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Geologic Resources Division, Paleontology Program

National Park Service Welcomes Three New Paleontologists

The ranks of paleontologists in the NPS has been recently increased by three, bringing the total number to 15.

Phil Gensler – Hagerman Fossil Beds

Phil was hired as Hagerman Fossil Beds National Monument's (HAFO) staff paleontologist in May 2002. Originally from northwestern Pennsylvania, Phil received a B.A. in Environmental Science with a Geology minor from Edinboro University of Pennsylvania in 1994. He then worked as a County Technician at Crawford County Conservation District issuing permits relating to construction encroachments of wetlands, lakes, and streams. In 1996 Phil started his graduate work at Northern Arizona University, Flagstaff, Arizona in the Quaternary Sciences Program. He is completing his Masters and his thesis describes the mid-Pleistocene vertebrate fauna from the Coyote Badlands in Anza-Borrego Desert State Park, California.

Phil has worked as a seasonal museum technician at HAFO during the 1998 and 1999 field seasons and as a physical scientist from 2000 – 2001. Also, during 2001 he was acting Park Paleontologist at HAFO. In addition to his work in Anza-Borrego and at HAFO he has been involved in Pliocene and Pleistocene-aged vertebrate paleontology projects throughout Arizona, Idaho, California, Nevada, and northern Mexico.

Bill Parker - Petrified Forest

Bill is the new paleontologist at Petrified Forest National Park. Born in New Haven, Connecticut he completed his B.S. in Geology/Paleontology at Northern Arizona University in 1999, and is nearing completion of his M.S. in Geology, also at Northern Arizona University.

Bill says that being able to do paleontology at Petrified Forest National Park is a dream come true since his main interests in the field are the archosaurian reptiles of the Late Triassic. His Master's thesis involves the description of a new skeleton of the aetosaur *Desmatosuchus haplocerus* from Northern Arizona [editor's note, see Park Paleontology 6(1)]. Bill says, "I guess that one could consider it fate that I study aetosaurs. I was born in New Haven, Connecticut and spent the first 6 years of my life just "down the street" from a historical quarry that produced the first aetosaur skeleton known from the eastern United States." His interest in fossils was kindled by repeated visits to the Yale Peabody Museum to see the dinosaurs when he was a kid and he is still in possession of his first (and only) self-authored dinosaur "book", a ragtag assortment of several drawings that he created and painstakingly taped together when he was about 7 years old. Unfortunately the first portion of his paleontological career came to an end as he "outgrew" his dinosaur fever.

After high school Bill had no real interest in attending college and instead went to work in the hospitality industry. After several years of managing kitchens in restaurants he felt the call to return to school. At first torn between archaeology and geology/paleontology he decided to spend a summer doing each. In 1996 he spent two months in the country of Belize excavating Maya sites on the western border. He is probably one of the few vertebrate paleontologists whose first dig was of *Homo sapiens*. Then in 1997 he spent two weeks in the Hell Creek Formation excavating *Triceratops* material and investigating a sizeable hadrosaur bone bed. Needless to say, although he greatly enjoyed both experiences, paleontology won out.

While searching for a senior thesis topic during his undergraduate studies at Northern Arizona University in 1998 his advisor mentioned a partial reptile (aetosaur) skeleton from the Chinle Formation of Arizona and thought it would be great experience to excavate the couple of bones and write up a description. The few bones turned into over two hundred with a relatively complete skeleton being present and his senior thesis turned into a Masters, along with a love for the late Triassic Period. In May, 2001 Bill was hired by Petrified Forest National Park to conduct a paleontological inventory of the park and he is still conducting surveys although in his present position the duties have expanded. While at the park he has excavated several significant specimens including another aetosaur skeleton, as well as several partial phytosaurs.

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Besides his Triassic work he has also worked in the Late Cretaceous of Utah, doing a paleontological inventory for the Manti-LaSal National Forest. His fieldwork and research has taken him all over Arizona, Utah, New Mexico, Texas, and even Mexico where he has done some Pleistocene work. His future goals involve not only finishing his work on the aetosaur but eventually to pursue a Ph.D.

Matthew Smith – John Day Fossil Beds

Growing up surrounded by the fossil-rich waterways of North Florida, Matt developed an early interest in the ancient and modern biota of his home state. In 1992 he decided to pursue a Zoology degree at the University of Florida, Gainesville. Other than a brief foray into the world of entomology with the Agriculture Department, he restricted his movements as much as possible to the halls of the Florida Museum of Natural History and the buildings immediately adjacent. While lurking about he discovered that the arcane field of fossil preparation was the only sensible avenue of study within the greater world of Paleontology, being that the preparation laboratory was where they kept the coffee maker. After earning his Bachelors, he headed to the Smithsonian Institution

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Three New NPS Paleontologists

Phil Gensler in the collections at Hagerman Fossil Beds with a shell of a fossil turtle.

Bill Parker excavating an aetosaur skeleton at Petrified Forest National Park.

