Dockery 1984
	Odostomia (*Odostomia*) *vicksburgella*	MacNeil and Dockery 1984
	Odostomia (*Odostomia*) sp.	MacNeil and Dockery 1984
	Oliva (*Strephonella*) *affluens*	MacNeil and Dockery 1984
	Oliva (*Strephonella*) *mississippiensis*	MacNeil and Dockery 1984
	Olivella (*Callianax*) *vicksburgensis*	MacNeil and Dockery 1984
	Olivella (*Callianax*) *vicksburgensis* var.	MacNeil and Dockery 1984
	Olssonella elongata	MacNeil and Dockery 1984
	Oniscidia harpula	MacNeil and Dockery 1984
	Onoba sp.?	MacNeil and Dockery 1984
	Persicula vicksburgensis	MacNeil and Dockery 1984
	Phalium (*Menthafontia*) *menthafons*	MacNeil and Dockery 1984
	Phalium (*Menthafontia*) *mississippiensis*	MacNeil and Dockery 1984
	Phalium (*Menthafontia*) sp.	MacNeil and Dockery 1984
	Phandella monroensis	MacNeil and Dockery 1984
	Phandella nepionica	MacNeil and Dockery 1984
	Phandella sp.	MacNeil and Dockery 1984
	Phandella transemma	MacNeil and Dockery 1984
	Phos (*Antillophos*) *hopkinsi*	MacNeil and Dockery 1984
	Phos (*Strongylocera*) *caseyi*	MacNeil and Dockery 1984
	Phos (*Strongylocera*) *vicksburgensis*	MacNeil and Dockery 1984
	Pleurofusia (*Xestocurcula*) *fessa*	MacNeil and Dockery 1984
	Pleurofusia (*Xestocurcula*) *plutonica*	MacNeil and Dockery 1984
	Pleurofusia clarkeana	MacNeil and Dockery 1984
	Pleurofusia clarkeana fascia	MacNeil and Dockery 1984
	Pleurofusia clarkeana juba	MacNeil and Dockery 1984
	Pleurofusia decliva	MacNeil and Dockery 1984
	Pleurofusia decliva asper	MacNeil and Dockery 1984
	Pleurofusia elegantula	MacNeil and Dockery 1984
	Pleurofusia hiwanneensis	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Pleurofusia longirostropsis*	MacNeil and Dockery 1984
	Pleurofusia longirostropsis bicollaris	MacNeil and Dockery 1984
	Pleurofusia menthafons	MacNeil and Dockery 1984
	Pleurofusia menthafons var. A	MacNeil and Dockery 1984
	Pleurofusia oblivia	MacNeil and Dockery 1984
	Pleurofusia servata	MacNeil and Dockery 1984
	Pleurofusia servata var. A	MacNeil and Dockery 1984
	Pleurofusia servata var. B	MacNeil and Dockery 1984
	Pleurofusia trichordia	MacNeil and Dockery 1984
	Pleurofusia wythei	MacNeil and Dockery 1984
	Pleuroliria cochlearis	MacNeil and Dockery 1984
	Pleuroliria cochlearis vetula	MacNeil and Dockery 1984
	Pleuroliria subsimilis	MacNeil and Dockery 1984
	Pleuroliria tenuis	MacNeil and Dockery 1984
	Pleurotoma eboroides	MacNeil and Dockery 1984
	Pleurotoma mississippiensis	MacNeil and Dockery 1984
	Pliciscala (*Nodiscala*?) *byramensis*	MacNeil and Dockery 1984
	Pliciscala (*Nodiscala*?) *caseyi*	MacNeil and Dockery 1984
	Pliciscala (*Nodiscala*?) n. sp.	MacNeil and Dockery 1984
	Pliciscala (*Punctiscala*) *cookei*	MacNeil and Dockery 1984
	Poirieria (*Panamurex*) *macneili*	MacNeil and Dockery 1984
	Pseudofulgur lirata	MacNeil and Dockery 1984
	Pseudofulgur vicksburgensis	MacNeil and Dockery 1984
	Pterynotus (*Pterochelus*) *angelus*	MacNeil and Dockery 1984
	Pterynotus (*Pteryonotus*) *burnsii*	MacNeil and Dockery 1984
	Pyramidella (*Voluspa*) *chavanoidea*	MacNeil and Dockery 1984
	Pyramidella (*Voluspa*) *leafensis*	MacNeil and Dockery 1984
	Pyramidella (*Voluspa*) sp.	MacNeil and Dockery 1984
	Pyramidella (*Voluspa*?) *microcosta*	MacNeil and Dockery 1984
	Pyrunculus laevipyrum	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Rictaxis andersoni*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *crassata*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *irrasa*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *mississippiensis*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *mississippiensis nuda*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *mississippiensis petila*	MacNeil and Dockery 1984
	Ringicula (*Ringiculella*) *mississippiensis* subsp.?	MacNeil and Dockery 1984
	Sablea minuta	MacNeil and Dockery 1984
	Sassia (*Byramia*) *abbreviata*	MacNeil and Dockery 1984
	Sassia (*Byramia*) *abbreviata* var.	MacNeil and Dockery 1984
	Sassia (*Byramia*) *caseyi*	MacNeil and Dockery 1984
	Sassia (*Byramia*) *mississippiensis*	MacNeil and Dockery 1984
	Sassia (*Cymatiella*) *fuscicava*	MacNeil and Dockery 1984
	Sassia (*Sassia*) *conradiana*	MacNeil and Dockery 1984
	Sassia (*Sassia*) *conradiana menthafons*	MacNeil and Dockery 1984
	Scalina methafontis	MacNeil and Dockery 1984
	Scalina rubricollis	MacNeil and Dockery 1984
	Scalina trigintanaria	MacNeil and Dockery 1984
	Scalina trigintanaria hopkinsi	MacNeil and Dockery 1984
	Scalina trigintanaria var.?	MacNeil and Dockery 1984
	Scaphander (*Coeloscapha*) *hilgardi*	MacNeil and Dockery 1984
	Scaphander (*Scaphander*) *primus*	MacNeil and Dockery 1984
	Scobinella caelata	MacNeil and Dockery 1984
	Scobinella famelica	MacNeil and Dockery 1984
	Scobinella macer	MacNeil and Dockery 1984
	Scobinella pluriplicata	MacNeil and Dockery 1984
	Scobinella pluriplicata subpluriplicata	MacNeil and Dockery 1984
	Sconsia lintea	MacNeil and Dockery 1984
	Sconsia prelintea	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Seila* aff. *S. constricta*	MacNeil and Dockery 1984
	Seila sp.	MacNeil and Dockery 1984
	Semicassis caelatura	MacNeil and Dockery 1984
	Semivertagus menthafontis	MacNeil and Dockery 1984
	Semivertagus silvacollinis	MacNeil and Dockery 1984
	Serpulorbis sp.	MacNeil and Dockery 1984
	Sigatica conradii	MacNeil and Dockery 1984
	Simnia (*Calpurna*) *cookei*	MacNeil and Dockery 1984
	Sinum (*Sigaretotrema*) cf. *S.* (*S.*) *danvillense*	MacNeil and Dockery 1984
	Sinum (*Sigaretotrema*) *mississippiensis*	MacNeil and Dockery 1984
	Sinum (*Sinum*) aff. *S.* (*S.*) *beatricae*	MacNeil and Dockery 1984
	Siphonochelus (*Laevityphis*) *curvirostratus*	MacNeil and Dockery 1984
	Solariella clearyensis	MacNeil and Dockery 1984
	Solariella fragum	MacNeil and Dockery 1984
	Solariella laevifundia	MacNeil and Dockery 1984
	Solariella menthafontis	MacNeil and Dockery 1984
	Solariella tallahalaensis	MacNeil and Dockery 1984
	Solariorbis sp.	MacNeil and Dockery 1984
	Spiradaphne lowei	MacNeil and Dockery 1984
	Spiradaphne lowei refugium	MacNeil and Dockery 1984
	Strombiformis caseyi	MacNeil and Dockery 1984
	Sulcocypraea healeyi	MacNeil and Dockery 1984
	Sulcocypraea lintea	MacNeil and Dockery 1984
	Sulcocypraea lintea menthafons	MacNeil and Dockery 1984
	Sulcucypraea cf. *S. healyi*	MacNeil and Dockery 1984
	Syntomodrillia collarubra	MacNeil and Dockery 1984
	Syntomodrillia funis	MacNeil and Dockery 1984
	Syntomodrillia funis var. A	MacNeil and Dockery 1984
	Syntomodrillia tantula	MacNeil and Dockery 1984
	Syntomodrillia tantula var. A	MacNeil and Dockery 1984
	Teinostoma (*Idioraphe*) *minuta*	MacNeil and Dockery 1984
	Teinostoma (*Idioraphe*) *verrilli*	MacNeil and Dockery 1984
	Teinostoma (*Teinostoma*) *caseyi*	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Telescopium leafensis*	MacNeil and Dockery 1984
	Terebra (*Laeviterebrum*) *spinula*	MacNeil and Dockery 1984
	Terebra (*Strioterebrum*) *alaba*	MacNeil and Dockery 1984
	Terebra (*Strioterebrum*) sp.	MacNeil and Dockery 1984
	Terebra (*Strioterebrum*) *tantula*	MacNeil and Dockery 1984
	Terebra (*Strioterebrum*) *vincta*	MacNeil and Dockery 1984
	Terebra (*Terebrellina*) *divisura clearyensis*	MacNeil and Dockery 1984
	Terebra (*Terebrellina*) *divisurum*	MacNeil and Dockery 1984
	Terebra (*Terebrellina*) *hiwanneensis*	MacNeil and Dockery 1984
	Tornatellaea brevispira	MacNeil and Dockery 1984
	Tornatellaea sp.?	MacNeil and Dockery 1984
	Tornus infraplicatus	MacNeil and Dockery 1984
	Triphora (*Euthymella*) *fuscicava*	MacNeil and Dockery 1984
	Triphora (*Triphora*) *bilineata*	MacNeil and Dockery 1984
	Triphora (*Triphora*) *menthafons*	MacNeil and Dockery 1984
	Triphora (*Triphora*) *meridionalis*	MacNeil and Dockery 1984
	Tritiaria falsus	MacNeil and Dockery 1984
	Tritiaria macilenta	MacNeil and Dockery 1984
	Tritiaria menthafons	MacNeil and Dockery 1984
	Tritiaria meyeri	MacNeil and Dockery 1984
	Tritiaria meyeri n. subsp.?	MacNeil and Dockery 1984
	Tritiaria mississippiensis	MacNeil and Dockery 1984
	Tritiaria mississippiensis cookei	MacNeil and Dockery 1984
	Tritiaria refugensis	MacNeil and Dockery 1984
	Tritiaria scapulistriata	MacNeil and Dockery 1984
	Tritiaria vaughani	MacNeil and Dockery 1984
	Tritiaria cf. *T. vaughani*	MacNeil and Dockery 1984
	Tropisurcula caseyi	MacNeil and Dockery 1984
	Turbinella wilsoni	MacNeil and Dockery 1984
	Turbonilla caseyi	MacNeil and Dockery 1984
	Turbonilla leafensis	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Turbonilla mississippiensis*	MacNeil and Dockery 1984
	Turricula (*Orthosurcula*) *byramensis*	MacNeil and Dockery 1984
	Turricula (*Orthosurcula*) *longiforma*	MacNeil and Dockery 1984
	Turritella boycensis	MacNeil and Dockery 1984
	Turritella caelatura	MacNeil and Dockery 1984
	Turritella caelatura var.	MacNeil and Dockery 1984
	Turritella carota	MacNeil and Dockery 1984
	Turritella caseyi	MacNeil and Dockery 1984
	Turritella mississippiensis	MacNeil and Dockery 1984
	Turritella mundula	MacNeil and Dockery 1984
	Turritella aff. *T. planigyrata*	MacNeil and Dockery 1984
	Turritella premimetes	MacNeil and Dockery 1984
	Turritella aff. *T. premimetes*	MacNeil and Dockery 1984
	Turritella rubricollis	MacNeil and Dockery 1984
	Typhis (*Typhinia*) *mississippiensis*	MacNeil and Dockery 1984
	Umbraculum sp.	MacNeil and Dockery 1984
	Urosalpinx? *aspinosus*	MacNeil and Dockery 1984
	Varicobela aldrichi	MacNeil and Dockery 1984
	Varicobela smithii	MacNeil and Dockery 1984
	Vetidrillia palmerae	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *cellulifera*	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *cervilirata*	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *laevicostata*	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *lintoidea*	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *multicostata*	MacNeil and Dockery 1984
	Vexillum (*Costellaria*) *tallahalaensis*	MacNeil and Dockery 1984
	Vitrinella (*Vitrinella*) *laevis*	MacNeil and Dockery 1984
	Vitrinella (*Vitrinella*) *meyeri*	MacNeil and Dockery 1984
	Vitrinella (*Vitrinella*) *vicksburgensis*	MacNeil and Dockery 1984
	Vitrinella (*Vitrinellops*) sp.	MacNeil and Dockery 1984
	Volema hopkinsi	MacNeil and Dockery 1984

