MAMMOTH TRUMPET

Volume 25, Number 2 ▪ April, 2010

Center for the Study of the First Americans
Department of Anthropology
Texas A&M University
4352 TAMU
College Station, TX 77843-4352
www.centerfirstamericans.com

Paleo Rock Art or Graffiti?

LARRY AGENBROAD

Since its discovery was reported in 1935, this petroglyph, the famous Utah "Moab mastodon," has sparked controversy. Some authorities regard this and other examples of incised or pecked images (petroglyphs) and painted images (pictographs) as either of dubious authenticity or outright fakes. Not so archaeologist Larry Agenbroad. Dr. Agenbroad is convinced this and many other images found throughout the West were created by Paleoamerican artists. (He believes the Moab artist depicted a mammoth, not a mastodon.) Unfortunately, the technical problems involved in dating rock art make it difficult for him and other experts to sway doubters. Read the details in our story on page 4.

The Center for the Study of the First Americans fosters research and public interest in the Peopling of the Americas. The **Center,** an integral part of the Department of Anthropology at **Texas A&M University,** promotes interdisciplinary scholarly dialogue among physical, geological, biological and social scientists. The **Mammoth Trumpet,** news magazine of the **Center,** seeks to involve you in the peopling of the Americas by reporting on developments in all pertinent areas of knowledge.

MAMMOTH TRUMPET

Volume 25, Number 2 | Center for the Study of the First Americans | Department of Anthropology

April, 2010 | Texas A&M University, 4352 TAMU, College Station, TX 77843-4352 | ISSN 8755-6898

World Wide Web site http://centerfirstamericans.org and http://anthropology.tamu.edu

decoding the woolly mammoth part III

A *Sporormiella* fruiting body releasing spores.

ASA KRUYS, TREE OF LIFE PROJECT

Timing Extinction by Proxy

AS PALEOECOLOGISTS Jacquelyn Gill and Jack Williams might tell you, it's amazing what you can learn from the tiniest things. After all, their recent studies of microscopic objects in ancient lake sediments have helped to clarify, in a delightfully indirect way, one of the more controversial questions in American prehistory.

Now that the pre-Clovis question has been resolved to the satisfaction of most authorities (**MT 22-3, -4,** "Clovis Dethroned"), there are few topics more vexing to First Americans researchers than the timing and causes of the mass extinctions at the end of the Pleistocene. Theories regarding the mechanisms that polished off imposing beasts like the megatherium, teratorn, and mammoth vary widely. Overkill by humans has been a perennial favorite since the 1960s, as have climate and vegetation changes in the wake of receding glaciers. Hyperdisease (**MT 14-1,** "Explaining Pleistocene Extinctions," and **MT 18-4,** "Tuberculosis Found in Mastodon Makes the Case for Hyperdisease in Megafauna") and, more recently, a devastating extraterrestrial impact (**MT 23-1 ff.,** "The Clovis Comet") have also had their days as hypotheses.

INSIDE

The latest revelations don't explain the causes of the extinctions, but they do shed light on their timing and provide vital clues that might ultimately help reveal the full truth. And it can all be traced to dung—or, more specifically, a microscopic fungus that lives in the dung of herbivores. A team led by Gill and Dr. Williams, both of the University of Wisconsin–Madison, recently studied a fungus called *Sporormiella* to pinpoint precisely when the populations of mammoths and mastodons began to decline. The results weren't exactly what they expected when they began—but then, that's science.

The humble, lovable dung fungus

In previous installments in this "Decoding the Woolly Mammoth" series we examined recent DNA studies that have illuminated the genetic history of the genus *Mammuthus* and its relationships to both the mastodon and modern-day elephants. In this episode we'll take a look at new science that links the demises of both mammoth and mastodon with other changes that occurred during the tumultuous transition from Pleistocene to Holocene.

In a paper published in the 25 November 2009 issue of *Science*, Gill, Williams, and three colleagues compared the frequencies of a number of paleoecological proxies in sediments collected from lakebeds in Indiana and New York State. In scientific parlance, proxies are distinctive markers that stand for other objects, living organisms, or events that are themselves difficult to detect in the fossil record. Think of proxies as clues that indirectly cast light on past ecological conditions. In this case, the proxies studied were *Sporormiella*; pollen from novel "no-analog" vegetation communities that have since been replaced by modern communities; and tiny flecks of charcoal from forest fires. All these proxies, washed or blown into the lakes by natural processes in amounts representative of the magnitude of the actuality each stands for, then settled to the lake bottoms in readily identifiable layers.

In this scenario, *Sporormiella* substitutes for the population of mammoths and mastodons. Which begs a question: How can microscopic spores stand for some of the largest animals ever to walk the Earth? Well, it's like this: *Sporormiella* is a common fungus that's specific to herbivore dung, and it has been demonstrated to occur in large numbers in the dung of mammoths and mastodon. It preserves readily and is easy to find and identify. Preserved macroscopic bones and other remains of mammoths and mastodons, on the other hand, are comparatively rare.

"*Sporormiella* is the only fungus we know of that has distinctive spores that are identifiable to genus and *only* grows on animal dung," Gill notes. "It's very important that the fungus we use in a study like this is identifiable by microscopy, and isn't responding to some other ecological/climatic condition on the landscape." The more poop, the more fungal spores; it's that simple. Gill explains that "you need large numbers of animals producing large amounts of dung to get enough spores in the lake sediments to notice." While *Sporormiella*

MAMMOTH TRUMPET

The Mammoth Trumpet (ISSN 8755-6898) is published quarterly by the **Center for the Study of the First Americans,** Department of Anthropology, Texas A&M University, College Station, TX 77843-4352. Phone (979) 845-4046; fax (979) 845-4070; e-mail csfa@tamu.edu. Periodical postage paid at College Station, TX 77843-4352 and at additional mailing offices.

POSTMASTER: Send address changes to:

Mammoth Trumpet
Department of Anthropology, Texas A&M University
4352 TAMU
College Station, TX 77843-4352

The **Center for the Study of the First Americans** is a non-profit organization. Subscription to the **Mammoth Trumpet** is by membership in the **Center.**

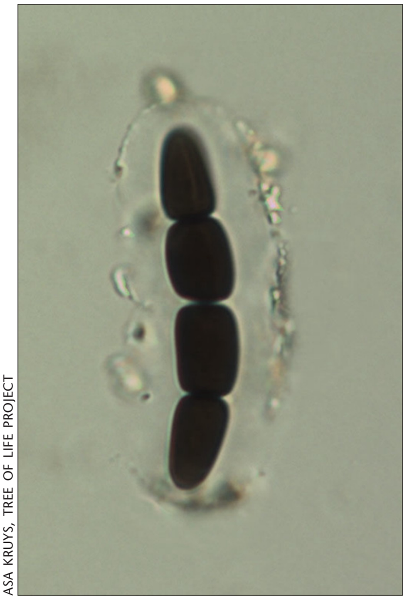
Mammoth Trumpet, Statement of Our Policy

Many years may pass between the time an important discovery is made and the acceptance of research results by the scientific community. To facilitate communication among all parties interested in staying abreast of breaking news in First Americans studies, the **Mammoth Trumpet,** a science news magazine, provides a forum for reporting and discussing new and potentially controversial information important to understanding the peopling of the Americas. We encourage submission of articles to the Managing Editor and letters to the Editor. Views published in the **Mammoth Trumpet** are the views of contributors, and do not reflect the views of the editor or **Center** personnel.

–Michael R. Waters, Director

also grows on the dung of smaller mammals and some birds, such as geese and grouse, these sources aren't thought to yield spores in sufficient numbers to be noticeable.

"It's got a couple of great advantages," Williams says of *Sporormiella*. "Until now, most of the work has been done with bones, which are critical since they tell you when mammoths and other species are at a location. The advantage of *Sporormiella* is that you can easily count the spores in sediment samples to get some kind of index of abundance. Now, it's a little tricky to go from the number of spores to the number of megafauna around the lakes, but they do offer a good proxy. Also, these are the same sediments we're pulling pollen and charcoal flecks from, so we can tell the exact relationships among them. This is important, because there's always some uncertainty in radiocarbon dates; but with these sediment cores, we have a well-known sequence we can compare with."

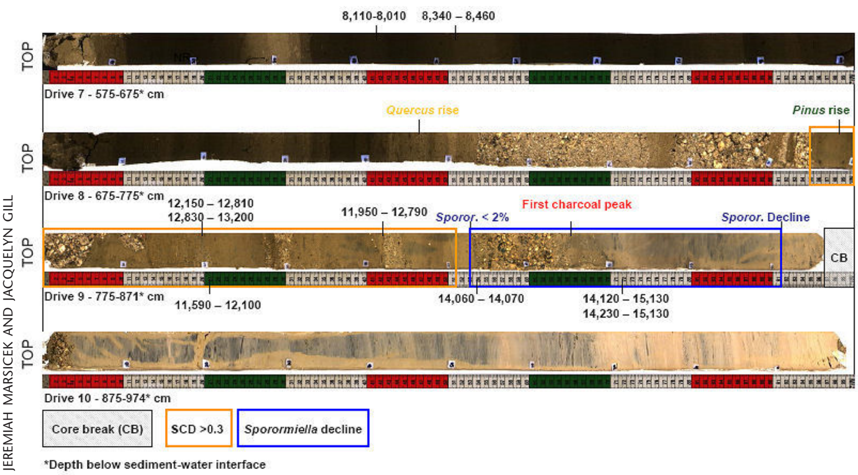


ASA KRUYS, TREE OF LIFE PROJECT

A *Sporormiella* spore tetrad in a gelatinous sheath.

Sporormiella's utility as a megaherbivore proxy was first documented by Owen Davis of the University of Arizona. In the mid 1980s, Davis noted that large numbers of *Sporormiella* spores were preserved in the dung of mammoths; he later realized that Pleistocene sediments also tended to exhibit relatively high numbers of the fungal spores, whereas they were all but gone during the Holocene—until the reintroduction of large grazing animals. This observation offered a clever solution that helped to offset, at least somewhat, the scarcity of large herbivore fossils.

But Davis's epiphany was essentially overlooked until 2003, when David Burney of Fordham University in New York published a paper demonstrating the connection between *Sporormiella* and large megaherbivores in prehistoric Madagascar. Subsequent studies by Burney and his colleagues at Fordham compared *Sporormiella* spores and other paleoecological proxies in sites elsewhere. "A big inspiration for us was Guy Robinson's work," Williams says. "He published on these associations in 2005 in New York State, and showed the connections between *Sporormiella,* vegetation changes, and fire regime." In fact, Dr. Robinson is one of Gill and Williams's coauthors for the 2009 *Science* study (the others were Katherine Lininger of the University of Wisconsin–Madison Department of Geography and Stephen Jackson of the University of Wyoming Department of Botany).



JEREMIAH MARSICEK AND JACQUELYN GILL

High-resolution core photographs from Appleman Lake, Indiana, showing significant events, including the *Sporormiella* decline and carbon spike. Dates are in CALYBP.