Matt Smith in the lab at John Day Fossil Beds puzzling over one of the latest finds.

in Washington DC to build supportive fiberglass and plaster jackets for some of their oversized fossils due to be shipped to their new facility Maryland. In secret he kept close watch on the masterful preparators employed there, and dared to dream that he could one day apply some of their techniques to fossils outside of a crowded, metropolitan setting. He came close to realizing this idle reverie when he traveled to La Paz, Bolivia to assist the staff at el Museo Nacional del Historie Natural in mounting the skeleton of *Eurygenium pacenium*, a rather unusual Notohippid. While there, he was also lucky enough to go and work for a few short days at the beautiful field locality of Salla, famous for some of the earliest primate fossils in South America. Returning from Bolivia in May of 1998, and at a loss for what to do next, he applied for seasonal employment at John Day Fossil Beds National Monument as a laboratory technician. One thing led to another, and four years latter he was offered a permanent position as a full time preparator. In this way his musings while in Washington came full circle, and he now works and resides in the wilds of the beautiful John Day River Basin.

What is a Notohippid?

A distinctive group of hoofed mammals evolved in South America called the notoungulates. They ranged in size from small rabbit-like forms to the massive *Toxodon*, which stood over 2 m high at the shoulder. One group called the Notohippids (meaning southern horse) has features of the skull and incisors similar to that of horses.

Fossil Walrus Skull Found on the Outer Banks near Cape Hatteras

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In 1990, a park visitor to Cape Hatteras National Seashore came across an ancient walrus skull washed up on the beach in Salvo, North Carolina. National Park Service rangers acquired the walrus skull and sent the specimen to the Smithsonian Institution where it has been analyzed and preserved since 1990. David Bohaska, Museum Specialist at the Smithsonian Institution has been studying the walrus skull, and has determined that the skull is one of the best specimens found. The walrus skull was largely intact except for missing its two tusks.

The Walrus Skull has been returned to Cape Hatteras National Seashore to be placed on exhibit at the Graveyard of the Atlantic Museum, Hatteras, North Carolina.

The National Park Foundation has provided funding to obtain a carbon 14 date on the skull in order to try and determine its exact age. The skull is currently at Stafford Research Laboratories in Boulder, Colorado where a sample from the tusk is being removed for analysis.

Right: View of the palate of the skull of fossil walrus found at Cape Hatteras National Seashore. Photo by: Doug Stover

Further Reading

Deméré, T. A. 1994. The Family Odobenidae, a phylogenetic analysis of fossil and living taxa. In, Berta, A. and T. A. Deméré (eds.), Contributions in Marine Mammal Paleontology Honoring Frank C. Whitmore, Jr. Proceedings of the San Diego Society of Natural History 29: 99-123.

Fay, F.H., 1981. Walrus *Odobenus rosmarus* (Linnaeus, 1758). pp. 1-23. In S.H. Ridgway and R.J. Harrison, eds., Handbook of Marine Mammals. Vol. 1. Academic Press, London.

Miller, R.F. 1997. New records and AMS radiocarbon dates on Quaternary walrus (*Odobenus rosmarus*) from New Brunswick. Géographie physique et Quaternaire 51(1): p. 1-5.

Riggs, S.R., W.J. Cleary and S.W. Snyder. 1995. Influence of inherited geologic framework on barrier shoreface morpholoy and dynamics. Marine Geology 126:213-234.

The Occurrence and Distribution of Fossil Shells on U.S. mid-Atlantic Beaches

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Many of the National Parks in the western United States are known for their variety and abundance of spectacular vertebrate and invertebrate fossils. In the past few years, however, fossil discoveries of a more subtle nature have been made on the beaches of the mid-Atlantic coastal parks. In the National Seashores of the East, calcium carbonate remnants of former living organisms, transported and deposited on the beaches over the past several thousand years, reveal a part of the story of the dynamic processes of coastal evolution reaching back over the past several million years.

Mercenaria (commonly known as the Quahog clam) is a robust mollusk found along the Atlantic coast of the U.S. Though other shells are part of this story too, they are typically more fragile than *Mercenaria* and do not as readily survive the coastal waves and weather. In this brief article, therefore, *Mercenaria* specimens collected from Cape Hatteras and Cape Lookout National Seashores will be used as examples to explore questions about their geologic age, their sources, and the geologic processes that carried them from their source to the location where they were found.

Where do we find these shells?

Coastal regions, particularly barrier islands and beaches, are extremely dynamic geologic environments. During the past million years (the last half of the Pleistocene epoch), an alternating fall and rise of sea level associated with glacial cycles has occurred approximately ten times (roughly every 100,000 years) as major northern hemisphere ice sheets have expanded and contracted. Approximately 18,000 years ago, when ice sheets were at their maximum volume, global sea level was at a low point of about 120 meters below the current level, and coastal landforms were far from their present locations. Subsequent deglaciation caused a global rise in sea level, causing a transgression of the shoreline upward and landward across the continental shelf, eventually (within the past 5,000 years) reaching the modern shoreline position.

