AN OVERVIEW OF PALEONTOLOGICAL RESOURCES PRESERVED WITHIN PREHISTORIC AND HISTORIC STRUCTURES

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Abstract—The occurrence of fossils and fossiliferous stone within historic and prehistoric structures is relatively widespread and presents some unique insights into the human dimensions of paleontological resources. Fossil invertebrates, vertebrates, plants, and trace fossils are all known to occur within building stones incorporated into a wide variety of structures. The presence of fossils within structures can be either intentional or unintentional actions by individuals involved with the design and construction of these man-made features. This overview of fossils within historic and prehistoric structures enables a greater understanding of the scope, significance, distribution, and management issues associated with the preservation, conservation, and protection of these fossiliferous cultural resources.

INTRODUCTION

Although paleontological resources are primarily recognized as occurring in geologic strata, being held within museum collections, or on display in museum exhibits, fossils sometimes occur within a cultural resource context. Kenworthy and Santucci (2006) presented an initial inventory of National Park Service (NPS) fossils preserved in association with cultural resources which illustrated several broad context categories, including archeological sites, ethnographic stories and legends, historic records and archives, and within prehistoric and historic structures (Santucci, 2017). The historic and prehistoric structures category is particularly well suited for documentation of these culturally associated paleontological resources, along with their human and geologic histories.

Paleontological resource inventories and research undertaken in NPS areas and affiliated sites, such as national landmarks or national register properties, continue to yield information and examples of fossils preserved within prehistoric and historic structures. Although the focus of this publication is directed toward NPS and affiliated sites, it is recognized that fossils are documented from within prehistoric and historic structures around the world, and several non-NPS examples are presented here.

This inventory organizes the fossils documented within prehistoric and historic structures into four taxonomic categories based on the predominant types of fossils preserved within the structures. The four taxonomic categories include: 1) Paleobotany (limited to petrified wood); 2) Fossil Invertebrates; 3) Fossil Vertebrates; and, 4) Fossil Footprints and Other Trace Fossils. Within this organization, most of the taxonomic identification of fossils preserved in prehistoric and historic structures will be limited to higher taxonomic categories rather than precise genera and species names; determining genera and species in many groups requires study techniques that are not feasible to use on specimens embedded in structures.

Fossils in prehistoric and historic structures include body fossils, petrified wood, and trace fossils. Body fossils represent actual physical morphological elements of the organism such as shells, bones, teeth, and leaves or molds/casts of such parts. For example, limestones, which can be almost entirely composed of body fossils or fragments of marine organisms, are commonly used as building stones. Petrified wood is particularly well suited as a "building stone" due to its aesthetic properties and durability. Trace fossils, such as burrows, tracks/trackways, or coprolites, represent evidence of an organism's activity without preserving any part of the actual organism.

The use of fossils and fossiliferous stones in the construction of prehistoric and historic structures frequently appears to be based upon intentional decisions rather than merely coincidental occurrences. At minimum, the apparent conscious and purposeful use of fossils or fossiliferous materials suggests an awareness or interest in these ancient remains by the individuals involved with designing and building these structures. In a few instances, fossils have been intentionally incorporated into the design of a structure as a curiosity to draw public attention or promote tourism. In a number of more modern and historic structures, the use of fossils in the architectural design and fabric is based on aesthetics, artistic expression, or as intentional design elements. Architectural designer Mary Colter intentionally incorporated features of the natural environment and landscape in her design of a number of buildings and structures at Grand Canyon National Park, which are national register properties (Grattan, 1992). Colter integrated fossils from the canyon in two stone fireplaces constructed within Bright Angel Lodge. In these and other cases, the utilization of fossils may reflect human values and other human dimensions associated with paleontological resources (Santucci et al., 2016).