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Mollusca: Gastropoda (snails) (continued)	*Volvulella subspinosa*	MacNeil and Dockery 1984
	Xenophora (*Stellaria*) *conica*	MacNeil and Dockery 1984
	Xenophora (*Xenophora*) *humilis*	MacNeil and Dockery 1984
	Xenophora (*Xenophora*) cf. *X.* (*X.*) *reclusa*	MacNeil and Dockery 1984
Mollusca: Scaphopoda (tusk shells)	*Cadulus* (*Polyschides*) *corpulentus*	MacNeil and Dockery 1984
	Cadulus (*Polyschides*) *quadriturritus*	MacNeil and Dockery 1984
	Cadulus (*Polyschides*) *vicksburgensis*	MacNeil and Dockery 1984
	Dentalium mississippiensis	MacNeil and Dockery 1984
	Dentalium opaculum	MacNeil and Dockery 1984
	Dentalium polygonuum	MacNeil and Dockery 1984
	Dentalium strenuum	MacNeil and Dockery 1984
	Dentalium varicostata	MacNeil and Dockery 1984
	Dentalium zephyrinum	MacNeil and Dockery 1984
	Fustiaria (*Episiphon*) *menthifonta*	MacNeil and Dockery 1984
	Fustiaria (*Fustiaria*) sp.	MacNeil and Dockery 1984
	Fustiaria (*Rhabdus*) sp.	MacNeil and Dockery 1984
Arthropoda: Crustacea: Malacostraca (crabs, lobsters, etc.)	*Callianassa berryi*	Rathbun 1935
	Necronectes vaughani	Rathbun 1935
	Portunus (?) *vicksburgensis*	Stenzel 1935
Arthropoda: Crustacea: Ostracoda (seed shrimp)	*Actinocythereis dacyi*	Hazel et al. 1980
	Actinocythereis quadrataspinata	Hazel et al. 1980
	Actinocythereis thomsoni	Hazel et al. 1980
	Alatacythere ivani	Hazel et al. 1980
	Argilloecia hiwanneensis	Hazel et al. 1980
	Aurila kniffeni	Hazel et al. 1980
	Bensonocythere sp.	Hazel et al. 1980
	Buntonia huneri	Hazel et al. 1980
	Bythocypris mississippiensis	Hazel et al. 1980
	Cocoaia vicksburgensis	Hazel et al. 1980
	Cytherella sp.	Hazel et al. 1980
	Cytherelloidea hiwanneensis	Hazel et al. 1980
	Cytherelloidea vicksburgensis	Hazel et al. 1980

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Arthropoda: Crustacea: Ostracoda (seed shrimp)	*Cytheromorpha rosefieldensis*	Hazel et al. 1980
	Cytheromorpha vicksburgensis	Hazel et al. 1980
	Cytheropteron danvillensis	Hazel et al. 1980
	Digmocythere russelli	Hazel et al. 1980
	Echinocythereis jacksonensis	Hazel et al. 1980
	Eucythere sp.	Hazel et al. 1980
	Ghardaglaia obovata	Hazel et al. 1980
	Hermanites weaveri	Hazel et al. 1980
	Hemicyprideis blanpiedi	Hazel et al. 1980
	Jugosocythereis vicksburgensis	Hazel et al. 1980
	Konarocythere fiski	Hazel et al. 1980
	Krithe hiwanneensis	Hazel et al. 1980
	Leguminocythereis edwardsae	Hazel et al. 1980
	Loxoconcha woodwardensis	Hazel et al. 1980
	Loxoconcha yazooensis	Hazel et al. 1980
	Macrocyprina gibsonensis	Hazel et al. 1980
	Occultocythereis kempi	Hazel et al. 1980
	Paracypris rosefieldensis	Hazel et al. 1980
	Paracytheridea byramensis	Hazel et al. 1980
	Patellacythere youngi	Hazel et al. 1980
	Pontocypris rosefieldensis	Hazel et al. 1980
	Pontocythere sp.	Hazel et al. 1980
	Psammocythere vicksburgensis	Hazel et al. 1980
	Trachyleberidea blanpiedi	Hazel et al. 1980
	Xestoleberis sp.	Hazel et al. 1980
Echinodermata: Echinoidea (sea urchins)	*Clypeaster rogersi*	Cooke 1942; Carter and Beisel 1987
	Rhyncholampas gouldii	Carter and Beisel 1987
	Schizaster (*Paraster*) *americanus*	Cooke 1942
Vertebrata: Chondrichthyes (sharks and rays)	*Otodus angustidens* (=*Carcharodon auriculatus*)	Dockery and Manning 1986; Hodnett et al. 2022
Vertebrata: Actinopterygii (ray-finned fishes)	*Ariosoma* sp.	Ivany et al. 2000
	Corvina gemma	Frizzell and Dante 1965

Appendix A-Table 3 (continued). Fossil taxa of the Vicksburg Group. The taxa included here come from a selection of publications which include fossil collections from in or near Vicksburg. Most listed species belong to either the Mint Spring or Byram Formations, with many appearing in multiple formations.

Group	Taxon	Reference
Vertebrata: Actinopterygii (ray-finned fishes) (continued)	*Corvina pseudoradians*	Frizzell and Dante 1965
	Holocentrites ovalis	Dockery and Thompson 2016
Vertebrata: Mammalia (mammals)	*Metamynodon* sp.	Manning et al. 1985
	Subhyracodon occidentalis	Manning 1997
Foraminifera	*Angulogerina rugoplicata*	Cushman 1935
	Anomalina vicksburgensis	Cushman 1922
	Bolivina caelata var. *byramensis*	Cushman 1923
	Bolivina garretti	Cushman 1935
	Bolivina mornhinvegi	Cushman 1935
	Bolivina vicksburgensis	Cushman 1922
	Bulimina ovata var. primitiva	Todd 1952
	Cristellaria vicksburgensis var. *aperta*	Cushman 1923
	Dentalina monroei	Todd 1952
	Discorbis arcuato-costata	Cushman 1935
	Entosolenia crumenata	Cushman 1935
	Orbitolites supera [*Lepidocyclina*]	Conrad 1865b
	Patellina advena	Cushman 1922
	Polymorphina advena	Cushman 1922
	Polymorphina cuspidata var. *costulata*	Cushman 1922
	Polymorphina vicksburgensis	Cushman 1922
	Pyrgo oligocenica	Cushman 1935
	Quinqueloculina cookei	Cushman 1922
	Quinqueloculina fulgida	Todd 1952
	Reussella rectimargo var. *hebetata*	Cushman 1945
	Rotalia dentata var. *parva*	Cushman 1922
	Rotalia incisura	Todd 1952
	Triloculina peroblonga	Cushman 1922
	Triloculina sculpturata	Cushman 1922
	Valvulineria sculpturata	Cushman 1935
	Verneuilina rectimargo	Cushman 1922

Appendix A-Table 4. Fossil genera identified in the Byram Formation in VICK through the 2022 survey.