Not *quite* as expected

"Our initial hypothesis was that the large herbivores would coexist with the no-analog vegetation communities," Gill recalls, "and that the modern communities would arise after the loss of large herbivores." If that had been the case, *Sporormiella* would have been abundant in the sediments that also exhibited the no-analog pollen frequencies; but, as Williams reports, "We found that the no-analog communities occurred *after* the *Sporormiella* frequencies dropped off."

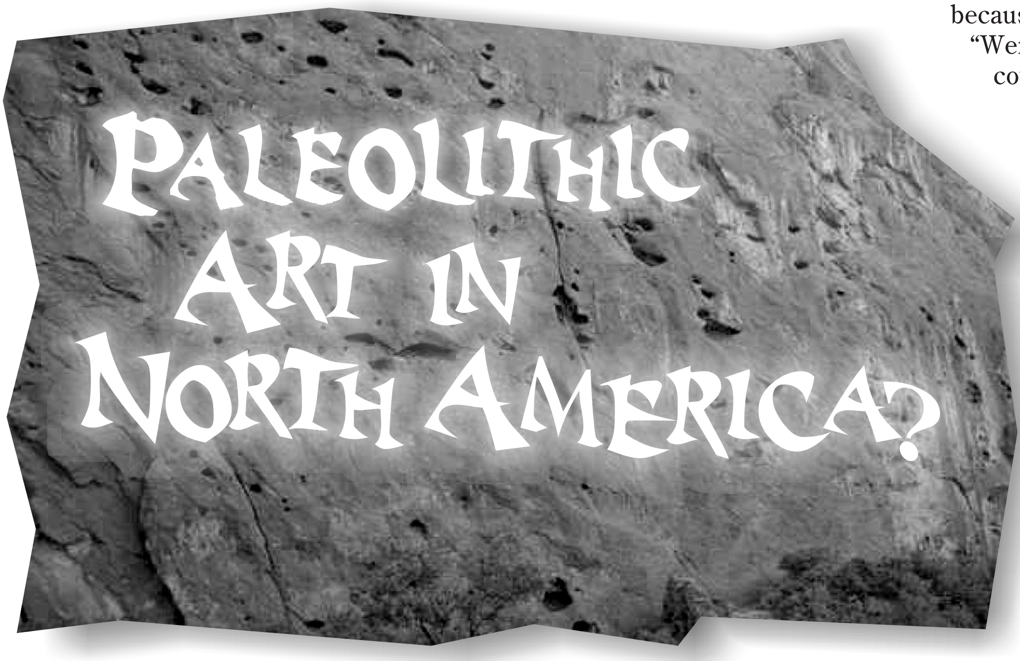
When *Sporormiella* frequencies declined at the end of the Pleistocene, they went from 2%-plus total frequency to near zero, and stayed there until large herbivores were reintroduced to North America about 500 years ago—following a pattern seen in other parts of the world. "We consistently see that values over 2% are megafaunal indicators," Gill explains. "Less than that we interpret as a population collapse. There are still animals on landscape, but the biomass is too low to register at that level."

In other words, mammoth and mastodon populations must have crashed thousands of years *before* the appearance of the vegetation communities we're familiar with today, not as a result of their appearance. The amount of charcoal in the sediments also increased after *Sporormiella* declined, so there were obviously more or larger fires in the post-megafaunal landscape than before.

The implications of these discoveries are simple but profound. The data suggest, for one thing, that the no-analog vegetation communities weren't the result of elephantid eating practices, since they followed the initial population declines; for the same reasons, vegetation changes probably didn't drive the extinctions, either. In fact, the circumstances may have been reversed, with the decrease in herbivory combining with unusual climatic conditions to drive the shift to both a no-analog vegetation regime and in-

continued on page 20

Paleolithic Art in North America?



When the Paleolithic cave paintings of Altamira in Spain were discovered in 1879, they were widely thought to be fakes. They are now accepted as part of the creative revolution that marks the appearance of modern humans in Europe. Indeed, the presence of symbolism and art now is considered to be the definitive signature of modern humans—*Homo sapiens sapiens*.

Since the discovery that people have lived in America during the Pleistocene epoch, scholars have searched for similar evidence of Paleolithic art in this hemisphere, largely without success. Archaeologist Gary Haynes concluded in 2002 that "there are no known cave paintings, portable artwork, carved figurines, or petroglyphs that *clearly and unambiguously* portray Clovis-era images."

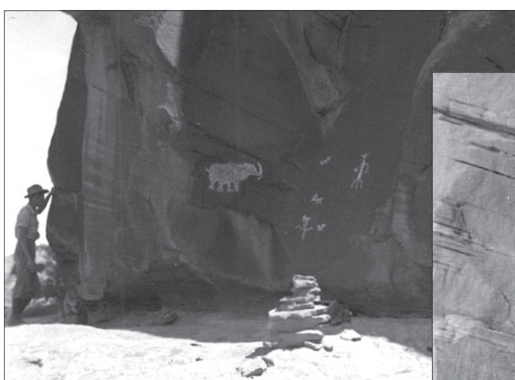
Archaeologists Larry Agenbroad, Alice Tratebas, David Whitley, and a few others disagree. Working independently across the western United States, these scholars have identified several petroglyphs that they regard as evidence for the creative revolution in America. Some of these sites previously have been dismissed as frauds, but as new sites are discovered and new methods are developed for dating petroglyphs, it's worth reviewing the evidence for Paleoindian rock art.

The Moab mastodon

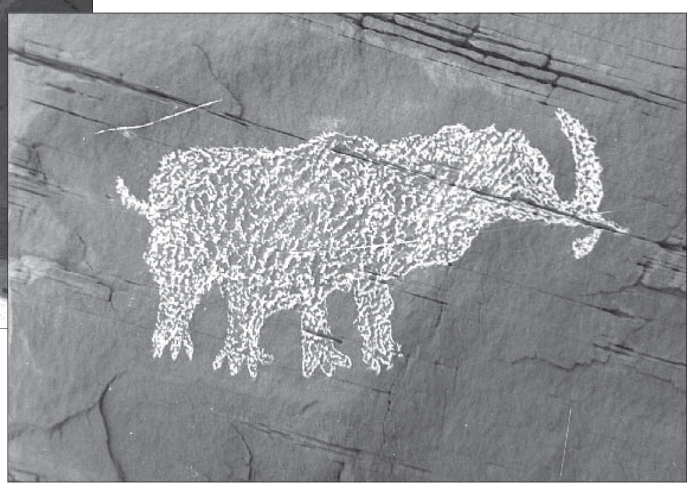
The earliest reported example of possible Paleoindian rock art is the "Moab mastodon," a nearly two-ft-long representation of what appears to be a mastodon or other proboscidean pecked into a somewhat inconspicuous cliff face near Moab, Utah. The first report of this remarkable petroglyph appeared in the October 1935 issue of *Scientific Monthly*. The author argued that the carving was not a hoax, because of its out-of-the-way location: "Were it the work of some itinerant cowboy or other person wishing to establish a hoax it doesn't seem that he would have deliberately placed the figure in a position where the likelihood of its discovery would be so remote."

On the other hand, while Dr. Whitley admits that it is "convincingly elephant-like" in appearance, it lacks any coating of rock varnish. Any exposed rock surface, particularly in a desert environment, accumulates layers of varnish consisting of windblown clay minerals that become glued to the surface. When ancient artists pecked or engraved their designs into the rock they broke through this layer of varnish and reset the "rock varnish clock."

Over time, petroglyphs develop their own layers of varnish, and the thickness of the varnish can provide an indication of the antiquity of the design. Since the Moab mastodon petroglyph has no discernible traces of varnish, either it is a recent creation or the varnish was removed from the petroglyph. Indeed, Agenbroad is convinced that "the Moab petroglyph is ancient and real," claiming



The Moab "Mastodon" petroglyph as it appeared in ▲ 1935. The petroglyph has been chalked to make it stand out for the photograph.



Detail of the Moab "Mastodon" petroglyph. ▶

BOTH: LARRY AGENBROAD

that it "has suffered from both well-meaning people, who 'refreshed' it with new pecking, and vandals, who used it for a rifle target." Regardless, the absence of varnish precludes any possibility of determining its original age.

Mammoth rock art in Utah

In a paper published in 2004, Dr. Agenbroad and coauthor Dr. India Hesse illustrated 10 additional examples of mammoth rock art from the Colorado Plateau, three of which are pictographs from Ferron Canyon. The remaining six are not identified as to location, but their map of mammoth rock art shows a total of seven locations in Utah. Agenbroad and his coauthor indicated these are representative examples, suggesting there are even other images of mammoth in the region.

They also showed more than 50 examples of rock art depicting bison, of which some may be Paleoindian in age. But some clearly are not, for they show hunters using the bow and arrow, which were not introduced until much later.

Agenbroad recognizes that the authenticity of some of the rock art has been questioned, particularly the pictographs, which seem less likely to have survived 13,000 years of weathering. As a result, he gives the petroglyphs more credibility than pictographs.

In support of the antiquity of the majority of the mammoth and bison depictions, Agenbroad and Hesse point out that the distribution of these images on the Colorado Plateau "closely approximates the distribution of these animals, as known from paleontological locations." Indeed, they observe that "some of the mammoth petroglyphs are in the same canyons that contain mammoth skeletal and fecal remains."

Paleoindian rock art in Wyoming

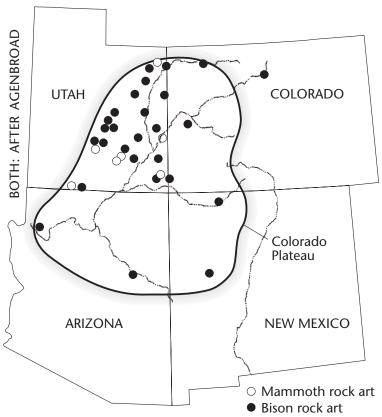
Rock art of possible Pleistocene age is not restricted to Utah. Alice Tratebas has described multiple styles of rock art in Wyoming that she thinks are late Pleistocene or early Holocene in age.

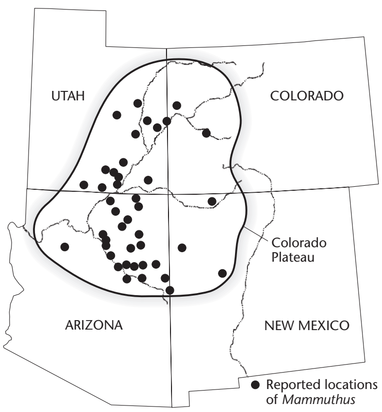
The Early Hunting Tradition in the southern Black Hills focused on depictions of animals, especially wapiti and mountain sheep, along with the occasional abstract symbol. The petroglyphs are pecked. In length they average 20–40 cm and range from about 10 to 85 cm.

The petroglyphs belonging to the Early Hunting Tradition are heavily weathered and extensively revarnished, which is a strong indication of a considerable antiquity. Moreover, whenever they are found together with petroglyphs of other traditions, the other styles always are superimposed over the Early Hunting Tradition petroglyphs.