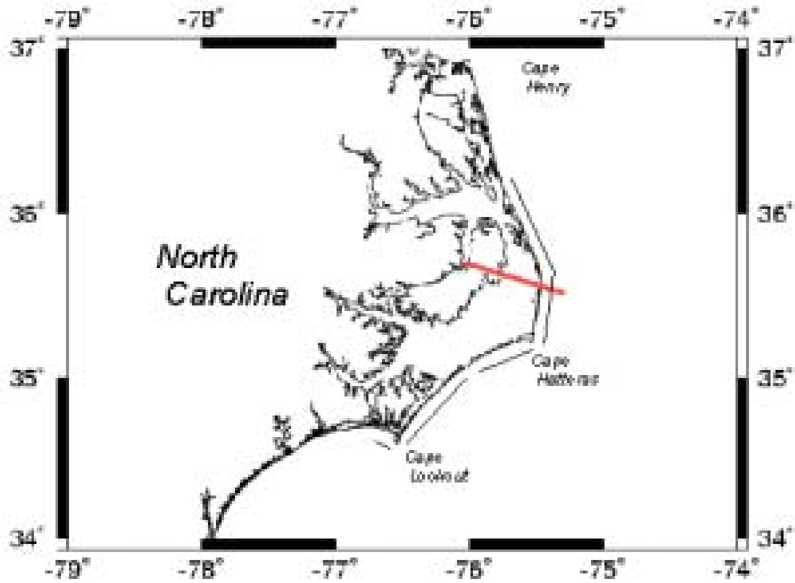

Figure 1. Map of the U.S. Atlantic Coast from Cape Henry (VA.) to Cape Fear (NC). Sampling of beaches for fossil material has occurred along the entire section of coast indicated by the coast-parallel lines. The heavy red line indicates the position of the schematic cross section shown in Figure 4.

Each interglacial high stand (period of ice sheet retreat) creates a variety of sedimentary deposits associated with estuary, marsh, lagoon, beach, and continental shelf environments. Subsequent glacial/interglacial sea level regressions and transgressions modify these pre-existing deposits through erosion and/or further sediment accumulation. Shells are part of this migration. Although only a small fraction may be preserved during their long history as fossils, some of these shells are transported and deposited (often by storms) on beaches, often in overwash deposits behind coastal dunes. Later, as the beaches migrate inland, some of these shells become exposed and/or re-deposited on the modern beach. Depending on its durability, fossil material incorporated into the original sedimentary unit (the source unit) may be exposed, transported, and re-deposited in a younger unit.

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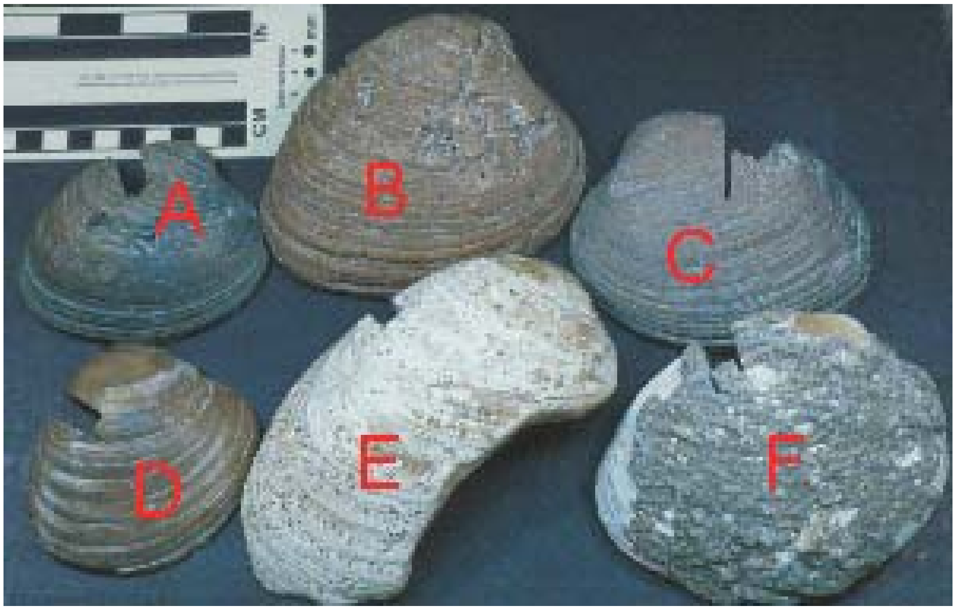

Figure 2. Cape Hatteras *Mercenaria* shells with D/L data. Shells collected approximately 5 km southwest of Cape Hatteras Lighthouse in January 1993, at Cape Point. Specimen D is approximately 7,500 years old based on a radiocarbon date; note matrix of cemented shell debris on specimen F - this matrix is common in rock fragments found on NC beaches. Specimen A: D/L = 0.37; Specimen B: D/L = 0.25; Specimen C: D/L = 0.31; Specimen D: D/L = 0.16; Specimen E: D/L = 0.46; Specimen F: D/L = 0.30.

Figure 3. Core Banks shells, collected April, 1993, due east of Davis NC. Specimen G : D/L = 0.24; Specimen H: D/L = 0.70; Specimen I: D/L = 0.27; Specimen J: D/L = 0.30; Specimen K: D/L = 0.24; Specimen L: D/L = 0.65

What do these fossils look like?

To better understand this concept of coastal evolution, shells collected on the Outer Banks of North Carolina, in Cape Hatteras and Cape Lookout National Seashores have been studied (Figure 1). Most of the shells collected are not particularly unusual in appearance, though some have a gray-blue, darkened coloration, possibly the result of being buried in the mud for hundreds of thousands of years. Because fossil and modern shells are frequently similar in appearance, over the past decade, geologic dating methods have been used to determine the frequency of occurrence of fossil shell material on mid-Atlantic beaches, specifically those that have not been affected by artificial beach nourishment (Wehmiller et al, 1995.)

How old are these shells, and how do we determine their age?