The intentional or deliberate use of fossils in the design and fabrication of structures may at times also be based upon the availability, proximity, or abundance of suitable paleontological resources within a local geographic area. The selection of fossils or fossiliferous blocks of stone would fundamentally be related to the qualities and characteristics of those resources which would deem them materially suitable or appropriate for use in structures. The use of these natural materials may also be based on utilitarian or opportunistic considerations. At Petrified Forest National Park, Arizona, there are two examples of structures in which blocks of locally abundant petrified wood have been incorporated during construction. The first structure, known today as "Agate House," was constructed nearly a thousand years ago by ancestral Puebloan people using blocks of locally obtained petrified wood as the building material (Reed, 1940; Cosgrove, 1951). The second and more modern structure, known originally as "Stone Tree House," was constructed using locally derived petrified wood prior to 1920, as a curiosity and tourist attraction. During the 1930s, this structure was renovated and expanded to become the "Painted Desert Inn," with the petrified wood infrastructure covered by stucco (Cole, unpublished report, 1976).

Another example where the use of paleontological resources may be based on opportunistic or utilitarian factors is represented by the Ice Age mammoth bone dwellings documented in Russia, Ukraine, and eastern Europe (Gladkih et al., 1984). These structures were constructed by Paleolithic hunters during the late Pleistocene using the bones and tusks of mammoths, which were either obtained from contemporaneous prey (Demay et

al., 2012) or were gathered from long-term accumulations as a source of building material in the treeless steppes (Lister and Bahn, 2007). The mammoth bones would provide the framework for dwellings in which skins and furs would be used to enclose and cover these shelters for use by ancient people.

The documentation, preservation, and protection of fossils associated with prehistoric and historic structures is important to better understand these non-renewable resources along with their scientific and educational values. Establishing baseline data regarding the scope, significance, distribution, and condition of these structures with fossils promotes responsible stewardship in compliance with natural and cultural resource laws and policies. This is particularly true for resources which occur within lands administered by the NPS, where there are management practices and standards established to ensure resource preservation.

PETRIFIED WOOD

The inventory for paleobotanical specimens associated with prehistoric and historic structures was limited to petrified wood. This may be largely due to the delicate nature or small size of many types of fossil plants such as leaves, flowers, fruit, seeds, cones, or microscopic pollen. Conversely, fossil wood is often preserved as large, dense, and mineralized remains more suitable for use in construction of buildings and other structures.

Agate House, Petrified Forest National Park, Arizona

One of the best examples of a prehistoric structure containing fossils as a building material is Agate House Pueblo at Petrified Forest National Park in Arizona. The Agate House is an eight-room pueblo constructed using the locally abundant petrified wood called *Araucarioxylon arizonicum* preserved within the Late Triassic Chinle Formation (Fig. 1). The historic structure is dated to the Pueblo II and III periods and is believed to have been occupied between 1050 and 1300 A.D. (Reed, 1940; Cosgrove, 1951). The Civilian Conservation Corps (CCC) partially reconstructed Agate House during 1934, and the historic structure was listed on the National Register of Historic Places in 1975.

Stone Tree House / Painted Desert Inn, Petrified Forest National Park, Arizona

The "Stone Tree House" was a petrified wood structure constructed at Petrified Forest National Monument sometime prior to 1920. This building was intentionally constructed using petrified wood as a curiosity and operated as a tourist attraction for about 12 years by Herbert David Lore. The structure originally included six small rooms for overnight lodging, a lunchroom, and a sales area for American Indian crafts (DeNormandie, 2004). In 1924, the "Stone Tree House" was incorporated into the design and construction of the Painted Desert Inn. Today, much of the petrified wood is now concealed beneath stucco (Fig. 2), applied by the Civilian Conservation Corps (CCC) after the NPS acquired the building in 1936 (Livingston, 1992; Cole, unpublished report, 1976). The Painted Desert Inn was designated a National Historic Landmark in 1987.

Theodore Roosevelt Lodge, Yellowstone National Park, Wyoming

The Theodore Roosevelt Lodge is a one-story log structure built between 1919 and 1920 near the Tower Junction area of Yellowstone National Park. Prior to the construction of the lodge, the area was a popular camping spot once used by President Chester Arthur in 1883 (National Park Service, 1983). The Wylie Permanent Camp Company developed a tent camp at this location in 1906 which was known as "Camp Roosevelt." A small portion of the foundation on the right side of the lodge incorporates pieces of petrified wood preserved in local strata associated with Eocene volcanism (Fig. 3). The use of the petrified wood in the foundation was clearly intentional, but a reference to this use or the purpose for this use has not been found in any historic records or archives associated with the lodge.