Group	Genus	Locality	Reference
Cnidaria: Anthozoa (corals)	*Archohelia*	VPFV-CVB22-0055	Conrad 1848a
Mollusca: Bivalvia (clams, oysters, etc.)	*Callista*	VPFV-CVB22-0055	Dockery 1982a
	Chamelea	VPFV-CVB22-0055	Dockery 1982a
	Corbula	VPFV-CVB22-0055	Dockery 1982a
	Crassatella	VPFV-CVB22-0055	Dockery 1982a
	Nemocardium	VPFV-CVB22-0055	Dockery 1982a
	Pecten	VPFV-CVB22-0055	Dockery 1982a
	Scapharca	VPFV-CVB22-0055	Dockery 1982a
Mollusca: Gastropoda (snails)	*Bathytoma*	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Chicoreus	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Conorbis	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Coronia	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Crassispira	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Euspira	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Latirus	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Natica	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Oliva	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Olivella	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Pleurofusia	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Pleuroliria	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Sinum	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Terebra	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Tritiaria	VPFV-CVB22-0055	MacNeil and Dockery 1984
	Conus	VPFV-CVB22-0062	MacNeil and Dockery 1984
	Siphonochelus	VPFV-CVB22-0062	MacNeil and Dockery 1984
	Turbinella	VPFV-CVB22-0062	MacNeil and Dockery 1984
Mollusca: Scaphopoda (tusk shells)	*Dentalium*	VPFV-CVB22-0055	Casey 1903

Charles Alexandre Lesueur illustrated a number of Vicksburg fossil taxa but the plates were not published before his death in 1847, as documented in Dockery (1982a, 1982b). The plates are of sufficient quality to identify many of the fossils to published taxa, but the great majority of the names Lesueur applied to them have never been used elsewhere, indicating he was planning on publishing descriptions. Because many of these names have no scientific standing and others were later formally used inadvertently by other authors for other taxa, it would be confusing to include them in the above tables, so they have been extracted and included in a separate table below (Appendix A-Table 5). Asterisks (*) indicate unpublished names. Double asterisks (**) indicate names that were later used by other authors. It is possible that some of the names not indicated by asterisks are also unrelated to other usages extant at Lesueur's time. Similarly, there may be false positives based on misspellings of existing taxa. Some instances of "f" as reported by Dockery have been changed to "s". Modern identifications of bivalves (Dockery 1982a) and gastropods (MacNeil and Dockery 1984) are included.

Appendix A-Table 5. Lesueur's Vicksburg taxa, as documented in Dockery (1982a, 1982b).

Group	Lesueur's Identification	Modern Identifications
Cnidaria: Anthozoa (corals)	*Oculina virginea*	–
Bryozoa (moss animals)	**Cellepora incideus*	–
	**Cupuloporites digitalis*	–
	**Cupuloporites discoides*	–
Mollusca: Bivalvia (clams, oysters, etc.)	**Arca bifasciata*	*Scapharca* (*Scapharca*) *lesueuri*
	Arca fragilis	*Barbatia mississippiensis*
	**Cardita semiradiata*	*Nemocardium* (*Nemocardium*) *diversum*
	**Corbula distorta*	*Corbula* (*Varicorbula*) *laqueata*
	Corbula rostrata	*Corbula* (*Caryocorbula*) *engonata*
	Crassatella tellinoides	*Crassatella* (*Crassatella*) *mississippiensis*
	**Cytherea circulifera*	*Pitar* (*Lamelliconcha*) *imitabilis*
	**Cytherea mortonia*	*Callista* (*Callista*) *sobrina*
	**Lima parvula*	*Limaria* (*Limaria*) *staminea*
	**Lucina lenticularia*	–
	Nucula concentrica Say?	–
	Ostrea paroxis	(formalized by Dockery 1982a)
	**Ostrea pseudofoliata*	*Lopha* (*Lopha*) *vicksburgensis*
	Panopea elongata	*Panopea* (*Panopea*) *oblongata*
	**Pecten limatula*	*Pecten* (*Pecten*) *byramensis*

Appendix A-Table 5 (continued). Lesueur's Vicksburg taxa, as documented in Dockery (1982a, 1982b).

Group	Lesueur's Identification	Modern Identifications
	**Pecten unicarinata*	*Pecten* (*Pecten*) *poulsoni*
	Pectunculus minutus	–
	Pinna radiata	*Atrina argentea*
	Tellina minutissima	–
Mollusca: Gastropoda (snails)	*Ampullaria depressa*	–
	**Buccinum circumscripta*?	*Galeodaria tricarinata*
	**Buccinum minutissma*	–
	**Buccinum reticulatum*	–
	**Buccinum*? *unidentata*	–
	**Bulla oviformis elongata*	*Cylichna nida*
	**Calyptrocrepidula*	–
	**Cassidaria bicostata*	–
	**Cassidaria granulata*	*Semicassis caelatura*
	**Cassidaria minutissima*	–
	**Cassidaria polita*	–
	***Cerithium undulatum*	*Terebra* (*Terebrellina*) *divisura*
	***Conus defrancii*	*Conus alveatus*
	**Conus nonperditus*	*Conus alveatus*
	**Conus peronii*	*Conus alveatus*
	**Fusus brogniartii*	*Clavilithes lesueuri*
	**Hyalites daudin*	–
	**Mitra pleurotomia*	–
	**Mitra sulcofus*	–
	**Murex coringera*	–
	Murex tubifera	*Siphonochelus* (*Laevityphis*) *curvirostratus*
	***Natica obovata*	–
	**Naticoides sigarettoides*	*Sigatica conradii*
	**Oliva saya*	–
	***Phasianellide* (=*Phasianella*) *elongata*	–
	***Pleurotoma costata*	*Crassispira* (*Crassispirella*) *abundans*
	Pleurotoma fusiformis	*Coronia* (*Coroniopsis*) *tenella*
	**Pleurotoma semserricta*?	*Conorbis porcellanus*
	**Pleurotoma undulata*	*Bathytoma congesta*
	**Potamida* (=*Potamides*) *cruciata*	–
	Ranella ventricosa?	–

Appendix A-Table 5 (continued). Lesueur's Vicksburg taxa, as documented in Dockery (1982a, 1982b).

Group	Lesueur's Identification	Modern Identifications
Mollusca: Gastropoda (snails) (continued)	**Sigareta striata*	*Sinum* (*Sigaretotrema*) *mississippiensis*
	**Solarium denticulata*	–
	**Trochus compressa*	–
	**Turbinella cliffordia*	*Turbinella wilsoni*
	Turbinella eburnea	*Caricella* (*Atraktus*) *demissa*
	Turbinella obsoleta	*Latirus protractus*
	**Turbinella rostrata*	*Dolicholatirus perexills*
	**Voluta harpoides*	*Lyria* (*Lyria*) *mississippiensis*
Mollusca: Scaphopoda (tusk shells)	***Dentalium fragilis*	–
	**Dentalium prolifera*	–
Annelida (segmented worms)	**Emphitrites dubia*	(probably the bivalve *Kuphus*)
Echinodermata: Echinoidea (sea urchins)	**Echinites fragilis*	–
Vertebrata: Chondrichthyes (sharks and rays)	*Raia quadrilobata*	–
	Squalus africanus	–
	**Squalus cuvierii*	–
	Squalus littoralis	–
	Squalus obscurus	–
	Squalus perlon	–
	**Squalus rissoi*	–
	**Squalus spalanzani*	–
Foraminifera	**Cruciolaria elliptica*	–
	**Cruciolaria orbicularia*	–
	**Discorbis subglobulosa*	–
	**Lenticulina dorbignya*	–
	**Lenticulina ferrussi*	–
	**Orbulites mamila*	–
	**Orbulites scutella*	–

Appendix B: Taxa Named From VICK Fossils

The following taxa listed in Appendix B-Table 1 were described from fossils collected within VICK. All of them were named after VICK was established as a park in 1899, but many of them predate the park's transfer to the NPS in 1933. Some of the species have since been assigned to other genera, or synonymized with other species; original usage is given here. A similar appendix (Appendix C) follows, listing taxa named from specimens possibly collected within VICK.

Institutional Abbreviations—USNM, Smithsonian Institution, National Museum of Natural History, Washington, D.C. Contact information for this repository can be found in Appendix D.

Appendix B-Table 1. Fossil taxa named from specimens found within VICK.

Group	Taxon	Age, Formation	Type Specimen	Citation
Mollusca: Bivalvia (clams, oysters, etc.)	*Trinacria menthifontis*	Oligocene, Mint Spring	USNM 340426	Dockery 1982a
	Crenella fenestra	Oligocene, Mint Spring	USNM 340430	Dockery 1982a
	Astarte planilamella	Oligocene, Mint Spring	USNM 340455	Dockery 1982a
	Tellina subprotexta	Oligocene, Mint Spring	USNM 340472	Dockery 1982a
Mollusca: Gastropoda (snails)	*Phos* (*Antillophos*) *hopkinsi*	Oligocene, Mint Spring	USNM 376473	MacNeil (in MacNeil and Dockery 1984)
	Pleurofusia wythei	Oligocene, Mint Spring	USNM 376491	MacNeil (in MacNeil and Dockery 1984)
	Phos (*Strongylocera*) *caseyi*	Oligocene, Mint Spring	USNM 498227	MacNeil (in MacNeil and Dockery 1984)
	Aporrhais (*Goniocheila*) *menthafontis*	Oligocene, Mint Spring	USNM 498245	MacNeil (in MacNeil and Dockery 1984)
	Ringicula (*Ringiculella*) *crassata*	Oligocene, Mint Spring	USNM 560917	MacNeil (in MacNeil and Dockery 1984)
	Scalina trigintanaria	Oligocene, Mint Spring	USNM 648883	MacNeil (in MacNeil and Dockery 1984)
Arthropoda: Crustacea: Malacostraca	*Portunus* (?) *vicksburgensis*	Oligocene, Vicksburg Group	Not stated	Stenzel 1935
Arthropoda: Crustacea: Ostracoda	*Ghardaglaia obovata*	Oligocene, Mint Spring	Specimen in sample 3/8 (at Louisiana State University)	Mumma (in Hazel et al. 1980)

Appendix B-Table 1 (continued). Fossil taxa named from specimens found within VICK.