The principal method employed to determine the geologic ages of these shells is amino acid racemization (AAR). This method relies upon the time-dependent alteration of proteins and their constituent amino acids preserved in the shell hard part. Natural amino acids exist in two geometric forms referred to as "left-handed" (L for "levo") and "right-handed" (D for "dextro"). Most living systems utilize only the left-handed amino acid. But over time, the left-handed form racemizes to create the right-handed form. As a result of this process, the ratio of right to left (D/L) grows from zero to 1.0 (an equal abundance of the two forms in equilibrium).

The rate of this reaction is dependent on temperature, so the "clock" is not an absolute one. However, the rate can be calibrated with independent dating methods (particularly radiocarbon – or Carbon-14) for a given region where temperatures are similar. In the climate of the mid-Atlantic region of the eastern U.S., the reaction takes at least one million years to reach equilibrium. Because the upper limit of radiocarbon dating is about 40,000 years, AAR age estimates can be made over a much greater time range than can be dated by radiocarbon. AAR is also an economical and rapid analytic method, hence it can be applied to a far larger number of samples than methods based on radioactivity.

Examples of the collections *Mercenaria* specimens from Cape Point (Cape Hatteras) and South Core Banks are shown in Figures 2 and 3. Each analysis used a fragment from either the hinge or central portion of the shell as indicated. The D/L ratios (for one amino acid known as isoleucine) for each shell are given in the captions. All but specimen J (Figure 2) are from the Pleistocene era (greater than about 12,000 years in age) based on the measured values of the D/L ratio. The one shell that is not Pleistocene (specimen J) is about 7,500 years in age, based on a radiocarbon analysis of this shell. The ratios for the older shells cluster into three groups with the following ranges: 0.24-0.31; 0.37-0.46; 0.65-0.70.

Figure 4 shows a representative geologic cross section for eastern North Carolina, with superposed layers representing the successively older coastal units that accumulated during Pleistocene sea level transgressions. These units are recognized in onshore drilled sections, and they are exposed on the inner continental shelf and shoreface of the modern barrier islands. Sedimentary units found in the onshore subsurface have the same D/L ratios as those found in beach specimens, indicating that these beach shells have been derived from correlative units that are being actively exposed and eroded by modern coastal processes.

How old are these Pleistocene shells?

This question can be answered by using models for the rates of amino acid racemization and/or estimated ages for selected onshore samples. Using this approach, the three clusters of D/L values summarized above represent ages of approximately 100,000, 300,000, and 700,000 years, respectively. These age estimates have

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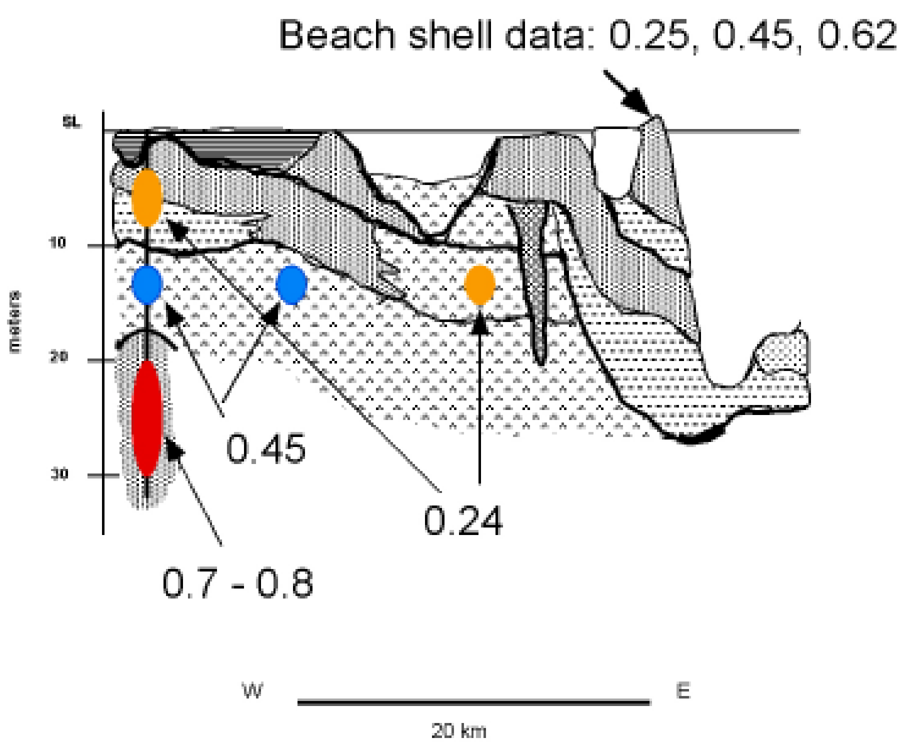

Figure 4. Representative geologic cross section of the N. C. coastal plain, showing D/L values obtained in subsurface onshore sections and in shells collected on the barrier island beaches. See Riggs et al. (1992) for background information on the onshore geology.

quite large uncertainties for a variety of reasons, but they suggest that some beach shells that may otherwise appear quite "well-preserved" are, in fact, several hundred thousand years in age.

How long has it been since they were eroded from their host unit and deposited at their present location?