Washington Monument Commemorative Stones, Washington, D.C.

One of the more unusual occurrences of petrified wood within a historic structure is associated with the Washington Monument on the National Mall in Washington, D.C. After the American Civil War, the final construction of the Washington Monument involved the addition of commemorative stones donated by every state, many foreign countries, and dozens of organizations (National Park Service, 2003; Jacob, 2005). At least a half dozen of the monument's commemorative stones display fossils, and the State of Arizona stone is perhaps the most notable. In 1924, large pieces of petrified wood obtained from the Chalcedony Forest from outside of Petrified Forest National Monument were incorporated into the Washington Monument as part of the Arizona State Stone (Fig. 4). This commemorative stone consists of nearly 6,000 pounds of an *Araucarioxylon arizonicum* petrified log cut into three sections (National Park

FIGURE 1. Agate House, constructed of petrified wood, Petrified Forest National Park, Arizona. NPS Photo.

FIGURE 2. Painted Desert Inn, showing the underlying foundation constructed of petrified wood, Petrified Forest National Park, Arizona. NPS Photo.

Service, 2003). The state's name is engraved across the logs and painted with gold leaf. A copy of F. H. Knowlton's (1889) publication on the petrified wood of Arizona and a photograph of petrified trees near Holbrook are also incorporated into the state stone (author unknown, 1924).

Disneyland, California, and Florissant Fossil Beds National Monument, Colorado

Florissant Fossil Beds National Monument, Colorado, preserves an extraordinarily diverse and well-preserved fossil record from the late Eocene Florissant Formation (Meyer, 2003). The fossil record from within and around the monument includes nearly 2,000 known species of fossils, including mostly insects, a few vertebrates, plants, and petrified wood. Prior to the creation of the monument, Walt Disney visited the privately-owned Pike Petrified Forest in 1956. Walt and his wife, Lillian, became interested in the standing petrified redwood (*Sequoia affinis*) stumps. Disney made an offer to purchase one of the petrified stumps, and the offer was accepted by the owner. The large petrified stump selected measured 7.5 feet (2.3 meters) in diameter and weighed approximately 5 tons (4.5 metric ton) (Meyer 2003; D. Smith, personal commun., 1999) and was presented to Mrs. Disney as a gift. Disney later placed the petrified redwood stump on display in Frontierland at Disneyland, in Anaheim, California, where it can be seen today (Fig. 5).

Other Historic Structures with Petrified Wood

Other historic structures maintained by the National Park Service are known to contain petrified word. At John Muir National Historic Site, California, pieces of petrified wood are embedded into a stone fireplace in Muir's home. At the Grand Canyon National Park Cemetery, several of the memorial headstones are made in part or entirely of petrified wood, including those for: Watson Lacy (teacher) (1883–1963); William J. Breed (geologist/paleontologist) (1928–2013); and Ted Terry (NPS employee) (1925–2013) and Martha Terry (Ted's wife) (1928–2001).

FOSSIL INVERTEBRATES

Although no statistical data or sources to reference were discovered during this research, it appears that the occurrence of invertebrate fossils within the building stone of historic and prehistoric structures represents the most common type of fossils in this context. This would be directly related to the natural occurrence and abundance of fossil invertebrates frequently observed in geologic strata. Some examples of sedimentary rock composed predominantly or entirely of accumulated fossil material or bioclasts include coquina, fossiliferous marine limestones, and ancient reef deposits. Below are just a few notable occurrences of invertebrate fossils preserved within the building stones of historic structures.

Castillo de San Marcos National Monument, Florida

The walls of the fortification preserved at Castillo de San Marcos National Monument, Florida, are constructed of coquina from the Pleistocene Anastasia Formation (Schroeder and Klein, 1954). Completed in 1695, Castillo de San Marcos incorporated coquina quarried from the nearby Anastasia Island.

FIGURE 3. Petrified wood in the foundation of the Theodore Roosevelt Lodge, Tower Junction, Yellowstone National Park, Wyoming. NPS Photo.

FIGURE 4. Petrified wood (*Araucarioxylon arizonicum*) in the Arizona Commemorative Stone, Washington Monument, Washington, D.C. NPS Photo.