Petroglyph of a camelid, possibly a llama, found in the Rodman Mountains in California. Dates on this image, while controversial, suggest it may be of pre-Clovis age.

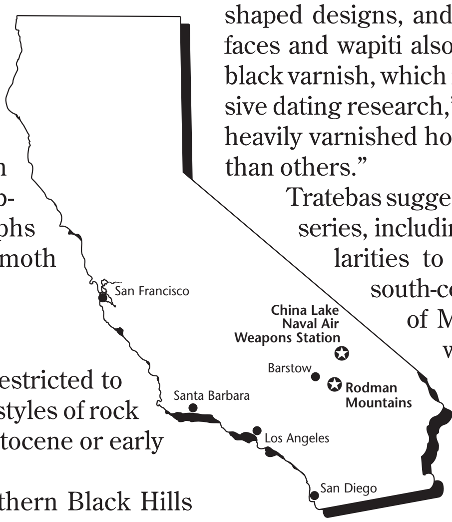
Another tradition identified by Dr. Tratebas is typified by the hoofprint style found at sites in the northern Black Hills. These petroglyphs are incised and abraded instead of being pecked, and some glyphs are much larger than those of the Early Hunting Tradition. And rather than animals and hunting scenes, the petroglyphs at these sites include hoofprints, vulva-shaped designs, and simple ground grooves, although bison faces and wapiti also are depicted. They are covered in thick black varnish, which is suggestive of great age. "Without extensive dating research," Tratebas explains, "we cannot say which heavily varnished hoofprint-style images are older or younger than others."





The remarkable coincidence of mammoth remains and petroglyphs of mammoths enhances the credibility that rock artists actually saw the beasts.

Tratebas suggests that the early pecked animal petroglyph series, including the Early Hunting Tradition, have similarities to the oldest documented petroglyphs in south-central Siberia and the neighboring regions of Mongolia. She notes that Legend Rock in western Wyoming has closer similarities to Siberian petroglyphs than Early Hunting.



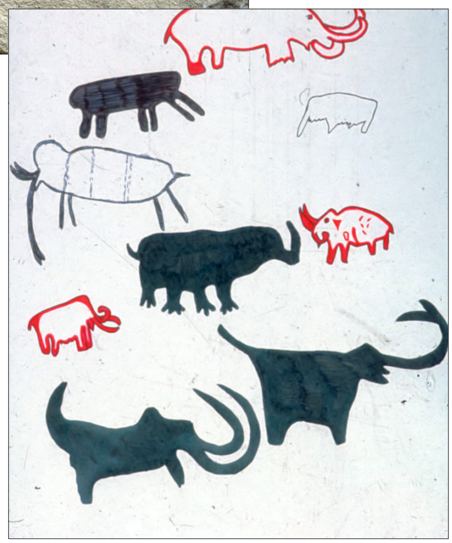
Mammoth and llama petroglyphs in California

Another mammoth petroglyph was discovered at China Lake in California. In February 2005, Carol Ormsbee, Jerry Grimsley, and Steve Swartz discovered a pecked image of a mammoth on the top of a basalt table rock in the Argus Range. Russell Kaldenberg, archaeologist for the China Lake Naval Air Weapons Station (**MT 20-3,** "Proboscidian & Equine Petroglyphs?"), described the mammoth petroglyph as "lightly patinated," although a second petroglyph, possibly representing a horse, was said to be "well patinated."

Whitley described a pecked image of "hornless and antlerless quadruped with a pronounced head and snout" and a hump on its back in the Rodman Mountains about 30 miles southeast of Barstow, California. He offered the provisional identification of the animal as a camelid. It is among the most heavily weathered of the approximately 800 petroglyphs at the site, which suggests it is among the oldest.

ALICE TRATEBAS

Petroglyph of an elk from the Black Hills of Wyoming. It is a typical example of what Tratebas has named the Early Hunter Style. ▲



LARRY AGENBROAD

Collage of mammoth petroglyphs (solid images) and pictographs (outlines) from Utah. The petroglyphs include the Moab "Mastodon," which Agenbroad interprets as a mammoth, in the center with three others. Agenbroad suspects the pictographs are relatively recent fakes. ▶

Early Ontario rock art

Another location that has yielded petroglyphs that have been interpreted as Paleoindian in affiliation is the Mud Portage site on Clearwater Bay in Lake-of-the-Woods, Ontario. Canadian archaeologists Jack Steinbring, Eve Danziger, and Richard Callaghan reported petroglyphs on a bedrock surface that, sometime after the petroglyphs were pecked, became partially buried under deposits of varying thickness, which contained artifacts from the Archaic period. They recorded 93 separate petroglyphs, 20 of which had been buried beneath the Archaic levels.

Some of these petroglyphs exhibited extensive revarnishing and tended to be located in the optimal locations on the rock surfaces, circumstances that suggest they were the first petroglyphs to be pecked. These are examples of what Steinbring defined as the Lake-of-the-Woods style. Other Lake-of-the-Woods–style petroglyphs include depictions of bison, lynx, turtle, and human and artifact shapes, including a harpoon head, as well as images that Steinbring, Danziger, and Callaghan characterize as "fantastic." Overall, however, Lake-of-the-Woods–style petroglyphs are predominantly naturalistic. Based principally on the stratigraphic evidence, they suggest these petroglyphs are 7,000–9,000 years old, but they speculate that the style could be even older and that the Mud Portage site reflects a late survival of the oldest cultural tradition in the Americas with roots in the Upper Paleolithic of the Old World.

LARRY AGENBROAD

Agenbroad with giant short-faced bear, *Arctodus simus.*

A mammoth fraud

Petroglyphs of elephant-like creatures may be the work of ancient Paleoindian artists or more recent hoaxers. The infamous Holly Oak pendant was a shell pendant alleged to have been found in 1864. Engraved on its surface was a woolly mammoth virtually identical to one engraved onto a fragment of mammoth tusk found at the French Paleolithic site of La Madeleine. This surprising evidence for Paleoindian art was accepted by some archaeologists until a radiocarbon date for the shell proved it to be only about a thousand years old. Evidently, the Holly Oak pendant was an attempt to manufacture evidence for the great antiquity of humans in America when such evidence hadn't yet been discovered.

Some elephant-like petroglyphs might not be hoaxes, but they also might not be evidence for Paleoindian art. Nevada State Museum archaeologist Donald Tuohy described a petroglyph from Yellow Rock Canyon in Nevada that he interpreted as an innocent 19th-century representation of a circus elephant.

Dating petroglyphs

In recent years, researchers have been searching for ways to obtain absolute ages for rock art, which would allow us to distinguish between ancient and modern proboscidean petroglyphs. Whitley has been at the forefront of this effort.

Recall that rock varnish is a thin, dark layer of various minerals that gradually accumulate on exposed rock surfaces. According to Whitley, these microlayers accumulate slowly, generally at a rate of "microns per thousands of years," but there is no direct correlation between varnish thickness and age.

The first technique developed to try to obtain an absolute date for petroglyphs is called Cation Ratio (CR) dating. It is based on the observation that certain elements, including potassium and calcium, leach out of the varnish layers much faster than others, such as titanium. Cutting or pecking through an existing layer of varnish resets the rock varnish clock for the exposed surface. Once a calibration has been worked out for a region, the ratios of these elements in varnish overlying a petroglyph can reveal the antiquity of the glyph. However, because of the complexities of the desert varnish chemical system, this dating technique turned out to be unreliable

Another technique, known as Varnish Micro-Lamination Dating (VML), is based on the observation that dark (manganese-rich) bands of varnish alternate with orange (manganese-poor) layers. These micro-laminations have been found to correlate with regional climatic changes, such as alternating wet and dry periods. So, in a given region these micro-laminations produce a record of the particular environmental changes that have occurred over time. With a large-enough series of micro-lamination sequences for a region, you can compare the lamination record overlying a petroglyph to the regional record to see where that petroglyph fits within that sequence.

Finally, the buildup of rock varnish on a rock surface occasionally encapsulates tiny amounts of organic matter. This material can be directly dated using AMS ^{14}C dating. There are significant problems with this technique, however. It appears that the mélange of organic bits incorporated into the varnish can be of vastly differing ages, so the AMS ^{14}C dates cannot be used reliably for dating rock art.

Despite their limitations, Whitley used all three independent dating methods, CR, VML, and AMS ^{14}C dating of organic materials within the weathering rind, to date the camelid petroglyph from the Mojave Desert. An age of 12,500–16,500 CALYBP was estimated for the petroglyph. Unfortunately, because of the problems associated with the desert varnish dating techniques, it is uncertain if this is the true age of the petroglyph.

Whitley also reported Paleoindian-era dates for additional Mojave Desert petroglyphs. An engraving of a snake has a CR age of 11,700 CALYBP, whereas two bighorn sheep have yielded dates in excess of 11,000 CALYBP using both CR and VML. Whitley also refers to two bighorn sheep petroglyphs from the Coso Range in the northern Mojave Desert that have been dated by CR and VML to more than 11,000 CALYBP. Again, new techniques will be needed to test the proposed ages of this rock art.

Tratebas obtained a series of 52 dates for Early Hunting style petroglyphs from the Black Hills of Wyoming and South Dakota. These CR and AMS ^{14}C dates range from about 11,600 to 4000 RCYBP. She concludes that if the dates are correct, the earliest rock art is "coeval with the Clovis culture" but that the rock art tradition continued through the end of the late Plains Archaic.


DAVID WHITLEY

Whitley at Little Petroglyph Canyon in the Coso Range, California. The panel behind him dates to less than 1500 RCYBP.

What does it all mean?

Tratebas believes rock art may be "the most underutilized data in North American archaeology." Given the evidence for Paleoindian petroglyphs, this is surprising for, as Tratebas argues, such images represent "a comparatively direct vehicle for the idea systems" of ancient cultures. For Paleoindian and early-Archaic hunting and gathering cultures with a limited material culture, this may be one of our only entrees into their symbolic world.

Agenbroad suggests the Paleoindian depictions of game animals "may have been made during 'hunting magic' rituals to bring luck in the hunt." Viewing the petroglyphs in a larger context, Whitley thinks that shamanism may be the key to understanding these early artistic expressions.

The evidence reviewed in this article suggests that Paleoindians created art similar in ways to contemporary cultures in other parts of the world. Specialists have been trying for years to find a way to date rock art. In the 1970s and 1980s new techniques showed promise for dating desert varnish at sites in the West. However, these proved to be unreliable. We can only hope that a new technology will emerge someday. Only by increasing the corpus of well-documented Paleoindian art will researchers be

continued on page 11


ALICE TRATEBAS

Tratebas at an exhibition of photographs from a northeast Siberian rock-art site.

Paleo Woman

America's First Ladies: Gone, but Not Forgotten

ALTHOUGH Dolly Madison and Jackie Kennedy were first ladies, they're a few millennia too young for this line of thought. Here our interest lies, not with the leading women of any American country, but with the earliest women on the American continents.