The answer to this question must consider several factors: the history of sea-level rise over the past few thousand years, the depth below present sea level of the source units, the transport distance that can be "survived" by these shells, and the very mechanisms by which these large shells are moved from submerged to emergent locations. These factors depend on storm events, rates of barrier island migration (in response to sea-level rise), the supply of sediment (sand) in the coastal system, and the geologic framework that underlies the barrier islands (Riggs et al., 1995). A large abundance of nearly complete Pleistocene shells indicates limited exposure to processes of fragmentation, suggesting proximity to source units. The ratio of fragmented to whole fossil shells varies widely along the Outer Banks, and it is remarkably low at Cape Point, suggesting that this area is an "island" of older sediments (Wehmiller et al., 1995).

The shells shown in Figures 2 and 3 are typical of the Pleistocene fossil shells found along the mid-Atlantic beaches of the US. The frequency of occurrence of these shells is controlled by a large number of factors, including the actual extent of the preserved record of Pleistocene sea levels in a given region, the extent to which these older records are "hidden" from modern coastal erosion by overlying sandy deposits, and the shell content of the older units. Based on information obtained at sites from New Jersey to northern Florida, the NC Outer Banks appear to offer the greatest concentration of these Pleistocene fossils.

What story is told by the fossil shells found in the Cape Hatteras and Cape Lookout National Seashores?

Although it may be difficult to use the ages of beach shells to identify the specific sources of these samples, beach samples do provide an integrated record of the geology of the coastal region. Beach sampling suggests where host units might be found on the continental shelf. Where large concentrations of fossils are found, it often indicates that older units are exposed on the nearby shelf, further suggesting an area vulnerable to erosion. More complicated and expensive sampling techniques (drilling and coring) on the continental shelf provide a more detailed record confirming these conclusions.

So even though the beach fossils may not be very unusual or striking in their appearance, they are a component of the continuing story of the evolution of coastal landforms that change on timescales of years to millennia.

Further Reading

Riggs, S. R., L. L. York, J. F. Wehmiller, and S. W. Snyder, 1992, Depositional patterns resulting from high frequency Quaternary sea-level fluctuations in northeastern North Carolina. In: C. H. Fletcher III and J. F. Wehmiller (editors), Quaternary Coasts of the United States: Marine and Lacustrine Systems. Tulsa, SEPM (Society for Sedimentary Geology) Special Publication No. 48, pp. 141-153.

Riggs, S. R., Cleary, W. J., and Snyder, S. W., 1995, Influence of inherited geologic framework on barrier shoreface morphology and dynamics. Marine Geology 126, 213-234.

Wehmiller, J.F., York, L. L., and Bart , M. L. , 1995, Amino acid racemization geochronology of reworked Quaternary mollusks on US Atlantic coast beaches: implications for chronostratigraphy, taphonomy, and coastal sediment transport. Marine Geology 124, 303-337.

See also: http://www.geology.udel.edu/wehmiller/shells.html

Acknowledgments:

Support from the U.S. National Science Foundation, the U. S. Geological Survey, and the U. S. National Park Service is gratefully acknowledged, as are the discussions with many collaborators in discussions or field collections, particularly P. L. Wehmiller, K. and R. Thieler, and S. Riggs.

Documenting outcrops of Middle Jurassic Aztec Sandstone with dinosaur tracks.

California Dinosaur Tracks: Inventory and Management

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California's only dinosaur tracks are Middle Jurassic in age and are located in the Aztec Sandstone in the eastern Mojave Desert near Mojave National Preserve. The Aztec crops out in the Mojave Block at Ord Mountain, the Soda Mountains, Cow Hole Mountains and in the Mescal Range.

The popularity of dinosaurs during the late 20th century prompted concern that no detailed inventory existed for California's only tracks. Not only are the tracks unique to the state, but early Jurassic track sites are rare in the western United States. Previous work identified trackways representing three bipedal coelurosaurs assigned to the ichnogenera *Anchisauripus*, *Grallator,* and an unnamed ichnogenus. In addition to the coeleurosaur tracks, tracks and trackways of more than 4 quadrupedal ichnogenera are represented. The track impressions of both quadrupeds and bipeds produce compression rings that suggest original slope of dune topography. Also preserved are sedimentary structures, cross-bedding, ripples, raindrops and trails and tracks left by invertebrates.

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Dinosaur tracks in the Azrec Sandstone.

One hundred and sixteen track and structure localities were recorded, including outcrop panels and loose slabs. Of importance, the second of two occurrences of a small (juvenile) bipedal trackway paralleling an adult trackway was located. All track locations were photographed and attitudes were taken of outcrops that reflected the local dune surface. Baseline data is now available for further inventory and management of the trackway site. Research questions that can now be addressed include, what are the characteristics of the sedimentary facies in which tracks are preserved, and where they are not preserved; and whether there is any biological or geographic significance to the direction of the tracks. This baseline data will help quantify research questions and help managers with further inventory and the appropriate management of the trackway sites.

Evans (1958) first recognized the tracks in the Aztec Sandstone of California. Descriptions of the three bipedal and four quadrupedal tracks were published by Reynolds (1989), who documented the direction of travel for the quadruped tracks and demonstrated that the bipeds had less directional preference. Review of Jurassic tracks in Utah and Wyoming (Kvale et al., 2001; Breithaupt et al., 2001) as well as field investigations in the Aztec of southern Nevada suggest that the ichnogenera and ichnospecies represented in the Mescal Range section are uncommon west of the Rocky Mountains.