FIGURE 5. Petrified tree stump collected during the 1950s from what is now Florissant Fossil Beds National Monument, Colorado, on display at Disneyland's Frontierland (Anaheim, California). Walt Disney Corporation Photo.

In the Spanish language, the word "coquina" refers to "tiny shell," and represents poorly to moderately consolidated fossiliferous deposits. Coquina typically consists of transported concentrations of marine fossils dominated by fragmented shells and other morphological elements of invertebrate exoskeletons (Bates and Jackson, 1984). Coquina are relatively soft and easy to quarry and was intentionally used in the construction of military fortifications. Additionally, the fabric and composition of coquinas are ideally suited to disperse the force and absorb the energy from impacts by cannon balls and other ordinance, minimizing damage to the walls of the fortification.

Bright Angel Lodge – Grand Canyon National Park, Arizona

One of the best-known examples where fossils were intentionally incorporated into the design of buildings and structures is found at Grand Canyon National Park. Mary Elizabeth Jane Colter served as the main designer and decorator for the Fred Harvey Company for 46 years, between 1902 and 1948. Colter's architectural designs for Grand Canyon were inspired by the artistic and aesthetic landscape of the canyon. During her tenure with the Fred Harvey Company, she designed and constructed six buildings in Grand Canyon National Park: Hopi House (1904), Hermit's Rest (1914), Lookout Studio (1914), Phantom Ranch (1922), Desert View Watchtower (1932), and Bright Angel Lodge (1935) (Anderson 2000; Grattan, 1992).

During the construction of the Bright Angel Lodge during the 1930s, Colter worked with the park's Chief Naturalist Edwin McKee to develop some rustic architectural elements which incorporated stones and fossils occurring in Grand Canyon National Park. Colter was considered a perfectionist in her work and scientific accuracy was paramount in portraying the natural environmental qualities in her design. Two fireplaces in the Bright Angel Lodge, one in the lobby and the famous "Geologic Fireplace" in the History Room (Fig. 6), contain rocks and fossils from the Grand Canyon. The "Geologic Fireplace" is configured with stones to depict the geological sequence of strata found along the Bright Angel trail from the river to the canyon rim (Berke, 2002). The Bright Angel Lodge is listed on the National Register of Historic Places and is also a National Historic Landmark (National Park Service, 1975).

National Mall Memorials – Lincoln Memorial, Washington Monument, Jefferson Memorial, Capitol Reflecting Pool, Martin Luther King, Jr. Memorial, Washington, D.C.

Many iconic memorials and historic buildings in Washington, D.C., including those administered by the National Park Service on the National Mall, contain fossils in the stones used in their construction. The Lincoln Memorial, Jefferson Memorial, Washington Monument, and the Capitol Reflecting Pool contain quarried blocks of the extremely fossiliferous Mississippian Salem Limestone, commonly referred to by the trade name "Indiana Limestone" (Patton and Carr, 1982) (Fig. 7A-B). Many federal buildings in the Washington, D.C. area, including the Main Interior Building and the Pentagon, have been constructed using the fossiliferous "Indiana Limestone." Abundant and diverse marine invertebrate fossils, including sponges, coral, bryozoans, brachiopods, bivalves, gastropods, cephalopods, ostracods, and crinoids, have been reported from the "Indiana Limestone" (Cumings et al., 1906; Kenworthy and Santucci, 2006).

The Martin Luther King, Jr. Memorial is one of the most recent additions to the National Mall and was dedicated on August 28, 2011. The Martin Luther King, Jr. Memorial visitor contact station and bookstore contains blocks of the fossiliferous Jura Beige Limestone quarried near the village of Treuchtlingen, in southern Germany (Fig. 7C-D). This rock, quarried for building stone, is commonly referred to as the "Treuchtlinger Marmor" (Treuchtling Marble), which is a fossiliferous limestone that contains abundant Jurassic ammonite and belemnite fossils (Bantz, 1970).

Reptile House – National Zoo, Washington D.C.

Jurassic ammonites and belemnites occur within and were intentionally utilized as design elements in the building stone of the Reptile House at the National Zoo in Washington, D.C. (Fig. 7-E). The fossils are preserved in a commercial limestone from Spain known as the "Red Alicante Stone" (Goode, 1974).