The first installment of this series discussed James Adovasio and Elizabeth Chilton's explanations of how these first females came to be forgotten. Taking that information into account, now we'll outline their ideas on how to find Paleo Woman. Their suggested ways of peering into the past include a closer examination of perishables, a glance at grave goods, spatial patterning and French methodology, and simply altering our outdated perceptions.

This fragment of an early-Archaic coiled basket parching tray from Cowboy Cave in Utah dates to 8600 CALYBP. Although coiled basketry technology wasn't present in Paleoindian times, basketry made using other techniques was. Ed Jolie, doctoral candidate in Anthropology at the University of New Mexico, says this utensil, which was almost certainly made by a woman, "attests to the great antiquity of basket weaving, generally, in the Americas."

COWBOY CAVE (42WN420) FS 1403.6. COURTESY OF THE UTAH MUSEUM OF NATURAL HISTORY

Perish the thought: Less-than-lasting artifacts that defy the odds

Stone tools may have an unrivaled presence in ancient American sites now, but at the time of deposit these sites no doubt contained all kinds of artifacts that were either subsequently destroyed over the millennia or, sadly, went unnoticed or were ignored during excavation. In those happy instances, however, when "extreme circumstances" occur and perishables persist, a door to the Pleistocene opens a little wider; especially in regards to women, who are credited with preparing many kinds of perishable items and participating in activities that left perishables behind, particularly food preparation. Not only do food remains from plants give archaeologists a peek at food resources and diet, Dr. Chilton explains, they can also identify a seasonal encampment or an occupation of longer duration if the plant remains are of types that flourished in specific seasons. Such perishables can also be used as clues to reconstruct a paleo environment, she notes, "an important avenue of research for understanding the contexts of social choices made by Paleoindians." Blood residue is another valuable food-related perishable source of information for Chilton because analysis can reveal the types of animals that were consumed.

In Chilton's view, some archaeologists place too much emphasis on associating perishable materials with women. "Instead," she counters, "I would say that finding or understanding the full ranges of behaviors and choices helps us flesh out a more complete picture of daily life for men, women, old, and young." [Although she correctly contends that artifacts made of organic materials were doubtless produced and used by all segments of the population, most archaeologists would probably agree they give us the best window for glimpsing the behavior and lifestyle of women in particular. –Ed.]

In *The Invisible Sex,* Dr. Adovasio and his coauthors dedicate a section to the crucial role played by fiber arts. "The String Revolution, a technical breakthrough," they write, "had profound effects on human destiny—probably more profound effects than any advance in the technique of making spear points, knives, scrapers and other tools out of stone." A quick raking of the mind will produce any number of articles made of woven fibers—rope, baskets, mats, sandals, articles of clothing, blankets, the list goes on—and in many societies making such items is often the task of women. The earliest evidence of fiber comes from the Dolni Vestonice I site in the Czech Republic, dated to 26,000–29,000 CALYBP. And this evidence already shows a great deal of sophistication, so it's no giant leap to surmise that the First Americans possessed string technology on arriving in the New World. Furthermore, Adovasio discusses circumstances where deterioration of perishables is kept at bay. In some dry caves, for example, the ratio of fiber goods to stone tools is an astounding 20:1. Likewise, in sites covered with water and in permafrost, where aerobic bacteria are excluded, wood and fiber artifacts may constitute 95 percent of the assemblage. Too often in the past either perishable evidence has been disregarded or archaeologists lacked the training or technology to recover it successfully. But Adovasio looks to a brighter future: "New archaeological techniques and technologies have also recently emerged to make perishable artifacts and other items accessible to scrutiny." This will help archaeologists better understand how Paleo Woman spent her time.

The effects of the dead:
What good are grave goods?

Speaking of perishables, it seems the best way to discover Paleo Woman's role would be to go straight to the source. Any grave goods buried with her would certainly shed a great deal of light on exactly what she did all day; hard evidence. The problem, as Adovasio explains, is that "we have very few human remains from the Clovis era or before and very few in the thousand or so years thereafter." Nevertheless evidence exists of ancient woman snubbing her nose at the 1950s cultural norm. Both Adovasio and Chilton cite as an example Indian Knoll, an Archaic burial ground in Kentucky. Here atlatl counterweights were found in 76 graves, 13 of them graves of women. The question Adovasio asks concerning these 13, albeit presumably, female hunters is, "Were they seen as actual women, just like other women except that they hunted, or were they seen as some other additional gender?" Chilton further explains that as burials go, it isn't uncommon to find males interred with presumably female effects, such as pottery. She holds that burial belongings can't necessarily be interpreted as concrete evidence of what that person actually did in life, because "burials tend to report all sorts of beliefs of the living. We can't know if that person was buried with items he or she used in life, or whether those were gifts from living family members." However, Chilton and Adovasio believe there is a way to get an accurate idea of what an individual did in life, provided the skeleton is decently preserved. "Burial data," Chilton says, "aren't just about the artifacts that are there, but if the preservation is good enough they could tell you something about the activities that at least one individual was taking part in." Under close study, extreme or disproportionate muscle attachments in arms could reveal habitual use of spears or atlatls; in the legs, high mobility. Arthritis could also be a telltale sign of certain use, as could broken limbs. The activities of one individual, however, do not a *cultural* picture paint. For that, Chilton reminds us, the remains of large numbers of people need to be examined. The individual burials that tend to occur with Paleolithic and other ancient people only give us a glimpse of a scattered few. "It gives you inspiration, it gives you ideas, it gives you suggestions for things you should be looking at," Chilton explains. "But I would say for Paleoindians the amount of burial data is just not sufficient to use . . . alone."

TEXAS A&M UNIVERSITY REPOSITORY—PHOTOGRAPHIC ARCHIVES

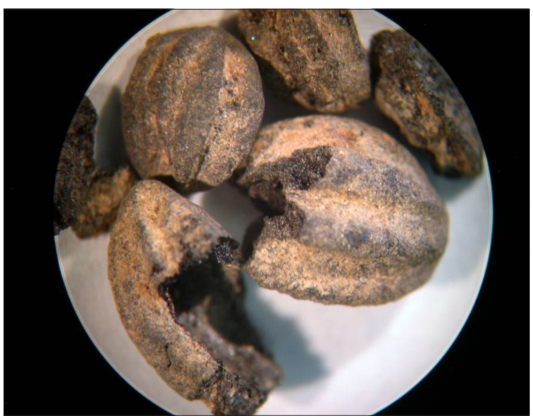
Attention to details:
Spatial patterning and French methodology

It might seem a paradox to think there could be a way of uncovering something as abstract as culture by means of sound statistics. Stranger still is that there is more than one such way. Chilton suggests two ways, both of which require analyzing the evidence in minute detail.

The first is spatial patterning, a technique that requires a thorough layout of a site, something like the floor plan of a house.

Residues, like the accretions on this Archaic point from the Hinds Cave in Texas, can illuminate the lifestyle of ancient cultures (MT 22-4, "Little Things Mean a Lot: The Search for Starch Grains at Archaeological Sites). Testing blood residues with antigens can identify the species of game that became a meal, and vegetal residues on tools can often be traced to the plant that formed a part of the diet. In one instance, says TAMU palynologist Vaughn Bryant, 60,000-year-old starch grains were identified to the plant genus, sometimes to the species. Residue, Dr. Bryant advises, "can be found on many artifacts . . . *if you look for it!*"

It's important to surmise what was most likely going on in each area, just as with a house, where bedrooms are for sleeping, the living room is a communal area, and the kitchen is for food preparation and consumption. "In order to interpret site plans," Chilton explains, "we need to evaluate the function of archaeological features, the patterning of these tasks, the duration of the site occupation, and the relationship among contemporaneous sites in the region." Such information could reveal a great deal about cultural activity. For instance, is there one large communal area that could contain 20 people, or a hundred? Or are there several smaller communal areas for different family groups? To gain access to some piece of paleo culture illuminates a facet not only of Paleo Woman, but of an entire group of paleo people.

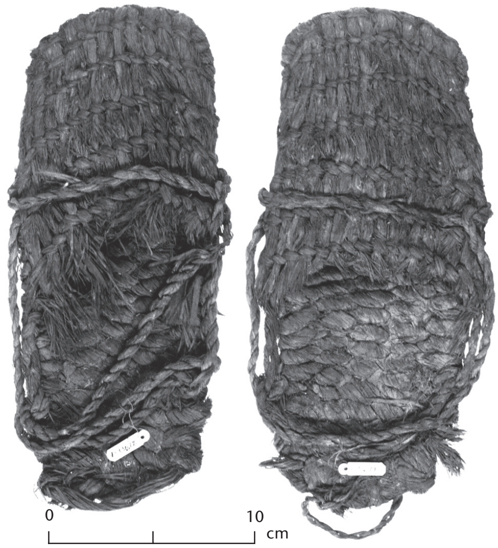


JOSEPH GINGERICH

These hawthorn plum seeds recovered from hearth contents date to nearly 11,000 RCYBP (MT 22-2, "A Spring That Keeps Flowing—The Shawnee-Minisink Clovis Site"). This kind of perishable evidence confirms that Clovis people were opportunistic hunter-gatherers and didn't subsist solely on mammoth chops and bison burgers.

Chilton scotches the idea, however, of extrapolating from a few sites to a generalized description of Paleoamericans across both continents of the New World. "We should not expect all

Paleoindians to have been the same;" she explains, "we should not expect the same social analogue to apply equally well across environmental, temporal, and social boundaries." What's required, she asserts, is "a series of social models that



Fort Rock Cave sandals from the Great Basin that date to earlier than 9200 CALYBP (MT 24-3, "Walking in Their Shoes"). Different wear patterns and other minute details are clues to curator Tom Connolly. "The sandals as a whole set," Dr. Connolly tells us, "give you the profile of a community." Making these intricately woven, durable items was likely a task that fell to women. Adovasio notes that when artifacts used to manufacture plant-fiber items are recovered from graves from a wide array of sites around the world, they inevitably derive from the graves of females; the male shoemaker appears to be a modern-day phenomenon.

UNIVERSITY OF OREGON MUSEUM OF NATURAL AND CULTURAL HISTORY

are built upon fine-grained analyses and interpretations of site plans, feature patterning, and site hierarchies at a regional level." In other words, this technique is most helpful when utilized on many paleo sites, not just a few.

The same line of reasoning applies to the other method she champions, *chaîne opératoire,* a French approach that basically translates to a chain of operation, or the order in which something is done or constructed. If spatial patterning is thorough, then *chaîne opératoire* is downright meticulous. Taking front and center in this process is debitage (interestingly enough, an anglicized French word, *débitage,* that means "waste"). In this case it's certainly true that one (let's just say) person's trash is another person's treasure. Chilton believes that debitage can tell us a lot about cultural

Carbonized pieces of basketry with rim, plaited from birch bark with 1/1 interval, from Meadowcroft Rockshelter in Pennsylvania. Mercyhurst Archaeological Institute curator Jeff Illingworth ascribes this particular piece to the Archaic. Presumably it could have been used for anything, but most likely for transport or storage of material. "Whoever made it," says Dr. Illingworth, "was part of what appears to be a very, very long tradition of making this type of basketry in the greater northeastern United States."