Group	Taxon	Age, Formation	Type Specimen	Citation
Foraminifera	*Anomalina vicksburgensis*	Oligocene, Mint Spring	Syntypes Cushman Collection 59668 (USNM)	Cushman 1922
	Bolivina vicksburgensis	Oligocene, Mint Spring	Cushman Collection 23770 (USNM)	Cushman 1922
	Patellina advena	Oligocene, Mint Spring	USNM 371297	Cushman 1922
	Polymorphina advena	Oligocene, Mint Spring	Cushman Collection (USNM)?	Cushman 1922
	Polymorphina cuspidata var. *costulata*	Oligocene, Mint Spring	USNM 371186	Cushman 1922
	Polymorphina vicksburgensis	Oligocene, Mint Spring	Cushman Collection 25639 (USNM)	Cushman 1922
	Quinqueloculina cookei	Oligocene, Mint Spring	Syntypes USNM 371228	Cushman 1922
	Rotalia dentata var. *parva*	Oligocene, Mint Spring	Cushman Collection 59665 (USNM)	Cushman 1922
	Triloculina peroblonga	Oligocene, Mint Spring	USNM 372110	Cushman 1922
	Triloculina sculpturata	Oligocene, Mint Spring	USNM 372112	Cushman 1922
	Verneuilina rectimargo	Oligocene, Mint Spring	Cushman Collection (USNM)?	Cushman 1922
	Bulimina ovata var. *primitiva*	Oligocene, Byram	Cushman Collection 47525 (USNM)	Todd 1952
	Dentalina monroei	Oligocene, Byram	Cushman Collection 47540 (USNM)	Todd 1952
	Quinqueloculina fulgida	Oligocene, Mint Spring	Cushman Collection 47517 (USNM)	Todd 1952
	Rotalia incisura	Oligocene, Byram	Cushman Collection 47558 (USNM)	Todd 1952

Appendix C: Taxa Potentially Named From VICK Fossils

The following taxa listed in Appendix C-Table 1 were described from fossils collected somewhere in or near VICK, but the locality information is insufficient to be certain about the exact location. Most of them were named before 1900, and the provenance for many of them is limited to the Vicksburg Group of Vicksburg. As with Appendix B, many of the species have since been assigned to other genera, or synonymized with other species; original usage is given here. Many of these taxa were described at a time when including catalog and repository information were not included; this information has been reconstructed from various later sources, including Schuchert (1905), Moore (1962), Richards (1968) (which has numerous typographical errors), Dockery (1982a), and MacNeil and Dockery (1984). Taxa reportedly from Vicksburg in Whitfield (1865) are actually from Alabama, per Palmer and Brann (1966). Most of the type specimens are holotypes, the original singular type specimen designated by the original authority. Some are syntypes (abbreviated “Syn.” in the table), a series of specimens, or cotypes (an obsolete term meaning approximately the same thing). Others are lectotypes (abbreviated “Lecto.” in the table), which were designated post-hoc when an authority did not designate a holotype. “Oligocene” has been abbreviated as “Olig.” and “Group” in the Stratigraphy column has been abbreviated “Grp.”

Institutional Abbreviations—**ANSP**, The Academy of Natural Sciences of Drexel University, Philadelphia, Pennsylvania; **PRI**; Paleontological Research Institution, Ithaca, New York; **USNM**, Smithsonian Institution, National Museum of Natural History, Washington, D.C. Contact information for these repositories can be found in Appendix D.

Appendix C-Table 1. Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Cnidaria: Anthozoa (corals)	*Madrepora mississippiensis*	Olig., Vicksburg Grp.	Unspecified ANSP cotypes	Conrad 1848a
	Madrepora vicksburgensis	Olig., Vicksburg Grp.	Unknown	Conrad 1848a
	Turbinolia caulifera	Olig., Vicksburg Grp.	Unknown	Conrad 1848a
Bryozoa (moss animals)	*Lunulites vicksburgensis*	Olig., Vicksburg Grp.	Probable syn. ANSP 13411	Conrad 1848a
	Membrendoecium lowei	Olig., Byram	USNM 64233	Canu and Bassler 1920
	Reptocelleporaria glomerata	Olig., Vicksburg Grp.	Unspecified ANSP type	Gabb and Horn 1862
Mollusca: Bivalvia (clams, oysters, etc.)	*Abra protexta*	Olig., Vicksburg Grp.	ANSP 30704	Conrad 1871
	Amphidesma mississippiensis	Olig., Vicksburg Grp.	ANSP 30678	Conrad 1848a
	Amphidesma perovata	Olig., Vicksburg Grp.	ANSP 30679?	Conrad 1848b
	Arca delicatula	Olig., Vicksburg Grp.	ANSP 997	Casey 1903
	Arca mississippiensis	Olig., Vicksburg Grp.	Syn. ANSP 30682	Conrad 1848a
	Avicula argentea	Olig., Vicksburg Grp.	Syn. ANSP 30644	Conrad 1848a
	Byssoarca lima	Olig., Vicksburg Grp.	ANSP 30642	Conrad 1848a
	Byssoarca mississippiensis	Olig., Vicksburg Grp.	ANSP 30648	Conrad 1848a
	Byssoarca protracta	Olig., Vicksburg Grp.	ANSP 30650	Conrad 1848a
	Cardita aldrichi	Olig., Vicksburg Grp.	USNM 646501	Casey 1903
	Cardium (*Trachycardium*) *precursor*	Olig., Vicksburg Grp.	USNM 136748	Dall 1900
	Cardium diversum	Olig., Vicksburg Grp.	ANSP 30651	Conrad 1848a
	Cardium eversum	Olig., Vicksburg Grp.	ANSP 30653	Conrad 1848a
	Cardium glebosum	Olig., Vicksburg Grp.	ANSP 30650?	Conrad 1848a
	Cardium vicksburgense	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848a
	Chione (?*Chamelea*) *craspedonia*	Olig., Vicksburg Grp.	USNM 136738	Dall 1903
	Chione (*Lirophora*) *victoria*	Olig., Vicksburg Grp.	USNM 155311	Dall 1903
	Corbis staminea	Olig., Vicksburg Grp.	Syn. ANSP 30666	Conrad 1848a
	Corbula engonata	Olig., Vicksburg Grp.	ANSP 30676	Conrad 1848a
	Corbula filosa	Olig., Vicksburg Grp.	ANSP 13215	Conrad 1865a

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Corbula intastriata*	Olig., Vicksburg Grp.	ANSP 30553	Conrad 1848a
	Corbula laqueata	Olig., Vicksburg Grp.	ANSP 1103?	Casey 1903
	Crassatella mississippiensis	Olig., Vicksburg Grp.	ANSP 30664	Conrad 1848a
	Cyathodonta vicksburgensis	Olig., Vicksburg Grp.	USNM 5176	Dall 1903
	Cytherea astartiformis	Olig., Vicksburg Grp.	ANSP 4144	Conrad 1848a
	Cytherea imitabilis	Olig., Vicksburg Grp.	ANSP 20172	Conrad 1848a
	Cytherea mississippiensis	Olig., Vicksburg Grp.	ANSP 30660	Conrad 1848a
	Cytherea perbrevis	Olig., Vicksburg Grp.	ANSP 30657	Conrad 1848a
	Cytherea semipunctata	Olig., Vicksburg Grp.	ANSP 30658	Conrad 1848b
	Cytherea sobrina	Olig., Vicksburg Grp.	ANSP 30661	Conrad 1848a
	Kellia oblonga	Olig., Vicksburg Grp.	ANSP 30678	Conrad 1848b
	Lima staminea	Olig., Vicksburg Grp.	Syn. ANSP 30656	Conrad 1848a
	Loripes eburnea	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848a
	Loripes? turgida	Olig., Vicksburg Grp.	ANSP 30681	Conrad 1848a
	Lucina (*Cyclas*) *subrigaultiana*	Olig., Vicksburg Grp.	USNM 644599	Meyer 1886
	Lucina choctavensis	Olig., Vicksburg Grp.	USNM 644600	Meyer 1886
	Lucina mississippiensis	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848a
	Lucina perlevis	Olig., Vicksburg Grp.	ANSP 30659	Conrad 1848a
	Lucina vicksburgensis	Olig., Vicksburg Grp.	Syn. ANSP 994	Casey 1903
	Macoma sublintea	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1871
	Mactra funerata	Olig., Vicksburg Grp.	ANSP 30668	Conrad 1848a
	Mactra inaequilateralis	Olig., Vicksburg Grp.	USNM 644601	Meyer 1886
	Mactra mississippiensis	Olig., Vicksburg Grp.	ANSP 30669	Conrad 1848a
	Modiola mississippiensis	Olig., Vicksburg Grp.	ANSP 30647	Conrad 1848a
	Nucula serica	Olig., Vicksburg Grp.	ANSP 30675	Conrad 1848a
	Nucula vicksburgensis	Olig., Vicksburg Grp.	ANSP 30674	Conrad 1848a
	Ostrea vicksburgensis	Olig., Vicksburg Grp.	ANSP 30645	Conrad 1848a

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Bivalvia (clams, oysters, etc.) (continued)	*Panopaea oblongata*	Olig., Vicksburg Grp.	ANSP 30643	Conrad 1848a
	Pectunculus arctatus	Olig., Vicksburg Grp.	ANSP 30647	Conrad 1848a
	Pinna argentea	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848a
	Pitaria (*Lamelliconcha*) *calcanea*	Olig., Vicksburg Grp.	USNM 136750	Dall 1903
	Psammobia lintea	Olig., Vicksburg Grp.	Syn. ANSP 30671	Conrad 1848a
	Psammobia mississippiensis	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848b
	Psammobia papyria	Olig., Vicksburg Grp.	Syn. ANSP 30672	Conrad 1848a
	Solecurtus vicksburgensis	Olig., Vicksburg Grp.	USNM 644607	Aldrich 1885
	Tellina euryterma	Olig., Vicksburg Grp.	Unspecified ANSP type	Gabb 1861
	Tellina pectorosa	Olig., Vicksburg Grp.	ANSP 30685?	Conrad 1848a
	Tellina perovata	Olig., Vicksburg Grp.	Missing (ANSP)	Conrad 1848b
	Tellina pilsbryi	Olig., Vicksburg Grp.	Syn. ANSP 1002A-C	Casey 1903
	Tellina serica	Olig., Vicksburg Grp.	ANSP 30686?	Conrad 1848a
	Tellina vicksburgensis	Olig., Vicksburg Grp.	ANSP 30684?	Conrad 1848b
	Venericardia vicksburgensis	Olig., Vicksburg Grp.	Unknown	Casey 1903
Mollusca: Cephalopoda (octopuses, nautiloids, squids, etc.)	*Aturia* (*Aturia*) *berryi*	Olig., Glendon?	Missing (USNM?)	Stenzel 1940
Mollusca: Gastropoda (snails)	*Actaeon andersoni*	Olig., Vicksburg Grp.	ANSP 13411	Conrad 1848a
	Acteon (*Acteon*) *pretextilis*	Olig., Mint Spring	USNM 498132	MacNeil (in MacNeil and Dockery 1984)
	Adeorbis laevis var. *vicksburgensis*	Olig., Mint Spring	USNM 644581	Meyer 1886
	Admetula inflata	Olig., Mint Spring	USNM 498186	Dockery (in MacNeil and Dockery 1984)
	Atys (*Atys*) *pinguis*	Olig., Mint Spring	USNM 498135	MacNeil (in MacNeil and Dockery 1984)
	Bathytoma congesta fontis	Olig., Mint Spring	USNM 498160	MacNeil (in MacNeil and Dockery 1984)