The age of the Aztec Sandstone in the Mescal and Goodsprings Ranges was originally referred to the Jurassic (Hewett, 1956; Evans, 1958) but its exact position within the Jurassic has been questioned. The first tentative dates on the Delfont Volcanics that overlie the Aztec in the Mescal Range were in the 150 Ma range, and two of the dinosaurian ichnogenera found in the formation were previously known from the Newark Supergroup of the Connecticut Valley which spans the Triassic and the Jurassic. Recent work on andesite interbedded with the Aztec in the Cowhole sequence gave a date of 173 ± 4 million years and a date on the basal ignimbrite that overlies the sequence has permitted more accurate placement of the age of the formation at 170 ± 2 million years.

Based on the dates from the Cowhole section the age of the dinosaurian trackways would be middle Jurassic, and based on the stratigraphic relationships in the Mescal Range, no younger than mid-Cretaceous. A middle Jurassic age accords well with the relationship of two ichnogenera, *Anchisauripus*, and *Grallator*, to the tracks in the Jurassic portion of the Newark Supergroup as well as in the Moenave Formation of northeastern Arizona (Irby, 1993). The unnamed ichnogenus from the Mescal Range is smaller than tracks with similar morphology from the lower Cretaceous of South Dakota (Anderson, 1939) and the Jurassic of China (Zhen et al., 1986), and presumably indicates a pre-Cretaceous age.

Some or the research questions being pursued include:

-Do the tracks reflect the population dynamics of each ichnogenera?

-How do the dynamics of quadrupedal ichnogenera relate to those dynamics of the bipeds.

-How do the dynamics of all ichnogenera relate to the specific substrate; what were they doing as they crossed dune sand; can feeding habits be speculated upon?

-The size of the foot imprint varies both with age of individual and with consistency of substrate. Can parameters for variation by age be distinguished from differentiation due to substrate?

-Further work on direction and bearing of bipedal and quadrupedal track makers. Data can be corrected to adjust for anticlinal folding.

-Tracks apparently are best or only preserved in certain sandstone lithologies. Can environmental parameters be applied to those lithologies?

-Track bearing horizons can now be measured to the lowest overlying volcaniclastic unit. If this unit can be dated, it will provide time constraints on the local ichnogenera.

-Population diversity may be studied by detailed measurements of the print size of the large sample of one ichnogenus.

Summary

Recently acquired UTM coordinates record 116 tracks, trackways or structures in the Aztec Sandstone of the Mescal Range in the eastern Mojave Desert. The 2001 inventory identified loose slabs or outcrops containing 44 panels with bipedal coeleurosaur tracks, 73 panels with quadruped tracks, 19 panels with invertebrate tracks, and five localities where sedimentary structures were recorded. Plots of the loci suggest that tracks occur in two arenaceous facies of the Aztec Sandstone. Among the more interesting discoveries during the survey was a new panel that contained small and large tracks of the unnamed ichnogenus walking in parallel directions.

The inventory of the Mescal Range tracks provided critical base line data for management and demonstrates the need for further inventory and research in the Aztec Sandstone. The detailed location data allows resource managers to determine if sandstone blocks and outcrops are subject to movement, degradation or removal. The photographic record will indicate whether outcrops and individual tracks are subject to degradation by weather or vandalism. Further surveys are needed as other outcrops remain to be examined for track impressions and the existing data only describes sets of conditions where track preservation is most likely to exist. Annual review of changes to California's only dinosaur track site will determine if the current level of resource management is adequate for their long-term preservation for scientific study, education, and interpretation.

References

Anderson, S.M. 1939. Dinosaur tracks in the Lakota Sandstone of the Eastern Black Hills, South Dakota. Journal of Paleontology 13(3):361-364.

Beckerman, G.M., J.P. Robinson, and J.L. Anderson. 1982. The Teutonia Batholith pp. 205-220 in E.G. Frost and D.L. Martin (eds.). Mesozoic-Cenozoic Tectonic Evolution of the Colorado River Region, California, Arizona, and Nevada. Cordilleran Publishers, Geological Society of America Field Trip.

Breithaupt, B.H., E.H. Southwell, T.L. Adams and N.A. Matthews. 2001. Innovative documentation methodologies in the study of the most extensive dinosaur tracksite in Wyoming. Pp. 113-122 in V.L. Santucci and L. McClelland (eds.). Proceedings of the 6th Fossil Resource Conference. Technical Report NPS/GRD/GRDTR-01/01.

Evans, J.R. 1958. Geology and mineral deposits of the Mescal Range quadrangle, San Bernardino County, California. Scale 1:24,000, University of Southern California, Unpublished Masters Thesis.

Fleck, R.J., M.D. Carr, G.A. Davis and C.B. Burchfiel. 1994. Isotopic complexities of the Delfont Volcanic Rocks, eastern Mescal Range, southeastern California. Stratigraphic and tectonic implications. Geological Society of America Bulletin 106:1242-1253.

Fleck, R.J. and R. E. Reynolds. 1996. Mesozoic stratigraphic units of the eastern Mescal Range, southeastern California. San Bernardino County Museum Association Quarterly 43(1):49-54.

Hewett, D.F. 1956. Geology and mineral resources of the Ivanpah Quadrangle, California and Nevada. United States Geological Survey Professional paper 275: 172 pp.

Irby, G.V. 1993. Early Jurassic dinosaur track sites, northeastern Arizona. pp. 15 - 23 in D. Boas and M. Dornan (eds.). First Annual Symposium, Fossils in Arizona. Mesa Southwest Museum.