MERCYHURST ARCHAEOLOGICAL INSTITUTE

traditions. How? That's where *chaîne opératoire* comes in. "The idea," Chilton explains, "is if you look at the micro level you can start to see patterns and learn traditions." And what better process to look at in microscopic detail than flintknapping, where every nick and scrape is recorded in a small, lasting piece of debitage? As these techniques were passed on from parent to child, from generation to generation, the process can be traced, admittedly with ridiculously tedious analyses. Were certain ways of making stone tools passed down through a single family line, or was the process basically identical throughout an entire group? How did it change through generations? If such analyses could be conducted throughout paleo sites it would be like seeing a fingerprint on a piece of pottery. Except it wouldn't be that of a single individual in a brief instance of time, but that of the paleo people as a whole, stretching out across their entire existence.

The idea behind spatial patterning and *chaîne opératoire* is that if such data are collected, and at the same time sex and gender roles kept in mind, hypotheses can be made based on hard data and tested using ethnographic records on modern hunter-gatherers. In this way researchers may find parallels between ancient Americans and contemporary foraging peoples.

A shift in perception: Banishing bias and taking a closer look at data

Though misconceptions about Paleo Woman still linger, they don't hold sway as they used to. It's safe to say that our picture of early Americans is being revamped and a more accurate and inclusive depiction is emerging. Chilton and Adovasio caution that we mustn't impose limitations on these people without proof. We can't assume that women never made stone tools or hunted simply because June Cleaver never did. Of course June Cleaver never studied archaeology.

According to Chilton, it's common when studying these early periods of time to avoid cultural questions that deal with gender and sexual division of labor because they are considered much too ancient to be accessible. When archaeologists try to fill in the blanks, she notes, all too often they supply answers that apply to their own modern culture. She cautions that these aren't questions that can be "tacked on at the end." Instead, "you have to acknowledge how a society structures itself; very often it is based in both sexual and gender relationships." What's important, she says, is to "keep that at the beginning of your analysis and challenge yourself not to make assumptions." Challenge is certainly the word.

On the subject of male dominance among archaeology professionals, Adovasio points out that, according to the 1994 field census from the SAA (Society for American Archaeology), in recent years female students in both undergraduate and graduate levels of archaeology have enjoyed a slight majority over males. This should certainly promote a feminine perception of the Pleistocene. He acknowledges, however, that 64 percent of today's professors and the archaeological work force are male. "Part of the problem," he admits, "is the matter of combining family and career that is often faced by professional women." Chilton suggests that other factors continue to impede the advance of women in archaeology. Nevertheless, Adovasio and Chilton concur that the proportions today aren't terribly lopsided. Not bad considering that few women worked at prestigious employment a hundred years ago.

Lost and found

The picture painted of Paleo Woman in the traditional view was of a shallow, passive creature content to watch the action from the sidelines. She has come a long way from that cardboard-thin character. The attention now being paid to the perishable articles she likely created all those years ago, and new techniques that wring ever more information from them, help define the breadth of her activities. Grave goods, though limited, give us glimpses of some aspects of her life and help us appreciate the toll life took on her body. Slowly, through the methods of spatial patterning and *chaîne opératoire,* puzzle pieces are beginning to fall into place. And through all of this a broader perception about the life of a Pleistocene woman is emerging.

Will Paleo Woman finally be found? The truth is she was never lost. We were. It's ridiculous to speak of trying to find women in the archaeological record , says Chilton, "because we find women all the time. There are all sorts of people out there, so it's not really a matter of finding them, it's assuming that they are there and then structuring our interpretations."

–K. Hill

How to contact the principals of this article:
J. M. Adovasio
Director, Mercyhurst Archaeological Institute
Mercyhurst College
501 East 38th Street
Erie, PA 16546
e-mail: jadovasio@mercyhurst.edu

Elizabeth Chilton
Associate Professor and Chair, Anthropology
Director, Center for Heritage and Society
University of Massachusetts Amherst
Amherst, MA 01003
e-mail: echilton@anthro.umass.edu

Paleolithic Art in North America?

continued from page 7

able to fathom the more esoteric aspects of the culture of these earliest Americans and to approach the meanings of the naturalistic animal representations.

–Bradley Lepper

Suggested Readings

Agenbroad, L. D. 2000 Paleoindian Rock Art of the Colorado Plateau. *Archaeology Southwest* 14(2):10.

Agenbroad, L. D., and I. S. Hesse 2004 Megafauna, Paleoindians, Petroglyphs, and Pictographs of the Colorado Plateau. In *The Settlement of the American Continents: A Multidisciplinary Approach to Human Biogeography*, edited by C. M. Barton, G. A. Clark, D. R. Yesner, and G. A. Pearson, pp. 189–95. University of Arizona Press, Tucson.

Kaldenberg, R. L. 2005 Possible Proboscidian Petroglyph Found at China Lake Naval Air Weapons Station. *Current Research in the Pleistocene* 22: 51–53.

Meltzer, D. 2009 *First Peoples in a New World: Colonizing Ice Age America*. University of California Press, Berkeley.

Steinbring, J., E. Danziger, and R. Callaghan 1987 Middle Archaic Petroglyphs in Northern North America. *Rock Art Research* 4:3–16, 150–61.

Tratebas, A. M. 2004 Rock Art and The Peopling of the New World. In *New Perspectives on the First Americans*, edited by B. T. Lepper and R. Bonnichsen, pp. 179–86. Texas A&M University Press, College Station.

Whitley, D. 2009 *Cave Paintings and the Human Spirit: The Origin of Creativity and Belief*. Prometheus Books, Amherst, New York.

How to contact the principals of this article:
Larry D. Agenbroad
The Mammoth Site in Hot Springs
1800 US 18 Bypass
P.O. Box 692
Hot Springs, SD 57747
e-mail: larrya@mammothsite.org

Alice M. Tratebas
Bureau of Land Management
P.O. Box 883
Newcastle, WY 82701
e-mail: Alice_Tratebas@blm.gov

David S. Whitley
Department of Geography
Arizona State University
24160 Woodbine Ct.
Tehachapi, CA 93561
e-mail: huitli53@gmail.com

MAMMOTH TRUMPET
Volume 25 ■ Number 2

On the Trail of the Domestic Dog Part I

ARCHAEOLOGISTS have been trying for many years to pinpoint the geographic region where the wolf was first domesticated, but the definitive answer has always eluded them. Recently, however, a team of researchers that includes Peter Savolainen of the Royal Institute of Technology in Stockholm decided to apply the science of genetics to the archaeological debate. By analyzing the mtDNA of regional domestic dogs (their database is a collection of samples from more than 1,000 dogs around the world), they conclude that the domestic dog originated in Southeast Asia about 16,000 years ago. And they confirm that the immediate forerunner to the domestic dog was the domesticated wolf.

Dr. Savolainen and his colleagues are convinced that genetics has solved the riddle of the dog's ancient origins, but in the minds of some prominent archaeologists the puzzle remains fragmented. What's more, the debate has moved past the origin of the domestic dog to implications for the New World: How and when did domestic dogs accompany humans to the Americas? In what manner and to what degree did their lives interact with those of early Americans?

Why mtDNA analysis?

Not all of a cell's genes are located on nuclear chromosomes, or even in the nucleus. Extranuclear genes are located on small circles of DNA in mitochondria, the cell's energy-storing organelle. These mitochondrial genes (mtDNA) don't conform to the same Mendelian laws that govern the distribution of nuclear chromosomes. Instead, mtDNA is derived strictly from the mitochondria in the cytoplasm of *maternal* cells. New mutations accumulated in mitochondrial DNA over the mother's lifetime are passed on to the offspring, along with those inherited from previous generations. By analyzing the mutations imprinted in mtDNA, therefore, scientists can track the genetic deviations of an individual's maternal ancestors.

Savolainen, 2009.

PETER SAVOLAINEN

The conclusions of Savolainen's team, published in the December 2009 issue of *Molecular Biology and Evolution,* merit an exceptional level of credibility because their research interfuses archaeological investigative techniques with genetics. MtDNA analysis of samples of blood and hair of ancient canids establishes if they are from dog or wolf. Subjecting the samples to radiocarbon dating, since the 1950s the most powerful tool in the archaeologist's kit, yields precise details on the pattern and timing of the global spread of dogs.

Savolainen's team identifies Southeast Asia as the origin of the dog because that geographical region possesses the greatest genetic diversity of dogs. Genetic diversity is measured by the number of mtDNA haplogroups present in a population (a haplogroup is a lineage that traces its origin to a common maternal ancestor that first possessed a particular mutation). There are 10 different haplogroups in the world's population of dogs, each dog having one haplogroup. According to the report, the full range of genetic diversity—all 10 haplogroups—was found only in Southeast Asia south of the Yangtze River (ASY) and only 5 haplogroups in, for example, Southwest Asia and Europe, indicating that the domestic dog originated in southern China less than 16,300 years ago. Because the largest number and variety of mtDNA lineages exist in ASY, the article concludes, in the language of statistics, that a single origin for all dogs in ASY is possible and that a single origin outside ASY seems impossible. Savolainen expresses the significance of this discovery for both geneticists and archaeologists: "Importantly, it seems the wolf was domesticated *only* in southern East Asia. Then the resultant dogs spread around the world. Thus, the 'art of wolf domestication' was practiced only once, in ASY."

Not all scientists are climbing aboard

However conclusive Savolainen's discovery may appear, some scientists remain unconvinced. For example, Stuart Fiedel, senior archaeologist of the Louis Berger Group in Richmond, Virginia, contends that publications on dog genetics remain contradictory and that a single dog ancestry in ASY may be completely wrong. "Village dogs in Africa may have as much genetic diversity as in East Asia," Dr. Fiedel mentions, pointing to the findings of Bokyo et. al (2009) as contradicting the original conclusions of Savolainen et. al. Fiedel also cites the claim of a much earlier domestication in western Europe, for example, in the Aurignacian of Belgium about 32,000 CALYBP. This assertion is based on skull morphology (Germonpre et al. 2008).

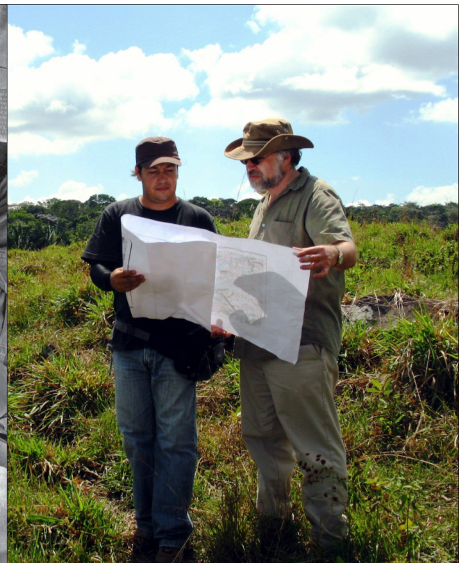
Savolainen deflects Fiedel's argument with hard data. "For Africa, we show that the analysis is wrong, simply." Savolainen's article repudiates the claim made in the recent study of Bokyo et al.—that the genetic diversity in Africa surpasses that of southern China—by showing that the African village dog sample had 41 haplotypes among 318 dogs, compared with 71 haplotypes among 281 dogs in the sample from southern China in Savolainen's study.