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Gastropoda (snails) (continued)	*Bittium* (*Argyropeza*?) *oldoi*	Olig., Mint Spring	USNM 498265	MacNeil (in MacNeil and Dockery 1984)
	Buccinum mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13478	Conrad 1848a
	Buccinum vicksburgensis	Olig., Mint Spring?	USNM 644613	Aldrich 1885
	Bulla crassiplica	Olig., Vicksburg Grp.	Lecto. ANSP 13412	Conrad 1848a
	Cadulus vicksburgensis	Olig., Byram	USNM 644575	Meyer 1885
	Caecum solitarium	Olig., Vicksburg Grp.	USNM 644585	Meyer 1886
	Calyptraea (*Trochita*) *conradi*	Olig., Mint Spring	USNM 498316	MacNeil (in MacNeil and Dockery 1984)
	Cancellaria funerata	Olig., Vicksburg Grp.	ANSP 13450	Conrad 1848a
	Cancellaria mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13447	Conrad 1848a
	Capulus (*Brocchia*) *langdoni*	Olig., Byram	USNM 479766	MacNeil (in MacNeil and Dockery 1984)
	Caricella demissa	Olig., Vicksburg Grp.	Lecto. ANSP 13455	Conrad 1848a
	Cassidaria lintea	Olig., Vicksburg Grp.	Lecto. ANSP 13506	Conrad 1848a
	Cassis caelatura	Olig., Vicksburg Grp.	Lecto. ANSP 13499	Conrad 1848a
	Cassis mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13501	Conrad 1848a
	Chenopus liratus	Olig., Vicksburg Grp.	Lecto. ANSP 13513	Conrad 1848a
	Clavella vicksburgensis	Olig., Vicksburg Grp.	Lecto. ANSP 13477	Conrad 1849
	Clavilithes lesueuri	Olig., Vicksburg Grp.	USNM 376563	Dockery (in MacNeil and Dockery 1984)
	Conomitra vicksburgensis laevigata	Olig., Mint Spring	USNM 498194	Dockery (in MacNeil and Dockery 1984)
	Conus alveatus	Olig., Vicksburg Grp.	Lecto. ANSP 13446	Conrad 1865a
	Conus protracta	Olig., Byram	USNM 644576	Meyer 1885
	Crassispira (*Crassispira*) *lyopleura*	Olig., Byram	USNM 376613	MacNeil (in MacNeil and Dockery 1984)
	Cypraea lintea	Olig., Vicksburg Grp.	Lecto. ANSP 13510	Conrad 1848a
	Cypraea sphaeroides	Olig., Vicksburg Grp.	ANSP 13513	Conrad 1848a
	Drillia harmonica	Olig., Mint Spring	USNM 481665	Casey 1903

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Gastropoda (snails) (continued)	*Ficus mississippiensis*	Olig., Vicksburg Grp.	Lecto. ANSP 13509	Conrad 1848a
	Fissurella mississippiensis	Olig., Vicksburg Grp.	ANSP 13534	Conrad 1848a
	Fulgoraria mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13453	Conrad 1848a
	Fulgur nodulatum	Olig., Vicksburg Grp.	ANSP 13468	Conrad 1849
	Fusus boettgeri	Olig., Vicksburg Grp.	Missing	Meyer 1885
	Fusus mississippiensis	Olig., Vicksburg Grp.	ANSP 13465	Conrad 1848a
	Fusus spiniger	Olig., Vicksburg Grp.	Lecto. ANSP 13466	Conrad 1848a
	Fusus vicksburgensis	Olig., Vicksburg Grp.	ANSP 13475	Conrad 1848a
	Galeodia tricarinata	Olig., Vicksburg Grp.	ANSP 13504	Conrad 1860
	Melongena crassi-cornuta [hyphen omitted in modern usage]	Olig., Vicksburg Grp.	ANSP 13470	Conrad 1848a
	Metula fragilis	Olig., Byram	USNM 479758	Casey 1903
	Microdrillia vicksburgella	Olig., Byram	Lecto. USNM 481645	Casey 1903
	Mitodrillia pharus	Olig., Mint Spring	USNM 498176	MacNeil (in MacNeil and Dockery 1984)
	Mitra cellulifera	Olig., Vicksburg Grp.	Lecto. ANSP 13463	Conrad 1848a
	Mitra conquisita	Olig., Vicksburg Grp.	Lecto. ANSP 13462	Conrad 1848a
	Mitra mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13460	Conrad 1848a
	Mitra staminea	Olig., Vicksburg Grp.	ANSP 13457	Conrad 1848a
	Mitra vicksburgensis	Olig., Vicksburg Grp.	Lecto. ANSP 13458	Conrad 1848a
	Murex (*Phyllonotus*) *dormani*	Olig., Byram	USNM 644373	Vokes 1963
	Murex migus	Olig., Mint Spring	Missing, formerly at the University of Palermo	de Gregorio 1890
	Murex mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13842	Conrad 1848a
	Murex stetopus	Olig., Mint Spring	PRI 26431	de Gregorio 1890
	Murex tingarus	Olig., Mint Spring	Missing, formerly at the University of Palermo	de Gregorio 1890
	Narica mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13529	Conrad 1848a

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Gastropoda (snails) (continued)	*Natica* (*Natica*) *caseyi*	Olig., Byram	USNM 648944	MacNeil (in MacNeil and Dockery 1984)
	Natica (*Naticarius*) *acuticallosa*	Olig., Byram	USNM 498385	MacNeil (in MacNeil and Dockery 1984)
	Natica decipiens	Olig., Vicksburg Grp.	Unknown	Meyer 1885
	Natica mississippiensis	Olig., Vicksburg Grp.	ANSP 13527	Conrad 1848a
	Natica vicksburgensis	Olig., Vicksburg Grp.	Lecto. ANSP 13531	Conrad 1848a
	Oliva mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13450	Conrad 1848a
	Olivella (*Callianax*) *vicksburgensis*	Olig., Mint Spring	USNM 498191	Dockery (in MacNeil and Dockery 1984)
	Olivella affluens	Olig., Vicksburg Grp.	Unknown	Casey 1903
	Oniscia harpula	Olig., Vicksburg Grp.	ANSP 13505	Conrad 1848a
	Phandella neponica	Olig., Byram	USNM 645103	Casey 1903
	Phorus humilis	Olig., Vicksburg Grp.	ANSP 13522	Conrad 1848a
	Pleurofusia trichordia	Olig., Byram?	ANSP 13436	MacNeil (in MacNeil and Dockery 1984)
	Pleurotoma (*Pleurofusia*) *longirostropsis*	Olig., Byram	Missing, formerly at the University of Palermo	de Gregorio 1890
	Pleurotoma (*Surcula*) *longiforma*	Olig., Vicksburg Grp.	Syn. USNM 645081 and 645082	Aldrich 1885
	Pleurotoma abundans	Olig., Vicksburg Grp.	Lecto. ANSP 13437	Conrad 1848a
	Pleurotoma cochlearis	Olig., Vicksburg Grp.	Lecto. ANSP 13420	Conrad 1848a
	Pleurotoma congesta	Olig., Vicksburg Grp.	Lecto. ANSP 13425	Conrad 1848a
	Pleurotoma cristata	Olig., Vicksburg Grp.	Lecto. ANSP 13427	Conrad 1848a
	Pleurotoma decliva	Olig., Vicksburg Grp.	ANSP 13430	Conrad 1848a
	Pleurotoma eboroides	Olig., Vicksburg Grp.	Lecto. ANSP 13439	Conrad 1848a
	Pleurotoma intacta	Olig., Vicksburg Grp.	ANSP 995?	Casey 1903
	Pleurotoma mississippiensis	Olig., Vicksburg Grp.	ANSP 13446	Conrad 1848a
	Pleurotoma plutonica	Olig., Vicksburg Grp.	ANSP 1000 or USNM 481635	Casey 1903