Kvale, E.P., G.D. Johnson, D.L. Mickelson, K. Keller, L.C. Furer, and A.W. Archer. 2001. Middle Jurassic (Bajocian and Bathonian) dinosaur megatracksites, Bighorn Basin, Wyoming, USA. Palaios 16:233-254.

Reynolds, R.E. 1989. Dinosaur trackways in the lower Jurassic Aztec Sandstone of California. Pp. 298-292 in D.D. Gillette and M.G. Lockley (eds.). Dinosaur Tracks and Traces. Cambridge University Press.

Zhen, S., J. Li, and C. Rao. 1986. Dinosaur footprints of Jinning, Yunnan. Memoirs of the Beijing Natural History Museum 33: 18 pp.

Ted Weasma of Mojave National Preserve with a GPS unit used for documenting the location of the dinosaur tracks in the Aztec Sandstone.

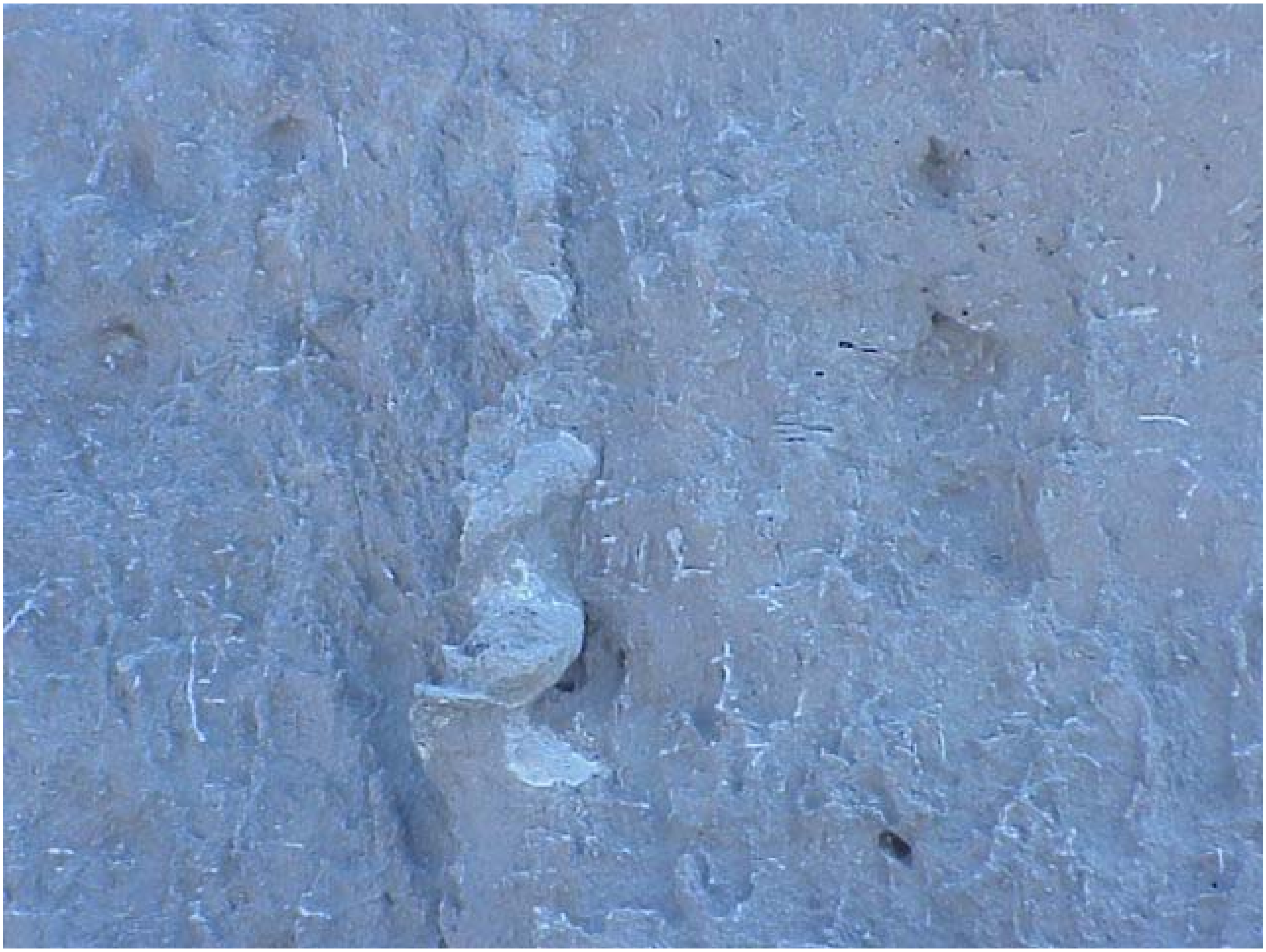
What Are Trace Fossils?

Fossils can be divided into two general groups – body fossils and trace fossils. Body fossils are the preserved anatomical parts of the plant or animal and provide direct evidence while trace fossils are produced by the animal's activities. A trace fossil is therefore indirect evidence of ancient life and provides information on the behavior of the organism. There are many different types of trace fossils. Dinosaur tracks and trackways are perhaps the best known. Often animal's burrows become filled with sediments and are preserved. Nest structures are another type of trace fossil. Evidence of feeding can be preserved as trace fossils such as insect chewing on leaves. Tooth marks on bones may be left by a predator while feeding on its prey or by rodents chewing on bones for the minerals. Other examples of trace fossils are borings. These may be into shells by marine organisms or may be made by insects in wood. Some insects like dermestid beetles can bore into bone. Eggs, gizzard stones, and dung are also considered trace fossils. The study of trace fossils is called ichnology.

