MAMMOTH TRUMPET

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Center for the Study of the First Americans
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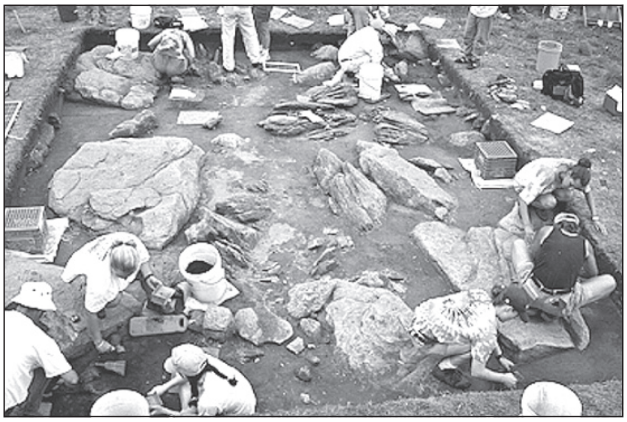
Paleoamericans in Yankee Country



NH STATE CONSERVATION AND RESCUE ARCHAEOLOGY PROGRAM

Stony and densely forested, New Hampshire has never yielded an easy living, certainly not for people occupying this beautiful land at the end of the Ice Age. When you don't have mammoth or bison on your menu, you've got to work hard for a no-frills existence. Lucky for Dick Boisvert, volunteers like this crew excavating the Jefferson II Israel River site in 1998 haven't lost sight of the work ethic. "I'd put them up against any professional crew in the business in terms of quality," says Dr. Boisvert, New Hampshire State Archaeologist, of the workers of the State Conservation and Rescue Archaeology Program. SCRAP trains tomorrow's archaeologists. Today the eager workers give Boisvert the means to document the archaeology of the Granite State. Our story on the discoveries being made in this rocky corner of New England starts on page 9.

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.

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The Silver Beach Elk Site:

A Case of MISLEADING ASSOCIATION

WHEN SWIMMERS discovered elk bones near a fluted projectile point at the bottom of Wisconsin's Middle Eau Claire Lake, Jean Hudson, associate professor of Anthropology at the University of Wisconsin–Milwaukee, saw her chance to capture a revealing new facet of Paleoindian life.

But it wasn't long before Dr. Hudson was snared in a not uncommon archaeological who-done-it in which initial clues suggestively tied Paleoindian hunters to the death of the elk—clues that subsequent scientific testing would prove false. Along the way, the zooarchaeological specialist and her research team encountered a varied cast of characters and rode a roller coaster of emotions while solving the mystery of the Silver Beach Elk site (47BA526).

JEAN HUDSON

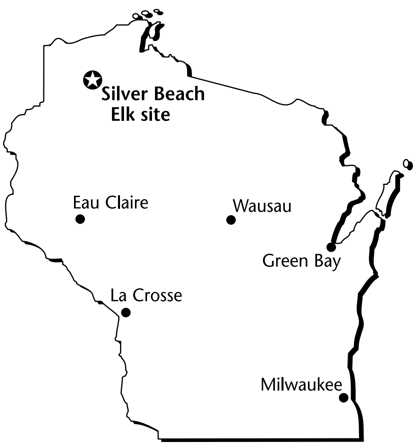
◀ **Nikki Johnson, who found the fluted point, demonstrates that it fits neatly through the holes in the elk scapula.**

INSIDE

An exciting beginning ripe with promise

The saga began in the summer of 2005 when Jacob Voelker, whom Hudson describes as a young man in his 20s, was swimming in the lake and looking along the bottom for interesting pieces of driftwood. About 5 ft below the water's surface, Voelker saw what he believed to be a unique piece, dove down, retrieved it, and swam to shore. But it wasn't driftwood. He had pulled up what appeared to Hudson to be a "half rack" of antlers from what looked like an elk. Voelker returned to the water and soon hauled out more bones.

Nearby children hurried over to join in the search. Nikki Johnson, the granddaughter of adjacent property owners Helen and Quentin Ruprecht, scuffled her feet across the lake bottom seeking bones and "stepped on something sharp." She pulled a "shiny rock" from the silty lake bottom and brought it ashore. Her grand-



father examined the pointed stone she had found less than a meter from the skeleton. Recognizing it as some kind of projectile point, Ruprecht thought the swimmers might have uncovered something significant. He set about contacting an archaeologist to examine the find.

Initial inquiry found only doubters. It couldn't be an elk, his first contacts argued. Sites elsewhere have shown that late-Pleistocene hunters in this area likely would have been stalking caribou, not elk. So Ruprecht must be mistaken, they contended, and declined his invitation to look at the site. But Ruprecht persisted. He contacted a family friend and biologist in Missouri, Lee Lyman, who was also familiar with elk. Lyman thought the find sounded interesting, but he, after all, was in Missouri, not Wisconsin. However, Lyman knew a Wisconsin archaeologist who might help—Dr. Jean Hudson.