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Gastropoda (snails) (continued)	*Pleurotoma porcellana*	Olig., Vicksburg Grp.	Lecto. ANSP 13443	Conrad 1848a
	Pleurotoma rotaedens	Olig., Vicksburg Grp.	Lecto. ANSP 13422	Conrad 1848a
	Pleurotoma servata	Olig., Vicksburg Grp.	Lecto. ANSP 13431	Conrad 1848a
	Pleurotoma tantula	Olig., Vicksburg Grp.	Lecto. ANSP 13433	Conrad 1848a
	Pleurotoma tenella	Olig., Vicksburg Grp.	Lecto. ANSP 13490	Conrad 1848a
	Pleurotoma vicksburgensis	Olig., Byram?	Lecto. ANSP 13430 or USNM 481670	Casey 1903
	Pleurotoma? *insignifica* var. *brevis*	Olig., Byram	USNM 644594	Meyer 1886
	Pliciscala (*Nodiscala*?) *caseyi*	Olig., Mint Spring	USNM 498279	MacNeil (in MacNeil and Dockery 1984)
	Polynices (*Euspira*) *byramensis*	Olig., Byram	USNM 352706	Cooke 1928
	Pyramidella (*Voluspa*) *chavanoidea*	Olig., Mint Spring	USNM 498247	MacNeil (in MacNeil and Dockery 1984)
	Pyramidella (*Voluspa*?) *microcosta*	Olig., Mint Spring	USNM 479994	MacNeil (in MacNeil and Dockery 1984)
	Ringicula (*Ringiculella*) *irrasa*	Olig., Mint Spring	USNM 498140	MacNeil (in MacNeil and Dockery 1984)
	Ringicula mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13414	Conrad 1848a
	Scalaria trigintanaria	Olig., Vicksburg Grp.	ANSP 13516	Conrad 1848a
	Scobinella caelata	Olig., Vicksburg Grp.	Lecto. ANSP 13441	Conrad 1848a
	Scobinella famelica	Olig., Byram	USNM 481622	Casey 1903
	Scobinella macer	Olig., Byram	USNM 481661	Casey 1903
	Sigaretus mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13527	Conrad 1848a
	Solarium bellastriatum vicksburgensis	Olig., Vicksburg Grp.	Cotypes USNM 6200	Dall 1892
	Solarium triliratum	Olig., Vicksburg Grp.	Lecto. ANSP 13519	Conrad 1848a
	Strombiformis caseyi	Olig., Mint Spring	USNM 498259	MacNeil (in MacNeil and Dockery 1984)

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Gastropoda (snails) (continued)	*Styliola hastata*	Olig., Mint Spring	USNM 644595	Meyer 1886
	Terebra (*Strioterebrum*) *vincta*	Olig., Vicksburg Grp.	USNM 560927	MacNeil (in MacNeil and Dockery 1984)
	Terebra divisurum	Olig., Vicksburg Grp.	Lecto. ANSP 13416	Conrad 1848a
	Terebra tantula	Olig., Vicksburg Grp.	Lecto. ANSP 13418	Conrad 1848a
	Tritiaria meyeri	Olig., Mint Spring	USNM 498220	MacNeil (in MacNeil and Dockery 1984)
	Tritiaria refugensis	Olig., Mint Spring	USNM 498221	MacNeil (in MacNeil and Dockery 1984)
	Tritiaria vaughani	Olig., Vicksburg Grp.	USNM 376549	MacNeil (in MacNeil and Dockery 1984)
	Triton abbreviatus	Olig., Vicksburg Grp.	ANSP 13402 or Lecto. ANSP 13480	Conrad 1848a
	Triton crassidens	Olig., Vicksburg Grp.	ANSP 13487	Conrad 1848a
	Triton mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13488	Conrad 1848a
	Triton subalveatum	Olig., Vicksburg Grp.	Cotypes ANSP 13470	Conrad 1849
	Turbinella perexilis	Olig., Vicksburg Grp.	ANSP 13474	Conrad 1848a
	Turbinella protracta	Olig., Vicksburg Grp.	ANSP 13472	Conrad 1848a
	Turbinella wilsoni	Olig., Vicksburg Grp.	Lecto. ANSP 13476	Conrad 1848a
	Turbonilla caseyi	Olig., Mint Spring	USNM 498251	MacNeil (in MacNeil and Dockery 1984)
	Turritella caseyi	Olig., Byram	USNM 498364	MacNeil (in MacNeil and Dockery 1984)
	Turritella caelatura	Olig., Vicksburg Grp.	ANSP 13519	Conrad 1848b
	Turritella mississippiensis	Olig., Vicksburg Grp.	Lecto. ANSP 13516	Conrad 1848a
	Typhis curvirostratus	Olig., Vicksburg Grp.	Holotype ANSP 13485 or Lecto. ANSP 13484	Conrad 1848a
	Volema hopkinsi	Olig., Byram	USNM 376553	MacNeil (in MacNeil and Dockery 1984)

Appendix C-Table 1 (continued). Fossil taxa potentially named from specimens found within VICK.

Group	Taxon	Stratigraphy	Type Specimen	Citation
Mollusca: Scaphopoda (tusk shells)	*Dentalium mississippiensis*	Olig., Vicksburg Grp.	ANSP 30659	Conrad 1848a
	Dentalium opaculum	Olig., Vicksburg Grp.	Unknown	Casey 1903
	Dentalium strenuum	Olig., Vicksburg Grp.	ANSP 998	Casey 1903
Arthropoda: Crustacea: Malacostraca (crabs, lobsters, etc.)	*Callianassa berryi*	Olig., Glendon	USNM MO 495112	Rathbun 1935
	Necronectes vaughani	Olig., Glendon	USNM MO 495108	Rathbun 1935
Foraminifera	*Angulogerina rugoplicata*	Olig., Byram?	Cushman Collection 21958 (USNM)	Cushman 1935
	Bolivina caelata var. *byramensis*	Olig., Vicksburg Grp.	Cushman Collection (USNM)?	Cushman 1923
	Bolivina garretti	Olig., Byram?	Cushman Collection 21955 (USNM)	Cushman 1935
	Bolivina mornhinvegi	Olig., Byram?	Cushman Collection 21954 (USNM)	Cushman 1935
	Cristellaria vicksburgensis var. *aperta*	Olig., Vicksburg Grp.	Cushman Collection (USNM)?	Cushman 1923
	Discorbis arcuato-costata [hyphen omitted in modern spelling]	Olig., Byram?	Cushman Collection 21963 (USNM)	Cushman 1935
	Entosolenia crumenata	Olig., Byram?	Cushman Collection 21950 (USNM)	Cushman 1935
	Orbitolites supera [possibly the same as "*O. crustulum*" attributed to Conrad (1865b) by Richards (1968)]	Olig., Vicksburg Grp.	Unknown	Conrad 1865b
	Pyrgo oligocenica	Olig., Byram?	Cushman Collection 21945 (USNM)	Cushman 1935
	Reussella rectimargo var. *hebetata*	Olig., Byram	Cushman Collection 1205 (USNM)	Cushman 1945
	Valvulineria sculpturata	Olig., Byram?	Cushman Collection 21961 (USNM)	Cushman 1935

Appendix D: Repository Contact Information

Contact information for institutions known to have collections from VICK or with significant "Vicksburg" collections are included below. Addresses, links, and email addresses to departments are included as available. This information is subject to change, particularly hyperlinks. Many other institutions potentially have specimens collected from lands now within VICK, but vague or nonexistent locality information prevents establishing this for certain.

The Academy of Natural Sciences of Drexel University (ANSP)
1900 Benjamin Franklin Parkway
Philadelphia, PA 19103
https://ansp.org

Cincinnati Museum Center (CMC)
1301 Western Avenue
Cincinnati, OH 45203
https://www.cincymuseum.org
information@cincymuseum.org

Le Havre Museum of Natural History
Pl. du Vieux Marché
Le Havre, France 76600
https://www.museum-lehavre.fr/

Louisiana Museum of Natural History
119 Foster Hall
Louisiana State University
Baton Rouge, LA 70803
https://www.lsu.edu/lmnh/index.php
The Louisiana Museum of Natural History includes the Louisiana State University Museum of Natural Sciences, which in turn includes the Louisiana State University Museum of Geoscience.

Paleontological Research Institution (PRI)
1259 Trumansburg Rd.
Ithaca, NY 14850
https://www.priweb.org/

Peabody Museum of Natural History at Yale University (YPM)
P.O. Box 208118
170 Whitney Ave
New Haven, CT 06520
https://peabody.yale.edu/
peabody.collections@yale.edu

Smithsonian Institution, National Museum of Natural History (USNM)
Department of Paleobiology
P.O. Box 37012
NHB MRC 121
Washington, DC 20013
https://naturalhistory.si.edu/research/paleobiology
paleodept@si.edu

University of California Museum of Paleontology (UCMP)
Museum of Paleontology
University of California
1101 Valley Life Sciences Building
Berkeley, CA 94720
https://ucmp.berkeley.edu/

University of Kansas (KU)
KU Biodiversity Institute & Natural History Museum
1345 Jayhawk Blvd.
Lawrence, KS 66045
https://biodiversity.ku.edu/
biodiversity@ku.edu

Appendix E: Paleontological Resource Law and Policy

The following material is reproduced in large part from Henkel et al. (2015); see also Kottkamp et al. (2020).

In March 2009, the Paleontological Resources Preservation Act (PRPA) (16 USC 460aaa) was signed into law (Public Law 111–11). This act defines paleontological resources as

> *…any fossilized remains, traces, or imprints of organisms, preserved in or on the [E]arth's crust, that are of paleontological interest and that provide information about the history of life on [E]arth.*

The law stipulates that the Secretary of the Interior should manage and protect paleontological resources using scientific principles. The Secretary should also develop plans for

> *…inventory, monitoring, and deriving the scientific and educational use of paleontological resources.*

Paleontological resources are considered park resources and values that are subject to the "no impairment" standard in the National Park Service Organic Act (1916). In addition to the Organic Act, PRPA will serve as a primary authority for the management, protection and interpretation of paleontological resources. The proper management and preservation of these non-renewable resources should be considered by park resource managers whether or not fossil resources are specifically identified in the park's enabling legislation.

The Department of Interior's final regulation for the Paleontological Resources Preservation Act was published in the Federal Register on August 2, 2022. The Office of Management and Budget (OMB) approved DOI's final PRPA regulation on September 1, 2022. This regulation specifically applies to four bureaus in the department including: Bureau of Land Management (BLM), Bureau of Reclamation (BOR), Fish and Wildlife Service (FWS), and National Park Service (NPS).

The Paleontological Resources Management section of NPS Reference Manual 77 provides guidance on the implementation and continuation of paleontological resource management programs. Administrative options include those listed below and a park management program will probably incorporate multiple options depending on specific circumstances:

- **No action**—no action would be taken to collect the fossils as they erode from the strata. The fossils would be left to erode naturally and over time crumble away, or possibly be vandalized by visitors, either intentionally or unintentionally. This is the least preferable plan of action of those listed here.
- **Surveys**—will be set up to document potential fossil localities. All sites will be documented with the use of GPS and will be entered into the park GIS database. Associated stratigraphic and depositional environment information will be collected for each locality. A preliminary fossil list will be developed. Any evidence of poaching activity will be recorded. Rates of erosion will be estimated for the site and a monitoring schedule will be developed based upon

this information. A NPS Paleontological Locality Database Form will also be completed for each locality. A standard version of this form will be provided by the Paleontology Program of the Geologic Resources Division upon request and can be modified to account for local conditions and needs.