CAN YOU IDENTIFY THE FOSSIL?

Name the fossil and the park where it is found.

Answer on page 9



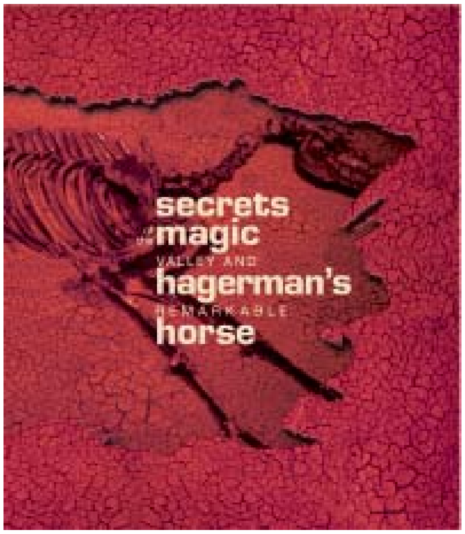
DID YOU KNOW?

The worldś largest concentration of caves (4) containing fossil ground sloth dung occurs in Guadalupe Mountains National Park.

The second largest number of caves with fossil ground sloth dung occurs in Grand Canyon National Park.

Dung of the extinct ground sloth, *Nothrotheriops shastensis,* from Rampart Cave, Grand Canyon National Park, Arizona.

Recent Literature on Park Paleontology Resources



Secrets of the Magic Valley and Hagerman's Remarkable Horse

Black Canyon Communications in cooperation with Hagerman Fossils Beds National Monument, the Hagerman Fossil Council and Boise State University is pleased to announce the publication of **Secrets of the Magic Valley and Hagerman's Remarkable Horse**. Edited by Boise State History professor Todd Shallat, the fully illustrated book tells the story of Idaho's Magic Valley, from the prehistoric Ice Age mammals to emigrants on the Oregon Trail to the complex harnessing of water that transformed a desert into an important agricultural region. But the story does not always match the myths and legends: "Humans alter nature, but nature bites back in a continuous process that results in a mythic landscape both human and natural with surprising secrets and unexpected twists" (p. 20).

In addition to telling the story through words, the book tells the story through hundreds of historic and contemporary photographs as well illustrations, maps, and paintings.

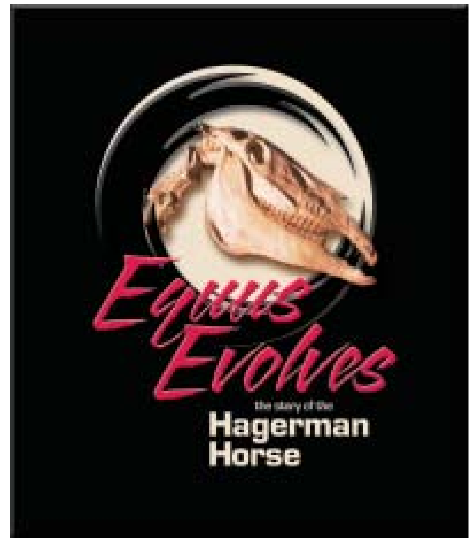
Chapters
1. Magic Mirror (geology and geography of Snake River Plain)
2. Equus Evolves (fossils and paleontology)
3. Arrows and Atlatls (archeology)
4. First Encounters (fur trade and exploration)
5. Devil's Backbone (Oregon Trail and emigration)
6. Staking Claim (ranching, farming, and mining)
7. Skull in the Quarry (fossil discovery and monument history)
8. Route 30 (roadside culture and landscape)
9. Making Magic (river ecology)

Includes bibliographical references and index. Photographs, Maps, Charts, Paintings, Illustrations

Price $29.95

Equus Evolves: The Story of the Hagerman Horse

In addition to the Secrets book, Black Canyon Communications and the Hagerman Fossil Council are also pleased to announce the publication of **Equus Evolves: The Story of the Hagerman Horse.** This book excerpts two chapters from the Secrets book along with two additional chapters that focus exclusively on the Hagerman Horse and the Hagerman Fossil Beds National Monument. The story sheds light on the fossil finds in Hagerman and how a natural wonder became a national monument.



Chapters
1. Living Rock (geology)
2. Equus Evolves (fossils and paleontology)
3. Skull in the Quarry (fossil discovery and monument history)
4. A Future Tied to the Past (future of research and development of the monument)

Includes bibliographical references and index. Photographs, Maps, Charts, Paintings, Illustrations

Price $12.50

Both publications are available from Hagerman Fossil Beds National Monument, P.O. Box 570, Hagerman, Idaho 83332

Skeleton of the Hagerman Horse, *Equus simplicidens*, from the Smithsonian Horse Quarry, Hagerman Fossil Beds National Monument.

Answer to Fossil Identification from page 8

It is part of a burrow of the extinct beaver *Palaeocastor* found at Agate Fossil Beds National Monument, Nebraska

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Denver, Colorado 80225

Flower of the plant, *Florissantia*, named for Florissant, CO, home of Florissant Fossil Beds National Monument.