Second Bank of the United States – Independence National Historical Park, Philadelphia

The Second Bank of the United States is a National Historic Landmark located within Independence National Historical Park, Pennsylvania. The bank was originally constructed between 1819 and 1824 in the center of Philadelphia's historic district. The building was a bank until the charter was revoked in 1836 and was then used by the Treasury Department as the U.S. Custom House. During the 1860s, the building underwent renovations, including the installation of new flooring on the main bank floor. The tiles used in the flooring consisted of a fossiliferous black limestone from the Ordovician Crown Point Formation, quarried from the Fisk Quarry in Isle La Motte, Vermont (Freise, 2020). The use of the fossiliferous limestone is an example of an intentional use of fossils based on their aesthetic values. The quarried stone was part of an ancient reef system and contain an abundance of marine invertebrate fossils including corals, gastropods, cephalopods, and crinoids (Fig. 7-F). Today the quarry is part of the Chazy Fossil Reef National Natural Landmark (Freise, 2020).

Medical Arts Building, Pittsburgh, Pennsylvania

The Medical Arts Building on Fifth Avenue in the Oakland section of Pittsburgh, Pennsylvania, is a well-known example of Art Deco architectural design. The building was designed and constructed in 1932 by architect Maximillian Nirdlinger (Van Trump, 1983). The first-floor entrance walls of the building are covered with highly fossiliferous, polished, black marble slabs from quarries in the Verona Province in the southern Alps of northern Italy. The black Italian marble is referred to as "Fossile Nero" and contains beautifully preserved remains of Jurassic ammonites (Fig. 7-G).

Eternal Light Peace Memorial – Gettysburg National Military Park, Pennsylvania

On July 3, 1938, in recognition of the 75th anniversary of the battle of Gettysburg, a peace memorial was dedicated at Gettysburg National Military Park, Pennsylvania, by President Franklin D. Roosevelt. More than 250,000 visitors, including approximately 1,800 veterans of the American Civil War, were in attendance at the dedication ceremony for what is known today as the Eternal Light Peace Memorial (Unrau, 1991). The memorial architect Paul Philipe Cret symbolically used stones from both a northern federal state (Maine) and a southern confederate state (Alabama) to represent post-Civil War unification of the United States. Cret used granite from Maine to form the base of the memorial and a lighter colored limestone

FIGURE 6. Bright Angel Lodge fireplaces at Grand Canyon National Park, Arizona. **A**. Fossil cephalopod within the stone fireplace in the lobby of the Bright Angel Lodge. **B**. History Room Fireplace with stones and fossils from the Grand Canyon. NPS Photos.

FIGURE 7. Invertebrate fossils in building stones. **A**, Closeup view of the Capitol Reflecting Pool, Washington, D.C., showing fossiliferous Mississippian Salem Limestone blocks with abundant crinoid columnals; **B**, Fossiliferous block of "Indiana Limestone" used as a Commemorative State Stone on display in the Washington Monument on the National Mall in Washington, D.C.; **C**, Specimen of the Jurassic ammonite *Aulacostephanus* sp. visible in the floor of MLKM; **D**, Specimen of the Jurassic belemnite *Hibolithes* sp. visible in the floor of the visitor center at the Martin Luther King, Jr. Memorial in Washington, D.C.; **E**, Jurassic ammonite specimen in the building stone of the Reptile House at the National Zoo in Washington, D.C.; **F**, Ordovician fossils embedded in the 1860s limestone floor of the Second Bank of the United States at Independence National Historical Park; **G**, Jurassic ammonites within Italian black marble on display at the Medical Arts Building in Pittsburgh, Pennsylvania. NPS Photos.

from Alabama for the shaft in the construction of the memorial. Marine fossils, including bryozoans and crinoids, are preserved within the limestone used in the memorial (Fig. 8).

FOSSIL VERTEBRATES

The occurrence of vertebrate body fossils preserved within prehistoric and historic structures is not as commonly encountered when compared to occurrences of petrified wood, invertebrate body fossils, or ichnofossils. Presented here are two examples of structures in which fossil vertebrate bones, of large extinct animals (dinosaurs and mammoths), are incorporated into the design and construction.