As for Europe, Savolainen claims that there are two archaeological samples related to dog domestication in this region and unfortunately no way to know for certain whether they are from dog or wolf. "*Our* study is of what is actually dogs today," Savolainen emphasizes. He suspects that the European results may be linked to possible tamings or domestications at other locations that never led to the modern dog. He allows the possibility that these dogs were later crossed with local wolf in different parts of the world, but that, he says, isn't domestication but dog-wolf crossbreeding. "In the female lines that we analyse [through mtDNA, which is maternally inherited] we find only two clear cases of this," he explains, "one in Scandinavia and one in the Middle East or Mediterranean region. The other way around, male wolf x female dog (which would show in the Y chromosome), we don't have any idea how frequent this has been."

Even Savolainen's article, though, admits to the precarious nature of genetic-archaeological research: "Because the wolf is now exterminated south of the Yangtze River, it would not have been possible to identify the region of origin for the dogs based on a genetic comparison of extant dog and wolf populations. Therefore, intraspecific studies of dogs, such as this, remain the only possibility for studying dog origins based on extant populations." Savolainen's research team readily confesses that, though archaeological studies in genetics offer many convincing answers, there are still limitations. Fiedel notes that in recent days, a new genetic study appeared (Gray et al., in *BMC Biology*), concluding that the genes that produce small-bodied dogs appeared only once, in an original center of domestication in the Near East; the authors tie this data to the archaeological evidence of dogs in the Natufian culture of Israel 13,000 CALYBP.

At issue, human culture at the time of domestication

Savolainen's article suggests that dog domestication emerged in East Asia as early as 16,000 years ago, possibly in the context of agriculture. There are already signs of sedentary life and emerging agriculture at least 11,000 years ago in South China, Savolainen adds. Based on the "approximate coincidence in time and place of dog origins and sedentary farming life," dogs may have originated among humans starting to get sedentary. On the other hand, the domestic dog may have predated plant cultivation. China had two centers of plant domestication and early agriculture: millet by the Yellow River, and rice by the Yangtze River area, both approximately 8,500 years ago according to the consensus opinion.



▲ Fiedel (*right*) in Costa Rica, 2010

◀ Haynes flaking elephant bone in Zimbabwe, 2008..

Fiedel is uncomfortable placing dog domestication so far south and linking it to agriculture. "Suppose the dogs in Western Europe are the real deal—so a sedentary lifestyle and agriculture isn't even important. They're not living in one place," he says. "That would detach dog domestication from agriculture and village life." Fiedel's primary interest is the New World. Consequently he sketches a timeline in order to wrap his mind around the ASY theory and its relation to early Americans. If dogs were domesticated 14,000 years ago when Paleoindians came to the New World, he theorizes, "then you have to have domestication by 14,000 ya in East Asia and there isn't any agriculture in that day. However, there's evidence of pottery in China and Siberia by 13,000 or even 15,000 ya, which does indicate people are somewhat settled most of the year, which is the situation that would give rise to domestication." At this point, few things are certain. Fiedel feels comfortable first doubting the idea of an agricultural society in prompting domestication, then rejecting the notion of a single point of origin for dog domestication in ASY. "If we just restrict ourselves to the hard archaeological evidence, the dogs we have from the Koster site [a site in Illinois, which we discuss in part II of this series], which are early Archaic dating from 9000 CALYBP, it doesn't match up with East Asia. I don't think anyone has found a Chinese neolithic site any earlier than that. There's just no cultural connection."

Perhaps a later entry into the New World

David Carlson, associate professor of Anthropology at Texas A&M University, offers another New World perspective—that the earliest Americans may have forged their way into the Americas without dogs. "The new data from southern China come as a surprise for an awful lot of people," Dr. Carlson admits. "If Clovis represents people who had moved into Alaska say 18,000 or even 16,000 years ago and were basically sitting at the top of the Ice-free Corridor, then it's not clear that there would be enough time for domestic dogs to diffuse from China all the way up there. So the first people to enter the New World may have come without dog." Carlson concludes that the domestic dog may have accompanied humans into the New World in later migrations, a theory that agrees with Fiedel's train of thought. Fiedel cites as an example Australia, which was colonized about 45,000 years ago: "They almost certainly did not have the domesticated dog with them," he says. "It's generally believed that the dog was introduced to Australia very late. Yet they successfully colonized the continent quite rapidly." Fiedel suggests that dogs were beneficial in the eventual peopling of the New World but not essential.

A Moche dog (a ceramic vessel in the form of a dog) from coastal Peru, ca. AD 100–800, in Larco museum, Lima.

STUART FIEDEL

Though humans may have dispersed through southern Asia before reaching northeast Asia, the immediate roots of the first Americans point to North and Central Asia. Recent studies of the mtDNA of native human populations in the Americas (**MT 24-4,** "Genetics Study: Two Paleoindian Migration Routes into the Americas") support the theory that Paleoindians arrived in the New World from Asia via Beringia by at least two routes: a coastal route along the Pacific coast of North and South America, and an interior colonization across the width and breadth of North America. All this to say, dogs most likely followed similar patterns of human migration, making it highly probable that the origin of dog domestication could be traced to East Asia.

The earliest Americans are known to have been hunter-gatherers, not farmers, and so if sedentary customs were prominent in East Asia ASY at the time of the first peopling of the New World, they seem to have been lost through migration. Just how dogs impacted the daily lives of the *first* Americans—if dogs were present at all—is left to our imagination, for there is no clear evidence of dogs in any Clovis site. The first site offering evidence of canine companionship in the Americas is the Koster site in Illinois, which we'll take up in part II of this series.

–Katy Dycus

How to contact the principals of this article:

David Carlson
Associate Professor of Anthropology
Department of Anthropology, 226
College Station, TX 77843-4352
e-mail: dcarlson@tamu.edu

Stuart J. Fiedel
Senior Archaeologist
Louis Berger Group, Inc.
Richmond, VA
e-mail: sfiedel@louisberger.com

Gary Haynes
Professor of Anthropology
Anthropology Department
University of Nevada, Reno
Reno, NV 89557-0096
e-mail: gahaynes@unr.edu

Peter Savolainen
Assistant Professor
Molecular Biotechnology
Albanova University Center
KTH- Royal Institute of Technology
SE-106 91 Stockholm, Sweden
e-mail: savo@biotech.kth.se

Suggested Readings

Fiedel, S. J. 2005 Man's Best Friend—Mammoth's Worst Enemy? A Speculative Essay on the Role of Dogs in Paleoindian Colonization and Megafaunal Extinction. *World Archaeology* 37:11–25.

Haynes, G. 2002 *The Early Settlement of North America: The Clovis Era.* Cambridge: Cambridge University Press, 2002.

Leonard, J.A., R.K. Wayne, J. Wheeler, R. Valadez, S. Guillen, C. Vila. 2002 Ancient DNA Evidence for Old World Origin of New World Dogs. *Science* 298 (5598): 1613–16.

Morey, D. and M. D. Wiant 1992 Early Holocene Domestic Dog Burials from the North American Midwest. *Current Anthropology* 33: 224–29.

Pang, Jun-Feng, C. Kluetsch, Xiao-Ju Zou, Ai-bing Zhang, Li-Yang Luo, H. Angleby, A. Ardalan, C. Ekström, A. Sköllermo, J. Lundeberg, S. Matsumura, T. Leitner, Ya-Ping Zhang, and P. Savolainen 2009 MtDNA Data Indicate a Single Origin for Dogs South of Yangtze River, Less than 16,300 Years Ago, from Numerous Wolves."*Molecular Biology and Evolution* 26:2849–64.

Walker, R. B., D. F. Morey, and J. H. Relethford 2005 Early and Mid-Holocene Dogs in Southeastern North America: Examples from Dust Cave. *Southeastern Archaeology* 24 (1):83–92.

In the Crucible of Scientific Inquiry

THE CLOVIS COMET REVISITED

FOR THOSE WHO REQUIRE certainty in their lives, science is something of a disappointment. Instead of delivering hard-edged Truth, its concern is more with approximating reality as we mere humans perceive it. By its very nature, science proceeds in fits and starts, by trial and error; and while it does tend to advance rapidly as established facts are added to the evidential edifice, it often takes years (if not decades) before specific hypotheses become firmly established—or fail completely. This is as true for First Americans studies as for any other scientific field of inquiry.

Take, for example, the stunning hypothesis proposed by physicist Richard Firestone, geophysicist Allen West, and 24 others in a 2007 paper: That a comet struck Pleistocene North America, putting an end not only to the Clovis culture but most of the megafauna as well (**MT 23-1, -2, -3, -4,** "The Clovis Comet"). The concept is certainly intriguing, but is the evidence for this so-called Extraterrestrial Impact Hypothesis (EIH) conclusive?

Critics claim it isn't—and in some cases, their arguments are backed by well-documented experimental results. One research team, led by geoarchaeologists Todd Surovell of the University of Wyoming and Vance Holliday of the University of Arizona, recently published their results in *Proceedings of the National Academy of Sciences,* the very journal in which the Impact Team's controversial report appeared. The Surovell study wasn't the first to question the conclusions of the Impact Team, but it serves as a good example of the caliber of inquiry the EIH has faced since its proposal.

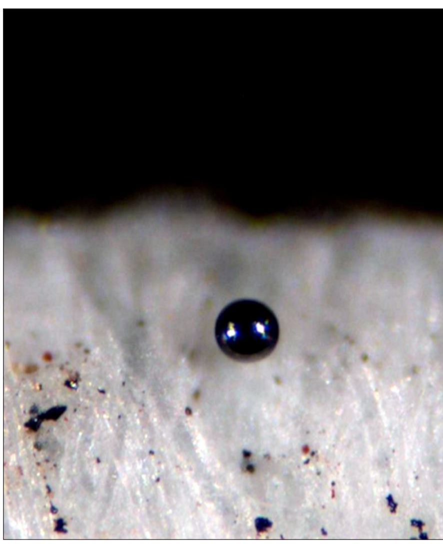
Scientific advancement at work

To get a better grip on what's so controversial about the EIH and why the Surovell team's challenge matters, it's necessary to take a look at the background science. Ultimately it goes back to astronomy and what's lurking out there beyond the atmosphere.