Ruprecht sent Hudson an e-mail explaining the finds, and some photographs. The material piqued her curiosity. "I was going to make a trip to northern Wisconsin for recreational purposes, to go on a kayacking outing," she recalls, "and said I would just sweep by and check it out." Hudson's scientific interest in the Paleoindian period of North America meshes nicely with her pastime of scuba diving. Excited at the prospect of finding bones underwater, possibly under excellent preservation conditions, with the added prize of the fluted point, she hoped to investigate a well-preserved Paleoindian site.

First results kindle hope

Although the site had been disturbed by

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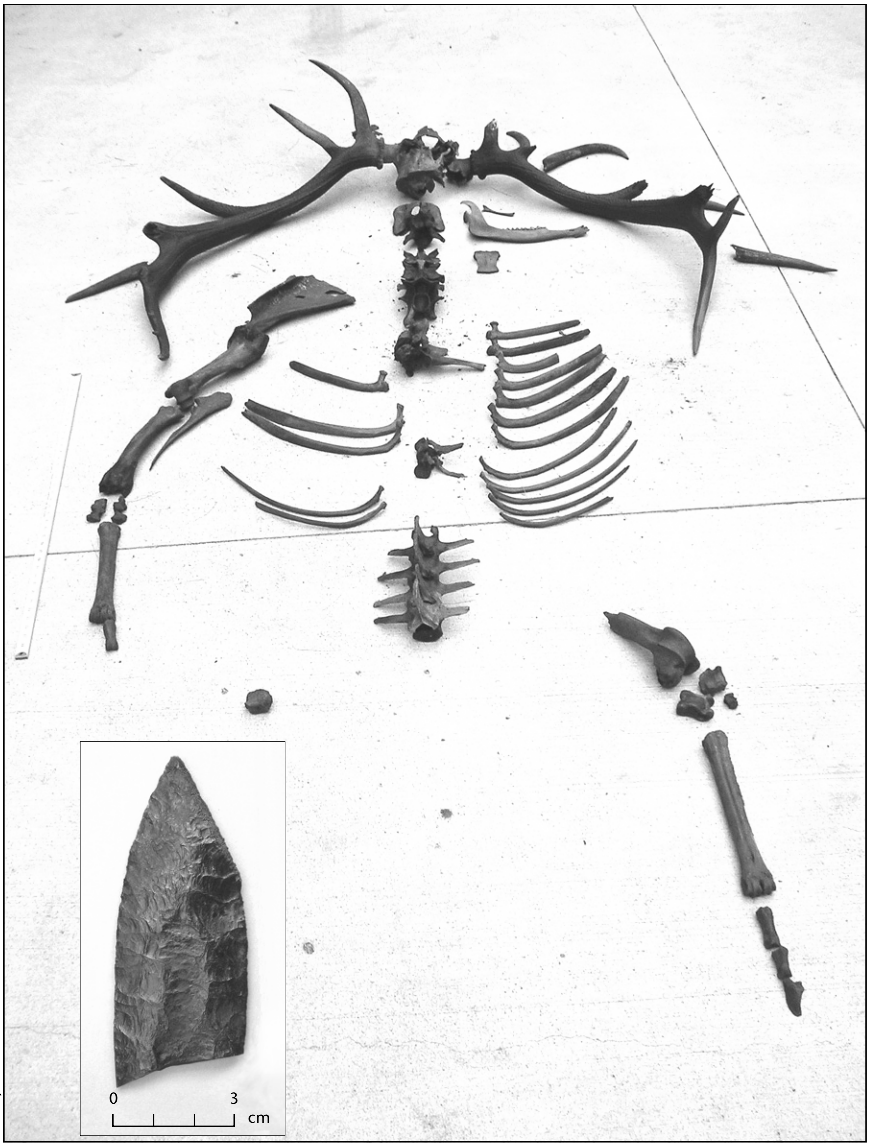
Mammoth Trumpet, Statement of Our Policy

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

removing about half the elk skeleton and the fluted point of a type known to be at least 10,000 years old, Hudson's first inspection in 2005 found additional bones visible on the lake bottom. What's more, she found the preservation conditions were amazing. The site hinted of great potential for examining in detail Paleoindian lifeways, such as what the people were hunting and eating. Plant remains might further illuminate life in Wisconsin at the end of the Ice Age. Her efforts went well, as Hudson describes in her article in *Current Research in the Pleistocene,* vol. 23 (2006). Early site exploration and artifact analysis confirmed the bones were those of an adult male elk (*Cervus elaphus*). The bones had been found in "spatial" association with a Gainey- or Clovis-style fluted point of jasper taconite, a material found 300–400 km away at Thunder Bay, Ontario, and at the Red Cedar site 130 km to the south. (Gainey points, characterized by a flute extending more than halfway up their length, are named after the site in Michigan where the style was first defined.)