Fossil Bone Cabin near Como Bluff, Wyoming

One of the best-known examples of a structure in which the fossilized remains of vertebrates were intentionally used as a building material is the famous "Bone Cabin" or "Fossil Cabin" near Como Bluff, Wyoming (Fig. 9A). Locally abundant dinosaur bones were used to construct the original sheepherder's cabin, which was completed by the Boylan family in 1933 (National Park Service, 2008). The building was intentionally constructed using fossilized dinosaur bones as a curiosity, a tourist attraction, a fossil museum, and a private residence. According to the National Register of Historic Places nomination (National Park Service, 2008), the Fossil Cabin gained notoriety when it was featured by Ripley's Believe It or Not!® and nicknamed the "Oldest Cabin in the World" (Fig. 9B).

Mammoth Bone Shelters, Eastern Europe, and Asia

The use of mammoth bones in the construction of dwelling structures as a building material is well documented in several Upper Paleolithic sites in Poland, Russia, and Ukraine (Kozlowski and Kubiak, 1972; Gladkih et al., 1984; Oliva, 1988; Pidoplichko, 1998; Iakovleva, 2015). The dwellings were believed to be constructed by Neanderthals and consist of circular or ring-shaped accumulations of imbricated mammoth bones, often in association with hearths (Fig. 10). One structure which measured 16 x 26 feet (5 x 8 meters) was constructed using 116 mammoth skeletal elements, including skulls, mandibles, tusks, pelvis, and long bones (Demay et al., 2012).

FOSSIL FOOTPRINTS AND OTHER TRACE FOSSILS

Occurrences of fossil footprints and other trace fossils within prehistoric or historic structures are not uncommon. In some instances, these trace fossils were intentionally incorporated during construction of structures, while other occurrences are merely coincidental. Vertebrate tracks are generally the most visually obvious type of trace fossil in building stone, but instances of invertebrate burrows and stromatolites are also known.

Stone Bridge – Gettysburg National Military Park, Pennsylvania

Stone slabs quarried from the Late Triassic-Early Jurassic Gettysburg Formation at the Trostle Quarry, York Springs, Pennsylvania, were used in the construction of a stone bridge

FIGURE 8. The Gettysburg National Military Park Peace Memorial with examples of marine invertebrate fossils preserved in the Alabama limestone portion of the memorial. NPS Photo.

at Gettysburg National Military Park during the mid-1930s. Several dinosaur tracks and a well-preserved silesaur track are visible in the capstone of a bridge along South Confederate Avenue within the park (Fig. 11A), and the stones containing them were placed to make the tracks visible. These tracks have been identified as *Atreipus milfordensis* and *Anchisauripus* sp. (Santucci and Hunt, 1995). In 1937, more than 50 additional track-bearing slabs were recovered from the Trostle Quarry and distributed to various museums (Cleaves 1937).

Bright Angel Lodge – Grand Canyon National Park, Arizona

A fossil vertebrate footprint is also incorporated into the fireplace in the lobby of the Bright Angel Lodge at Grand Canyon National Park (National Park Service, 1975). A more detailed discussion of the intentional use of fossils in structures by designer Mary Elizabeth Jane Colter is presented earlier in the