- **Monitoring**—fossil-rich areas would be examined periodically to determine if conditions have changed to such an extent that additional management actions are warranted. Photographic records should be kept so that changes can be more easily ascertained.
- **Cyclic prospecting**—areas of high erosion which also have a high potential for producing significant specimens would be examined periodically for new sites. The periodicity of such cyclic prospecting will depend on locality-specific characteristics such as rates of sediment erosion, abundance or rarity of fossils, and proximity to visitor use areas.
- **Stabilization and reburial**—significant specimens which cannot be immediately collected may be stabilized using appropriate consolidants and reburied. Reburial slows down but does not stop the destruction of a fossil by erosion. Therefore, this method would be used only as an interim and temporary stop-gap measure. In some situations, stabilization of a locality may require the consideration of vegetation. For example, roots can destroy in situ fossils, but can also protect against slope erosion, while plant growth can effectively obscure localities, which can be positive or negative depending on how park staff want to manage a locality.
- **Shelter construction**—it may be appropriate to exhibit certain fossil sites or specimens in situ, which would require the construction of protective shelters to protect them from the natural forces of weathering and erosion. The use of shelters draws attention to the fossils and increases the risk of vandalism or theft, but also provides opportunities for interpretation and education.
- **Excavation**—partial or complete removal of any or all fossils present on the surface and potentially the removal of specimens still beneath the surface that have not been exposed by erosion.
- **Closure**—the area containing fossils may be temporarily or permanently closed to the public to protect the fossil resources. Fossil-rich areas may be closed to the public unless accompanied by an interpretive ranger on a guided hike.
- **Patrols**—may be increased in areas of known fossil resources. Patrols can prevent and/or reduce theft and vandalism. The scientific community and the public expect the NPS to protect its paleontological resources from vandalism and theft. In some situations a volunteer site stewardship program may be appropriate (for example the "Paleo Protectors" at Chesapeake & Ohio Canal National Historical Park).
- **Alarm systems/electronic surveillance**—seismic monitoring systems can be installed to alert rangers of disturbances to sensitive paleontological sites. Once the alarm is engaged, a ranger can be dispatched to investigate. Motion-activated cameras may also be mounted to visually document human activity in areas of vulnerable paleontological sites.

National Park Service Management Policies (2006; Section 4.8.2.1) also require that paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and managed for public education, interpretation, and scientific research. In 2010, the National Park Service established National Fossil Day as a celebration and partnership organized to promote public awareness and stewardship of fossils, as well as to foster a greater appreciation of their scientific and educational value (https://www.nps.gov/subjects/fossilday/index.htm). National Fossil Day occurs annually on Wednesday of the second full week in each October in conjunction with Earth Science Week.

Related Laws, Legislation, and Management Guidelines

National Park Service Organic Act

The NPS Organic Act directs the NPS to manage units

> *…to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner as will leave them unimpaired for the enjoyment of future generations.* (16 U.S.C. § 1).

Congress reiterated this mandate in the Redwood National Park Expansion Act of 1978 by stating that the NPS must conduct its actions in a manner that will ensure no

> *…derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress.* (16 U.S.C. § 1 a-1).

The Organic Act prohibits actions that permanently impair park resources unless a law directly and specifically allows for the acts. An action constitutes an impairment when its impacts

> *…harm the integrity of park resources or values, including the opportunities that otherwise would be present for the enjoyment of those resources and values.* (Management Policies 2006 1.4.3).

Paleontological Resources Protection Act (P.L. 111-011, Omnibus Public Land Management Act of 2009, Subtitle D)

Section 6302 states

> *The Secretary (of the Interior) shall manage and protect paleontological resources on Federal land using scientific principles and expertise. The Secretary shall develop appropriate plans for inventory, monitoring, and the scientific and educational use of paleontological resources, in accordance with applicable agency laws, regulations, and policies. These plans shall emphasize interagency coordination and collaborative efforts where possible with non-Federal partners, the scientific community, and the general public.*

Federal Cave Resources Protection Act of 1988 (16 USC 4301)

This law provides a legal authority for the protection of all cave resources on NPS and other federal lands. The definition for "Cave Resource" in Section 4302 states

> *Cave resources include any material or substance occurring naturally in caves on Federal lands, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens, and speleothems.*

NPS Management Policies 2006

NPS Management Policies 2006 include direction for preserving and protecting cultural resources, natural resources, processes, systems, and values (National Park Service 2006). It is the goal of the NPS to avoid or minimize potential impacts to resources to the greatest extent practicable consistent with the management policies. The following is taken from section 4.8.2.1 of the NPS Management Policies 2006, "Paleontological Resources and their contexts":

> *Paleontological resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and managed for public education, interpretation, and scientific research. The Service will study and manage paleontological resources in their paleoecological context (that is, in terms of the geologic data associated with a particular fossil that provides information about the ancient environment).*
>
> *Superintendents will establish programs to inventory paleontological resources and systematically monitor for newly exposed fossils, especially in areas of rapid erosion. Scientifically significant resources will be protected by collection or by on-site protection and stabilization. The Service will encourage and help the academic community to conduct paleontological field research in accordance with the terms of a scientific research and collecting permit. Fossil localities and associated geologic data will be adequately documented when specimens are collected. Paleontological resources found in an archeological context are also subject to the policies for archeological resources. Paleontological specimens that are to be retained permanently are subject to the policies for museum objects.*
>
> *The Service will take appropriate action to prevent damage to and unauthorized collection of fossils. To protect paleontological resources from harm, theft, or destruction, the Service will ensure, where necessary, that information about the nature and specific location of these resources remains confidential, in accordance with the National Parks Omnibus Management Act of 1998.*
>
> *Parks will exchange fossil specimens only with other museums and public institutions that are dedicated to the preservation and interpretation of natural heritage and qualified to manage museum collections. Fossils to be deaccessioned in an exchange must fall outside the park's scope of collection statement. Systematically collected fossils in an NPS museum collection in compliance with 36 CFR 2.5 cannot be*

outside the scope of the collection statement. Exchanges must follow deaccession procedures in the Museum Handbook, Part II, chapter 6.

The sale of original paleontological specimens is prohibited in parks.

The Service generally will avoid purchasing fossil specimens. Casts or replicas should be acquired instead. A park may purchase fossil specimens for the park museum collection only after making a written determination that

- *The specimens are scientifically significant and accompanied by detailed locality data and pertinent contextual data;*
- *The specimens were legally removed from their site of origin, and all transfers of ownership have been legal;*
- *The preparation of the specimens meets professional standards;*
- *The alternatives for making these specimens available to science and the public are unlikely;*
- *Acquisition is consistent with the park's enabling legislation and scope of collection statement, and acquisition will ensure the specimens' availability in perpetuity for public education and scientific research.*

All NPS construction projects in areas with potential paleontological resources must be preceded by a preconstruction surface assessment prior to disturbance. For any occurrences noted, or when the site may yield paleontological resources, the site will be avoided or the resources will, if necessary, be collected and properly cared for before construction begins. Areas with potential paleontological resources must also be monitored during construction projects.

(See Natural Resource Information 4.1.2; Studies and Collections 4.2; Independent Research 5.1.2; Artifacts and Specimens 10.2.4.6. Also see 36 CFR 2.5.)

NPS Director's Order-77, Paleontological Resources Management

DO-77 describes fossils as non-renewable resources and identifies the two major types, body fossils and trace fossils. It describes the need for managers to identify potential paleontological resources using literature and collection surveys, identify areas with potential for significant paleontological resources, and conduct paleontological surveys (inventory). It also describes appropriate actions for managing paleontological resources including: no action, monitoring, cyclic prospecting, stabilization and reburial, construction of protective structures, excavation, area closures, patrols, and the need to maintain confidentiality of sensitive location information.

Excerpt from Clites and Santucci (2012):

Monitoring

An important aspect of paleontological resource management is establishing a long-term paleontological resource monitoring program. National Park Service paleontological resource monitoring strategies were developed by Santucci et al. (2009). The park's monitoring program should incorporate the measurement and evaluation of the factors stated below.

Climatological Data Assessments

These assessments include measurements of factors such as annual and storm precipitation, freeze/thaw index (number of 24-hour periods per year where temperature fluctuates above and below 32 degrees Fahrenheit), relative humidity, and peak hourly wind speeds.

Rates of Erosion Studies

These studies require evaluation of lithology, slope degree, percent vegetation cover, and rates of denudation around established benchmarks. If a park does not have this information, there may be opportunities to set up joint projects, because erosion affects more than just paleontological resources.

Assessment of Human Activities, Behaviors, and Other Variables

These assessments involve determining access/proximity of paleontological resources to visitor use areas, annual visitor use, documented cases of theft/vandalism, commercial market value of the fossils, and amount of published material on the fossils.

Condition Assessment and Cyclic Prospecting

These monitoring methods entail visits to the locality to observe physical changes in the rocks and fossils, including the number of specimens lost and gained at the surface exposure. Paleontological prospecting would be especially beneficial during construction projects or road repair.

Periodic Photographic Monitoring

Maintaining photographic archives and continuing to photo-document fossil localities from established photo-points enables visual comparison of long-term changes in site variables.

Appendix F: Paleontological Locality Data

The following table (Appendix F-Table 1) lists localities from the 2022 survey. There were 92 localities or, more accurately, locations which were documented or collected from. See the "Localities" section to understand the way each was categorized. Localities missing in the numerical list were removed due to specimens being identified as modern rather than paleontological, resulting in a final count of 72 localities. More detailed information is available to qualified researchers.