We've all seen shooting stars, which are basically dust grains immolating themselves in the upper atmosphere. These micrometeors are tiny, but there are lots of them. About 100 tons of interplanetary dust sifts down through the Earth's atmosphere each day. Larger debris isn't unusual, either. The planet sweeps up about 19,000 objects weighing three ounces or more annually. Fist-sized meteors come in daily. But extraterrestrial objects do come larger—orders of magnitude larger. Consider what would happen if a mass of ice or rock the size of Pike's Peak slammed into the Earth at 30,000 miles per hour. The resulting thermal pulse would incinerate all life within a radius of tens or hundreds of miles; earth tremors would occur continent-wide; fires would be ignited by the heat and falling debris; and if the object were large enough, soot and debris clouds would fill the sky, choking off sunlight for weeks or months. Those who survived the impact might later perish of starvation and cold.

If the EIH is correct, this is precisely what happened in North America at the end of the Pleistocene.

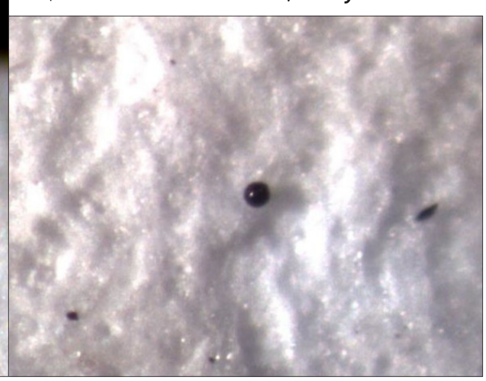
No scientist denies that such cataclysmic events occur; the evidence is in the geologic record for anyone to read. Indeed, they may even be more common than previously believed (see sidebar). But killer impacts should leave plenty of



TODD SUROVELL

◀ **A magnetic microspherule from the San Jon site in New Mexico.**

A 15-micron magnetic microspherule ▼ from Paw Paw Cove, Maryland.



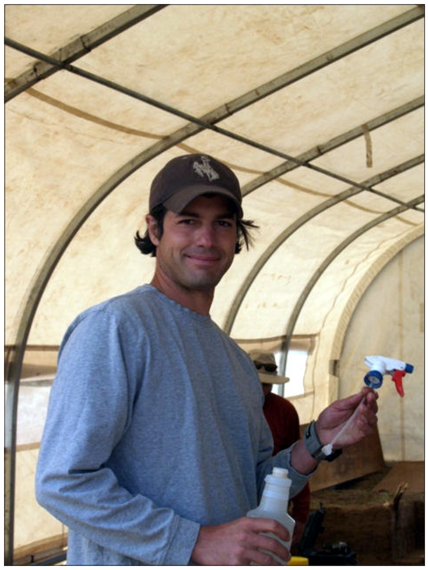
MALCOLM LECOMPTE

confirmation observable by the trained eye. The Impact Team claims to have found it in spades in Clovis-age sediments—in more than a dozen lines of evidence, ranging from tiny nanodiamond crystals to microscopic carbon and metallic spherules, scattered throughout North America and beyond. The carbon spherules are believed to be incinerated and aerosolized tree sap, and the magnetic metallic spherules are now thought to be micro-tektites derived from terrestrial ejecta (splatter) from an impact site.

Yet not everyone finds the EIH evidence convincing. Moreover, some researchers have been unable to reproduce the results of the original study. This is a particularly worrisome development, for in the back-and-forth whipsaw of scientific inquiry, one rule stands supreme: Experimental results must be reproducible, or they're useless.

A critical view

"To be honest, I'm not sure the impact hypothesis is incorrect," admits Todd Surovell, the senior author of the *PNAS* study published October 27, 2009. "All I know is that we found no support for it in our work."



Surovell in the field at Barger Gulch, Colorado, 2007.

TODD SUROVELL

Dr. Surovell's interest in the EIH was sparked when the Impact Team published their original study in 2007. "I was a bit taken aback, because I'd never considered a comet or asteroid impact as the cause of Pleistocene extinctions or the Younger Dryas stadial," he recalls. "Nonetheless, I found the evidence they published to be somewhat compelling. . . . I was so intrigued that I just wanted to see it for myself."

Surovell's coauthor, Vance Holliday, became interested in the EIH even earlier. "I came across a book by Firestone, West, and Warwick-Smith: *The Cycle of Cosmic Catastrophes: Flood, Fire, and Famine in the History of Civilization*," Dr. Holliday recounts. "It was the first publication to present the Clovis Impact hypothesis. I casually flipped through it, and kept coming across comments about archaeology and geology that I knew to be grossly in error. . . . My own research on playas was completely misstated, and the dating of the Carolina Bays [a series of elliptical depressions on the Atlantic coastal plain] was largely ignored or misstated. That's when my skepticism began to emerge."

The procedures Surovell used to extract magnetic grains from his soil samples.

TODD SUROVELL

Following protocols established by the Impact Team, Surovell's team collected and tested soil samples from seven Clovis-age sites across America. Two, Blackwater Draw and Topper, had been included in the previous study. Surovell et al. focused on two diagnostic markers selected by the Impact Team: magnetic mineral grains and magnetic microspherules. "In 2007 the Impact Team was promoting the magnetic microspherules as one of the key 'smoking guns' of an impact," Holliday explains. "Todd could process them in his lab. Though the process was extremely tedious, it didn't require much in the way of high-tech equipment or a lot of funding. So we went that route."

"I was just really intrigued by magnetic microspherules," Surovell says. "I'd never even heard of these things until I read Firestone et al., yet they were finding them in YDB [Younger Dryas Boundary] samples from Clovis sites across the country. I wanted to see these things for myself. They're highly spherical, shiny little grains about the diameter of a human hair. They look like tiny ball bearings. In my lab, we commonly call them 'space balls,' although after all of this work, I have my doubts concerning their origin."

Surovell began by processing samples sent to him by Holliday from Lubbock Lake, Texas, and San Jon, New Mexico, extracting the magnetic materials and calculating their abundance. Later, they collected YDB samples from five other sites. The results of the testing, which took a mind-numbing 18 months, were disappointing: They weren't able to reproduce any of the Impact Team's results. Not only were there no peaks associated with the YDB at any of their sites, in six sites the YDB concentrations were *lower* than the averages observed in other sediments. Holliday cites variable preservation as one factor that may have resulted in the divergent results. "Another possibility is that 'indicators' such as the magnetic microspherules are post-depositional features that form only locally," he notes. "This raises another problem I've had with the impact hypothesis: The proponents have never questioned their data or what it may mean, at least not in print."

As Surovell points out, "Using the same methods on similar samples, we should have found the same thing. We did not. Firestone et al. will tell you that we didn't replicate their methods, but we did everything we could to do so, including consulting with Allen West."

Dr. West believes that the radical differences between his team's results and the Surovell team's stem from a number of procedural errors. He agrees with Surovell on one point: "I believe they had good intentions, but simply failed to follow our protocol in adequate detail." He explains that because the markers are so tiny, proper protocols must be strictly followed to produce meaningful results. "Only scientists who have previously searched for trace materials would find our protocol clearly understandable," he says, "and to my knowledge, none of the Surovell group has ever worked with trace materials before. I don't believe they understood the need for carefully following the directions, and felt the changes were inconsequential."

First of all, he says, the sediment samples that the Impact Team collected from their study sites averaged just 3 cm thick (some were considerably thinner). In contrast, Surovell and his team collected samples from zones 5–28 cm thick. Second, he maintains, the magnetic samples examined by the Surovell team were far too small; they processed soil sample aliquots of 10–40 mg, whereas the Impact Team tested most or all of their soil samples. This resulted in marker samples up to 900 times smaller than the ones the Impact Team examined.

According to West, Surovell erred further by undercounting the magnetic microspherules he did find. According to his published procedures, Surovell counted only shiny, unfaceted, well-rounded spherules, whereas many of the microspherules found by West and his colleagues were sub-rounded and dull, and some were faceted. Ultimately, the Surovell counts were 50–100 times lower than the Impact Team's.

"I think Todd made a good effort to sample and took a good try at protocol," says space scientist Malcolm LeCompte, who is currently working independently of West on new EIH research, "but these protocols are very difficult, and size sorting is very important. These items are very small, right at the edge of magnification range . . . very hard to see at anything less than 180x. I had to persist myself to find them, and I might not have kept my interest up if the other markers hadn't been obvious." Dr. LeCompte points to Paw Paw Cove, Maryland, one of the Surovell team's sites, as an example of the failure of Surovell's protocol. "I don't think Todd realized when he did this survey that I had sampled Paw Paw Cove," he notes. "Where he found no spherules, I found a fairly rich yield—in the range of 200–300 spherules per kg—and the spherules were very small."

All these factors, West argues, caused the Surovell team to misinterpret their own data—and as a result, their densities for the magnetic materials are 1,000 times lower than the Impact Team's. Furthermore, he suggests that Surovell et al. misidentified the YDB in their samples, since peaks in one or both markers tended to occur either just above or just below their identified YDB layers.

J. H. HOFFECKER

Holliday at the Kostenki 21 site, Russia, 2001.

Holliday finds West's explanation annoying. "They're really condescending toward Todd, and make him out to sound incompetent—they made their lab protocols freely available, and Todd followed them to a T. Only after our results came out did they add comments about sampling interval and sample size—and essentially they imply that only they know how to conduct the analysis. What kind of scientific analysis is that? A specific point: They never published their sampling intervals or sampling protocols for any site in their 2007 paper." Surovell is less disturbed by West's criticism. "It's mildly annoying to hear that I was unable replicate their results because I'm incapable of 'following the directions,' particularly when we made a concerted effort to do so," he says, "but I guess that's the nature of the biz."

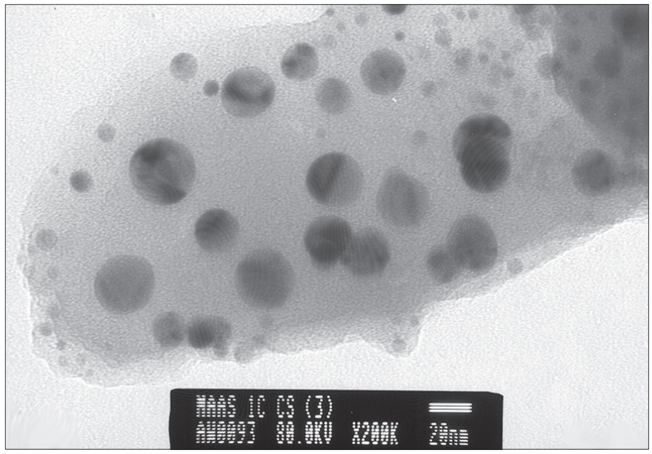
D. J. KENNETT

C. Vance Haynes (*left*) and West examining the "black mat" at the Murray Springs site in Arizona, 2006.

What's next?

The testing of the Extraterrestrial Impact Hypothesis continues, in the back-and-forth dialogue typical of good science. Despite the Surovell article and other recent critical reviews that have strenuously questioned the EIH, its proponents continue to produce data that support the theory. More results are forthcoming on both sides of the argument. In the EIH camp, the teams to which West and LeCompte belong have several projects in the works; West will soon publish a direct rebuttal to the Surovell team's *PNAS* article, and LeCompte is working at a number of sites that have produced copious amounts of various purported EIH markers in the YDB layers. In a sample of YDB strata from a site in New Jersey sent him by LeCompte and colleague Mark Demitroff, a periglacial geographer at the University of Delaware, West also found what appears to be shocked quartz—a well-accepted indicator of bolide impacts.