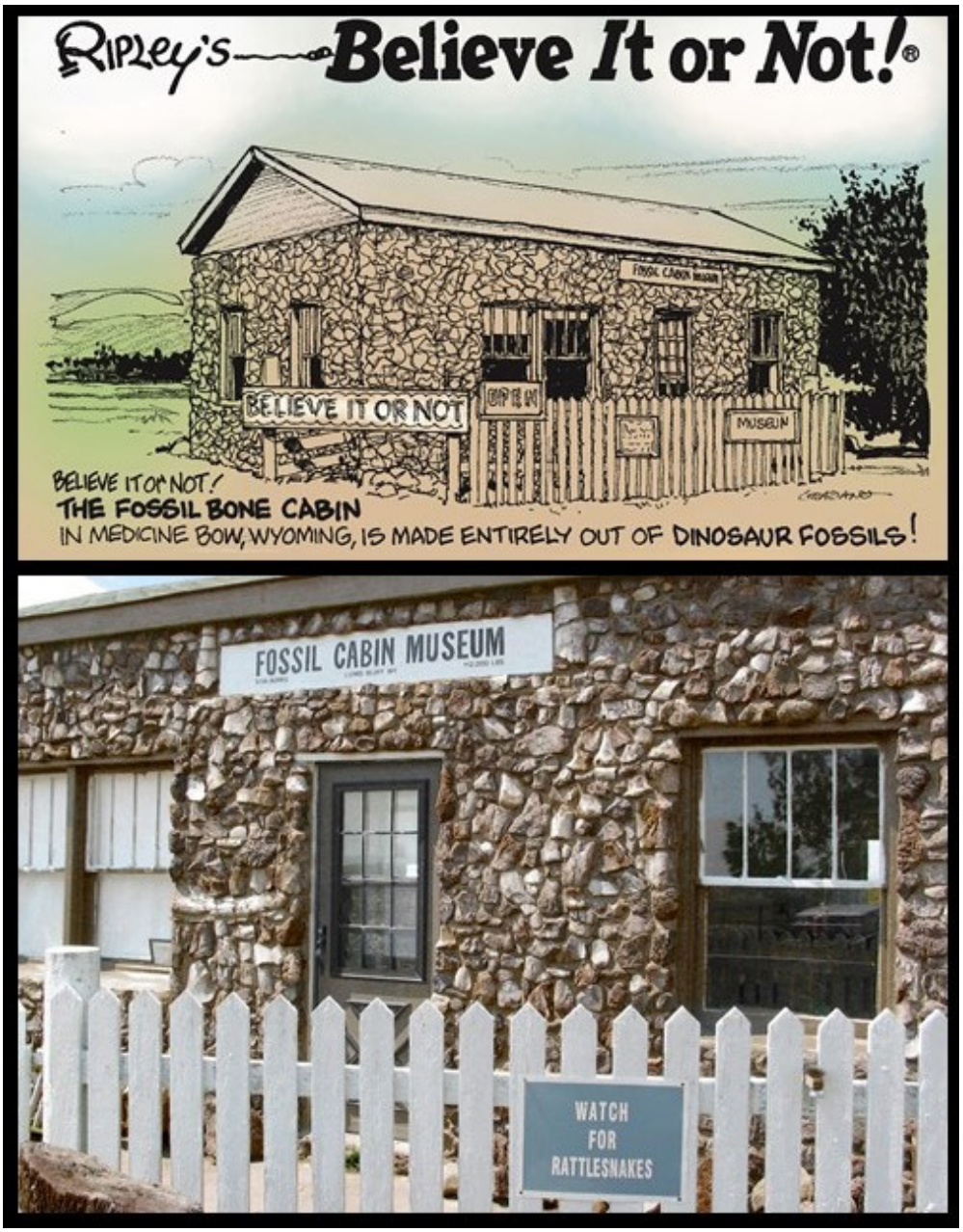

FIGURE 9. (below). The exterior of the "Fossil Bone Cabin" showing dinosaur bones used as a construction material. (NPS Photo); (above). Ripley's Believe It or Not!® cartoon of The Fossil Bone Cabin. Copyrighted image with permission from © 2020 Ripley Entertainment Inc.

FIGURE 10. Reconstruction of a Mammoth Bone Dwelling Structure on display at The Mammoth Site at Hot Springs, South Dakota. Photo Courtesy of Jim Mead, The Mammoth Site.

discussion regarding the use of fossil invertebrates in structures.

Stone Walkway and Restroom – Valley Forge National Historical Park, Pennsylvania

Fossil invertebrate burrows are preserved in stones used in the construction of the lower visitor center restroom facility at Valley Forge National Historical Park. Both vertical and horizontal fossil worm burrows, identified as the trace fossil ichnogenus *Skolithos*, occur within blocks of early Cambrian Chickies Quartzite (Wiswell, 1993; Kenworthy and Santucci, 2006). The Chickies Quartzite is the "type formation" for the ubiquitous worm burrow trace fossil *Skolithos* (Wise, 1960; Alpert, 1974). There is no indication or evidence that these building stones were intentionally selected during construction based on the occurrence of fossils.