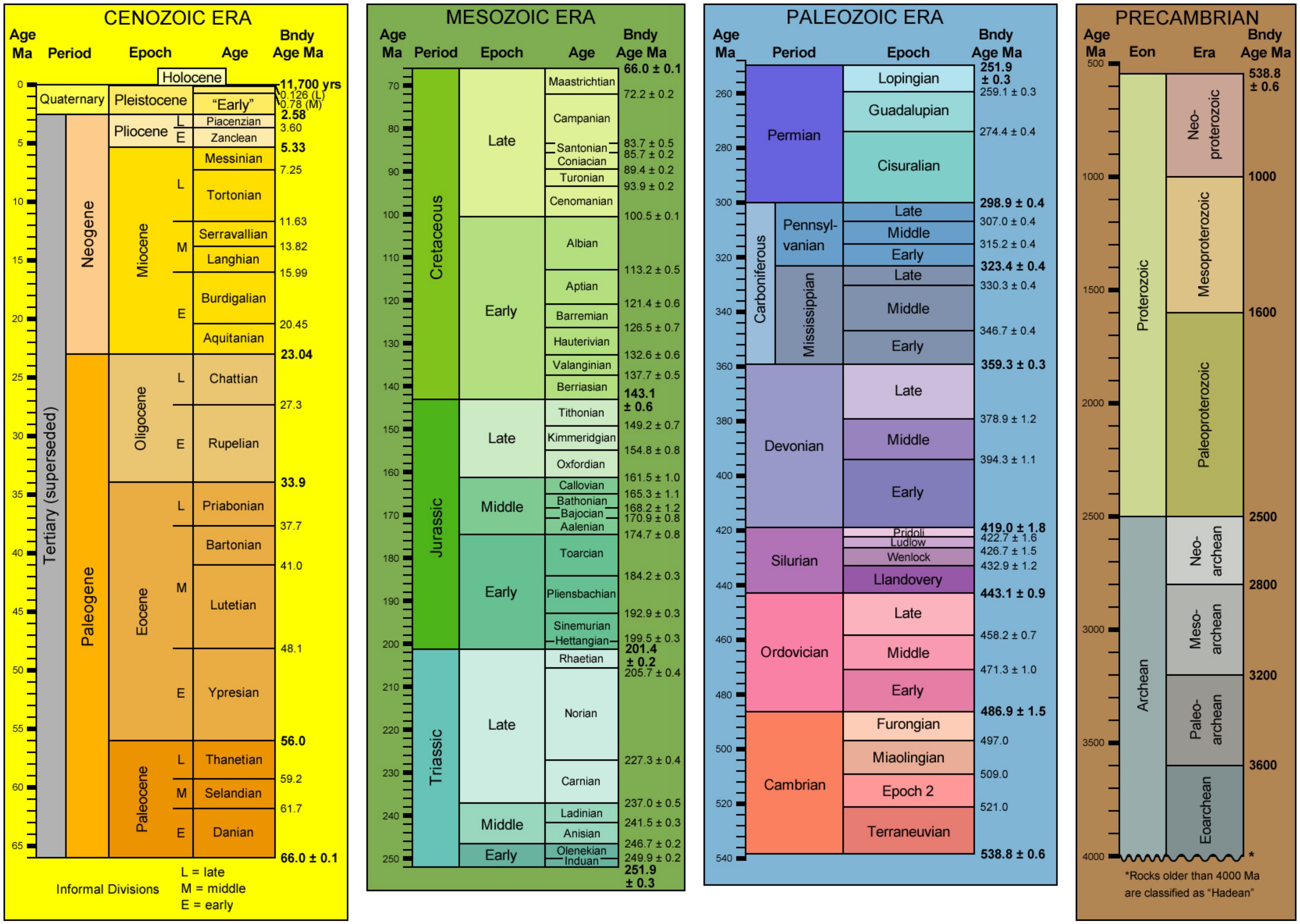
Appendix F-Table 1. Localities from the 2022 survey.

Count	Locality	Date	Stratigraphy
1	VPFV-CVB22-0003	1/18/2022	Quaternary: Loess
2	VPFV-CVB22-0004	1/18/2022	Quaternary: Loess
3	VPFV-CVB22-0005	1/18/2022	Quaternary: Loess
4	VPFV-CVB22-0006	1/19/2022	Quaternary: Loess
5	VPFV-CVB22-0007	1/25/2022	Quaternary: Loess
6	VPFV-CVB22-0008	1/25/2022	Quaternary: Loess
7	VPFV-CVB22-0009	1/25/2022	Quaternary: Loess
8	VPFV-CVB22-0010	1/26/2022	Quaternary: Loess
9	VPFV-CVB22-0011	1/26/2022	Quaternary: Loess
10	VPFV-CVB22-0012	1/26/2022	Quaternary: Loess
11	VPFV-CVB22-0013	1/27/2022	Quaternary: Loess
12	VPFV-CVB22-0014	1/27/2022	Quaternary: Loess
13	VPFV-CVB22-0015	2/1/2022	Quaternary: Loess
14	VPFV-CVB22-0016	2/2/2022	Quaternary: Clay rich conglomerate
15	VPFV-CVB22-0017	2/4/2022	Quaternary: Loess
16	VPFV-CVB22-0018	2/4/2022	Quaternary: freshwater travertine
17	VPFV-CVB22-0020	2/8/2022	Oligocene/Miocene: Catahoula Fm.
18	VPFV-CVB22-0021	2/8/2022	Quaternary: Loess overlaying Oligocene/Miocene
19	VPFV-CVB22-0022	2/8/2022	Quaternary: Loess
20	VPFV-CVB22-0023	2/9/2022	Indeterminant: Stream Bottom
21	VPFV-CVB22-0024	2/10/2022	Quaternary: Loess
22	VPFV-MMR22-0001	2/15/2022	Indeterminant: Stream Bottom
23	VPFV-MMR22-0002	2/15/2022	Indeterminant: Stream Bottom
24	VPFV-MMR22-0005	2/16/2022	Quaternary: Loess
25	VPFV-MMR22-0006	2/16/2022	Indeterminant: Stream Bottom
26	VPFV-MMR22-0008	2/16/2022	Quaternary: Loess
27	VPFV-MMR22-0009	2/18/2022	Quaternary: Loess
28	VPFV-MMR22-0012	2/18/2022	Quaternary: Loess
29	VPFV-MMR22-0014	2/20/2022	Quaternary: Loess
30	VPFV-MMR22-0015	2/20/2022	Quaternary: Loess
31	VPFV-CVB22-0025	2/23/2022	Quaternary: Loess
32	VPFV-CVB22-0026	2/23/2022	Quaternary: Loess

Appendix F-Table 1 (continued). Localities from the 2022 survey.

Count	Locality	Date	Stratigraphy
33	VPFV-CVB22-0027	2/23/2022	Quaternary: Loess
34	VPFV-CVB22-0028	2/23/2022	Quaternary: Loess and reworked Byram
35	VPFV-CVB22-0030	2/24/2022	Quaternary: Loess
36	VPFV-CVB22-0031	2/24/2022	Quaternary: Loess
37	VPFV-CVB22-0032	2/24/2022	Quaternary: Loess
38	VPFV-CVB22-0033	2/24/2022	Quaternary: Loess
39	VPFV-MMR22-0016	3/1/2022	Quaternary: Loess
40	VPFV-MMR22-0017	3/1/2022	Indeterminant: Stream Bottom
41	VPFV-CVB22-0034	3/2/2022	Catahoula Fm
42	VPFV-CVB22-0037	3/2/2022	Oligocene: Bucatunna Fm
43	VPFV-CVB22-0038	3/2/2022	Indeterminant: Stream Bottom
44	VPFV-CVB22-0040	3/3/2022	Oligocene: Mint Spring Bayou Fm.
45	VPFV-CVB22-0042	3/9/2022	Oligocene: Bucatunna Fm
46	VPFV-CVB22-0043	3/9/2022	Quaternary: Loess
47	VPFV-CVB22-0045	3/9/2022	Quaternary: Loess
48	VPFV-CVB22-0046	3/9/2022	Quaternary: Loess
49	VPFV-CVB22-0047	3/10/2022	Oligocene: Byram Fm.
50	VPFV-CVB22-0048	3/10/2022	Paleozoic: Pre-loess gravel
51	VPFV-CVB22-0049	3/10/2022	Paleozoic: Pre-loess gravel
52	VPFV-CVB22-0050	3/10/2022	Paleozoic: Pre-loess gravel
53	VPFV-CVB22-0051	3/10/2022	Paleozoic: Pre-loess gravel
54	VPFV-CVB22-0052	3/10/2022	Oligocene: Byram Fm.
55	VPFV-CVB22-0053	3/10/2022	Various
56	VPFV-CVB22-0054	3/10/2022	Oligocene: Byram Fm.
57	VPFV-CVB22-0055	3/18/2022	Oligocene: Byram Fm.
58	VPFV-CVB22-0056	3/19/2022	Paleozoic: Pre-loess gravel
59	VPFV-CVB22-0057	3/19/2022	Paleozoic: Pre-loess gravel
60	VPFV-CVB22-0059	3/19/2022	Oligocene: Byram Fm. , Paleozoic: Pre-loess gravel
61	VPFV-CVB22-0060	3/19/2022	Paleozoic: Pre-loess gravel
62	VPFV-CVB22-0062	3/19/2022	Oligocene: Byram Fm.
63	VPFV-CVB22-0063	3/19/2022	Pleistocene/Holocene, Paleozoic: Pre-loess gravel
64	VPFV-CVB22-0064	3/19/2022	Paleozoic: Pre-loess gravel
65	VPFV-MMR22-0019	3/23/2022	Quaternary: Loess
66	VPFV-MMR22-0021	3/23/2022	Quaternary: Loess
67	VPFV-MMR22-0023	3/25/2022	Indeterminant: Stream Bottom
68	VPFV-CVB22-0065	3/27/2022	Quaternary: Loess
69	VPFV-CVB22-0066	3/27/2022	Quaternary: Loess
70	VPFV-CVB22-0067	3/27/2022	Quaternary: Loess
71	VPFV-CVB22-0068	3/27/2022	Quaternary: Loess
72	VPFV-CVB22-0069	3/29/2022	Quaternary: Loess

Appendix G: Geologic Time Scale



Ma=Millions of years old. Bndy Age=Boundary Age. Layout after 1999 Geological Society of America Time Scale (https://www.geosociety.org/documents/gsa/timescale/timescl-1999.pdf). Dates after Gradstein et al. (2020).

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