LeCompte is hoping for a rapprochement with the Surovell



ALLEN WEST

Nanodiamonds imbedded in a matrix of glass-like carbon. Scale is in nanometers (millionths of a millimeter). These tiny objects only have one known origin: extraterrestrial impacts.

team now that additional evidence has surfaced. "I have great sympathy for Todd and his effort," he avers. "I know it wasn't a positive experience for him, but I'd like to get him involved in a corrective study. I'm hopeful we'll do that, as opposed to a rebuttal paper."

At the moment, however, Surovell isn't interested. He and his colleagues are confident in their results, and his true research focus lies with Paleoindian archaeology. "I spent 18 months on this with my colleagues," he notes, "and hundreds of hours in the lab. Given our results, I have no reason to continue. I'll leave that to people who are more expert than myself.

"That said," he muses, "you never know what the future will

COSMIC BULL'S-EYE

GO OUTSIDE on any clear night and look up. If you're patient, you may see the brilliant scratch of a meteor trail across the sky—dramatic proof that near-Earth space isn't as empty as we like to think. Fortunately, though, there's not too much out there that can hurt us—right? It's a well-established fact that only a tiny percentage of objects entering the Earth's atmosphere are larger than a grain of sand and that almost all burn up harmlessly on entry.

Yet there *is* that tiny percentage of larger objects that don't . . . and if space scientist Malcolm LeCompte is correct, that number may be higher than previously believed. Dr. LeCompte became skeptical of published impact-rate predictions when developing a remote sensing satellite imaging system that would have provided continuous monitoring of the terrestrial bolide flux — that is, the number of objects that strike Earth. This skepticism led him to look into research projects investigating impacts in the recent past, which, according to widely accepted theories, should not have occurred. "I came to the conclusion that the impact flux may be underestimated," LeCompte reports. "What got my interest was looking at bolide impacts, especially those at the threshold of detectability. Ground-based data and the increasing number of terrestrial craters discovered seemed to suggest that the impact rate might be higher than hypothesized. New research at Los Alamos also suggests that the destructive potential of smaller objects may be greater than previously anticipated. Impact rate increases as object diameter decreases. Therefore, the threat to Earth may be as much as an order of magnitude greater than previously thought."

Of course, this isn't proof that a comet collided with Earth at the end of the Pleistocene, with disastrous effect on the Clovis culture, much of the megafauna, and the Earth's climate, as the Impact Team and allies like LeCompte believe. Just because it might have happened and the odds for such an event are higher than we once expected doesn't mean the Clovis Comet *did* happen; and in fact, a number of other scientists have failed to reproduce the Impact Team's findings. To be fair, some of the skepticism surrounding the issue seems to be based on the perception that the impact hypothesis is both farfetched and unnecessary, given existing explanations for terminal-Pleistocene extinctions and the Clovis culture's exit from the world scene. Oh, it's easy to imagine that a 10-km Chicxulub impactor triggered the extinction of the dinosaurs 65 mya; the evidence is very compelling. But after all, that was so distant and long ago. . . .

In our solar system's younger days, there were plenty of space rocks bouncing around among the inner planets. All it takes is a casual glance at the moon to see how often it's been used for celestial target practice. Most of the features we collectively call "the Man in the Moon" are impact craters and associated lava bring. Five years ago, I never would have guessed that I would spent countless hours bent over a microscope, looking for tiny iron spheres from space."

–Floyd Largent

How to contact the principals of this article:

Allen West
GeoScience Consulting
Dewey, AZ 86327
e-mail: Allen7633@aol.com

Vance T. Holliday
Professor of Anthropology & Geosciences
School of Geography and Development
University of Arizona
406 Haury Building
Tucson, AZ 85726
e-mail: vthollid@email.arizona.edu

Todd A. Surovell
Department of Anthropology
University of Wyoming
1000 E. University Avenue
Laramie, WY 82071
e-mail: surovell@uwyo.edu

Malcolm A. LeCompte
Chief Technical Officer and Founder
AstroVision International, Inc.
211 Smith Drive
Camden, NC 27921
e-mail: mlecompte@astrovision.com

plains. When viewed through a telescope, the moon is revealed to be pockmarked by everything from tiny micro-craters to the grandeur of Tycho—and the lunar far side is even denser with impact scars. Like a faithful bodyguard prepared to interpose his own body to protect his charge, the moon has been absorbing cosmic bullets bound for the Earth for eons.

Nonetheless, our planet has taken its own share of hits. The moon itself is thought to have resulted from an encounter with an impactor the size of Mars more than four billion years ago. Furthermore, global satellite photos reveal nearly 200 large craters in the Earth's surface. Many are amazingly old, with some dating back 2.4 billion years, but some are much younger. The famous Barringer Crater in Arizona, for example, was punched into the Earth's crust by a rock half the size of a football field that struck at about 30,000 miles an hour 40,000–50,000 CALYBP.

Even today, objects constantly slam into the Earth; a wide variety of hits and near-misses have been recorded in the past century or so alone. The Tunguska explosion of 1908, with a yield equivalent to about 600 Hiroshima bombs, was most likely the result of a chunk of ice 50 m across exploding 7 km above the surface. Something detonated over the Amazon jungle near Brazil's Ria Curuca in the 1930s, leaving behind terrifying memories and elusive shards of green glass; and in 1972, a rock about 80 m in diameter ricocheted off the Earth's atmosphere, narrowly averting a cataclysmic impact event.

And the hits keep coming. In 1994, a 10-m rock blasting along at 30,000 mph exploded over Micronesia, fortunately very high in the atmosphere. Its approach and destruction were recorded by space-based sensors. In 2008, a stony asteroid about 5 m across exploded over the African nation of Sudan, generating a fireball visible from space and strewing more than 280 fragments across the Nubian Desert.

Clearly, extraterrestrial impacts even today are more common than most people think. Whether the Clovis Comet was a reality must wait for a better resolution of the evidence, as seen through the lens of time and intervening research; but to say it could *not* have happened is absurd, and recent research into the frequency of the impact flux certainly adds another tasty ingredient to the theoretical stew.


MALCOLM LECOMPTE

LeCompte at the Topper site in South Carolina, 2008.

How much danger are we in now from extraterrestrial impacts? Some scientists believe we're overdue for a dramatically large impactor, but LeCompte isn't so sure. He does point out, however, that our modern, fragile civilization has been lucky. Imagine the consequences if the Tunguska object had exploded over Moscow or Kiev instead of in the wilds of Siberia. "With concentrations of humans in the millions in small areas," LeCompte points out, "the vulnerability is definitely there. A kiloton-yield event occurs annually in the atmosphere. A Hiroshima-scale event comes every ten years or so, and we have a major event, like Tunguska or Ria Curuca, about once a century. There are plenty of them out there . . . so it gets scary. When you look at major catastrophes like the Haitian earthquake or a tsunami, our ability to respond isn't great."

LeCompte leaves us this chilling thought: "If it ever happened over London or New York, there would be hell to pay." Let's hope he isn't prophetic.

–Floyd Largent

Decoding the Woolly Mammoth

continued from page 3

creased fire frequency. You see, in woodlands where a great deal of deadwood and other fuel accumulates, fires are fairly common. Woodlands inhabited by large herbivores, however, tend not to suffer fires often, apparently because the big animals sweep the understory clear in their quest for food. This mechanism has been observed in modern-day Africa, prehistoric Madagascar, and elsewhere, and now it appears to have occurred in the broadleaf forests of prehistoric North America as well.

Gill is quick to note, however, that the relationship between declining megafauna populations and increased fire frequency isn't necessarily one of cause and effect. While the evidence does suggest that large animals played a larger role in mediating fire than previously thought, the charcoal increase might instead indicate a human presence. In any case, Williams points out that "we see a clear signal that *Sporormiella* declines first, then we get increases in charcoal and the development of no-analog vegetation regimes at about 13,700–14,800 CALYBP. If there's a cause-and-effect relationship, it's that megafauna declined first."

BOTH: DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF WISCONSIN–MADISON

Jack Williams collecting samples at ▲ Kirshner Marsh, Minnesota, August 2008.

Jacquelyn L. Gill. ▶

The unending quest

Both Gill and Williams emphasize that more research is required before the relationship between the decline of the megaherbivores and the rise in both no-analog vegetation communities and forest fires can be firmly established for North America. In particular, a closer examination of the *Sporormiella* record through time and space is required; that is, the population decline needs to be examined at sites all across North America, from intervals spanning the period immediately before, during, and after the last glaciation. Comparisons of *Sporormiella* records from sites near well-documented human activity should follow, and the research needs to be extended to other continents to determine how the *Sporormiella* decline correlates with a human presence, if at all. Gill also cautions that "some work needs to be done on lake levels and how diluted *Sporormiella* might get. Lake-level rises may do that. But it gets pretty dry about 5600 CALYBP, and we don't see a corresponding increase in *Sporormiella* as lake levels are reduced."

Williams, too, tends to be a bit careful in trusting that the extinctions drove vegetation changes, rather than the other way around. "That's one strong hypothesis," he allows, "but one that hasn't been ruled out yet is that climate change may have co-driven the vegetation changes along with the extinctions. We need to do more work: Do we see time-transgressive patterns from north to south, as if temperature change was the cause; or west to east, based on likely scenarios of human migration? I think there's very suggestive evidence that megafauna decline caused the changes, but I want to see evidence from more sites before I have full confidence in that hypothesis. . . . The most plausible scenario is a combination of climate changes, with human hunting being the final factor that pushed these final animal populations to extinction."

Gill agrees. "Our work at this point doesn't resolve the classic debate of humans vs. climate change," she says, "but we think we're resolving the mechanisms a bit. I don't think that what we're seeing is an artifact of change in hydrology or climate. Possibly the climate change is responsible for the initial declines in megaherbivore populations, but because of the timing of the vegetation changes you have to evoke a mechanism other than habitat loss to explain the decline. It seems that it's a consequence rather than a cause of extinction: it can't be that their food disappeared. As for humans, the onset of the decline puts us at the early end of the question of human arrival. There's growing evidence that puts humans in the Great Lakes region about the time we see our *Sporormiella* declines in Indiana.

"It's possible that the Clovis toolkit was adopted as a response to the decline in game," she speculates. "Maybe tools and techniques had to become more specialized for big game hunting. It's an intriguing hypothesis, but we need more data at sites across America, which is what we're working on right now." MT

–Floyd Largent

How to contact the principals of this article:

Jacquelyn L. Gill
Department of Geography
Center for Climatic Research
University of Wisconsin
Madison, WI 53706
e-mail: jlgill@wisc.edu

Jack Williams
Bryson Professor of Climate, People, and Environment
Director, Williams Lab
Department of Geography
Center for Climatic Research
University of Wisconsin
Madison, WI 53706
e-mail: jww@geography.wisc.edu