In 2017, park volunteer ambassador Tom Stack discovered some possible vertebrate footprints preserved in blocks of stone used in the construction of a walkway at Valley Forge National Historical Park. The fossil track blocks, which were obtained from a quarry outside of the park, are from the Triassic Stockton Formation. The NPS senior paleontologist (Santucci) visited the park to assess, confirm, and photograph the occurrence of the vertebrate ichnofossils, including *Atreipus milfordensis* (Fig. 11B).

Park Headquarters Plaza – Grand Canyon National Park, Arizona

Late Paleozoic vertebrate footprints are well documented from Late Paleozoic terrestrial strata at Grand Canyon National Park, Arizona (Lull, 1918; Marchetti et al., 2020). Fossil tetrapod tracks and trackways occur within the Manakacha Formation, Wescogame Formation, Hermit Shale, and Coconino Sandstone. Track-bearing slabs of Coconino Sandstone were cut and incorporated into park architectural features, including a stone bench and flooring in the plaza of the Grand Canyon National Park headquarters building on the South Rim (Fig. 11C).

Hogan – Bureau of Reclamation, Lower Colorado River Region, Flagstaff, Arizona

Near Flagstaff, Arizona, is an interesting occurrence of fossil vertebrate tracks within a historic Native American hogan, a structure that was typically used by indigenous people as a dwelling or for ceremonial purposes. The hogan is located on lands administered by the U.S. Bureau of Reclamation in the Lower Colorado River Region. The paleontological resources of the hogan were initially observed by Dr. Welles of the University of California Museum of Paleontology on a trip with a group of students on June 6, 1947. Distinctive fossil vertebrate tracks and burrows are preserved in rectangular slabs of the Triassic

FIGURE 11. **A**, Late Triassic vertebrate footprints preserved in stone blocks used in the construction of a bridge at Gettysburg National Military Park; **B**, Triassic vertebrate tracks preserved in a walkway at Valley Forge National Historical Park, Pennsylvania; **C**, Fossil footprints preserved in a slab of Coconino Sandstone used in the design of a bench in the plaza at the Grand Canyon National Park headquarters; **D**, Fossil vertebrate tracks and invertebrate burrows preserved in a rectangular block of Moenkopi Formation used in the construction of a historic hogan near Flagstaff, Arizona. NPS Photos.

Moenkopi Formation. These fossil track slabs are incorporated into the walls of the hogan and a large slab with many fossil foot prints is located directly outside of the structure. This long rectangular track slab appears to be intentionally placed near the hogan and possibly used as a bench for sitting or other activities. In and around the hogan are hundreds of fossil tracks of the ichnogenera *Rotodactylus* and *Chirotherium* (Fig. 11D). Two *Chirotherium moquinense* tracks from the hogan were collected in 1947 and now reside in the Museum of Northern Arizona collections (Henderek et al., 2017).

CONCLUSIONS

Many historic and prehistoric structures are constructed, faced, or ornamented with sedimentary rock either found locally or imported from elsewhere. Paleontological resources are occasionally preserved in these limestones, sandstones, or shales, creating unique occurrences of fossils in a cultural resource context. Fossils in prehistoric and historic structures include body fossils, petrified wood, and trace fossils. Fossil occurrences in these structures may be a result of happenstance (e.g., suitable local material happened to be fossiliferous) or by design (e.g., a particular fossiliferous stone was desired, or stone with interesting fossils was placed in visible locations).

Fossils found in cultural resource contexts, such as within historic or prehistoric structures summarized in this paper, reinforce the interconnectivity of humans and their natural surroundings (Santucci et al., 2016). The interconnectivity of these "cultural resource fossils" creates valuable interpretive opportunities to present the human dimensions of paleontological resources. Awareness of this interconnectivity and, in some cases, sacred values associated with some paleontological resources or localities should be considered in interpretation and paleontological resource management decisions. Fossils found in historic or prehistoric structures, especially those which are Natural Register Properties, Historic Landmarks, or included in the Cultural Resources Inventory System (CRIS) Historic Structures Inventory, may be subject to management, preservation, and protection standards and guidance. Therefore, the management implications associated with these human–fossil associations preserved in historic and prehistoric structures warrants further inventory and research.

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