With soaring expectations, she returned to the site in 2006 with three graduate students—Kira Kaufmann, Pete Fantle, and Toni Revane (who agreed to work in exchange for meals and lodging)—and proper diving equipment for systematically surveying and recording the site, and collecting artifacts and soil samples. Parts of two elk elements, the mandible and the hyoid, were recovered in situ, firmly embedded in the surface of the uppermost sand-and-gravel stratum of the lake bottom.



BOTH: JEAN HUDSON

Elk remains, with meter-stick for scale, and fluted point (*inset*).

Early analysis bolstered the possibility that Paleoindian hunters bagged elk earlier and farther north than suggested by existing data that links Gainey points with caribou and tundra or spruce parkland. Modern elk, on the other hand, are primarily associated with open woods, prairies, and wetlands.

Preliminary inspection of the skeleton revealed butchering cutmarks and "wounding marks," including two holes in the left scapula and two nick marks on adjacent ribs that strongly suggested the animal was brought down and butchered with stone projectile points and tools. Not satisfied with "spatial association," Hudson found that the fluted point even fit through the holes in the elk scapula. "And it was a very nice fit," she adds. Butchering activities also raised the possibility of finding an adjacent campsite. She remembers thinking, "Boy, wouldn't that be exciting!"

The skeleton offered Hudson and her team a bonus, what she calls "a prime teaching moment," when her students volunteered to butcher modern deer and elk carcasses with stone tools to create actual stone-tool butchering marks for comparison.

Crunch time: lab verification

Hoping to pinpoint the elk's age and thereby cement the assocation between the skeleton and the fluted point, Hudson sent a portion of the elk rib to Beta Analytic in Florida for radiocarbon dating to confirm they had indeed found a Paleoindian kill site.

Based on our existing state of knowledge, Hudson was convinced the site offered good potential to expand the body of ecological data and enlarge the database of regional distribution and dates for the Gainey and Clovis tool traditions around the Great Lakes.

Fleshing out a story

Aware that the story was incomplete and the link between Paleoindian hunter and elk largely circumstantial, Hudson nevertheless speculated hopefully on the elk's last day and felt she was "right there watching it happen."

Recreating the late Ice Age terrain from geological and environmental reconstructions done around Lake Superior, Hudson surmised that one, perhaps two Paleoindian hunters stalked the elk across a glacial outwash zone of braided streams and gravel bars. "If they were like hunters today, they would have been psyched," she notes, considering that they were chasing an animal weighing an estimated 800 to 1,000 pounds, "good sized, but not gigantic." Possibly using atlatals (spear throwers), the hunters hurled stone-tipped darts, hoping for an immediate kill by piercing the elk's heart or lungs. If the animal was running, its shoulder blades may have obscured the vital organs for an instant, causing the darts to pierce the scapula and nick some ribs in the process and accounting for the wounding marks found on the skeleton. After bagging the elk, the hunters partially butchered it on site. Over years the lake formed, putting the remains underwater.

This, at least, is the scene Hudson hoped would be proved credible if radiocarbon dating showed the elk was as old as known dates of similar Gainey fluted points.

Deflated hopes

The radiocarbon date for the rib sample wasn't what Dr. Hudson expected.

"The first date I got back placed the elk at only about 500 years old" (380 ± 40 RCYBP, Beta-215798). "I was shocked and dismayed," she confesses, "hoping there was some error and wondering what mistakes I could have possibly made in sending in the rib, which is not the most diagnostic element I could have chosen." Undaunted, she sent a sample from the interior portion of the elk skull close to the antlers to the Stafford Research Laboratory in Boulder, Colorado. Relying on Dr. Tom Stafford's superior expertise in purifying bone collagen, she hoped that eliminating all possibility of contamination would produce a date consistent with her hypothesized Paleoindian hunter–elk association. Hudson knew that RC-dating tests are expensive and often problematical when dating ancient bone. Fortunately for her, the Barnes Area Historical Association of residents in the area, excited at finding an archaeological site in their backyard, paid the costs, which can run as high as $1,300 per sample.

Hudson with elk mandible retrieved from in situ location on lake bottom, 2006.

TONI REVANE

Meanwhile, Hudson's academic life continued. She was preparing a paper on the Silver Beach Elk site when the Stafford lab reported more bad news. The sample dated the elk to 360 ± 15 RCYBP (UCIAMS-29115)—solid confirmation that the find wasn't what it seemed, and that the elk remains and the fluted point weren't associated in time.

She scrambled to revise her paper to include the new findings. "It forced me to do some rethinking," she says. "Part of you knows as a scientist that you are not allowed to be disappointed, as you want the best, most accurate answer there is." But it was clear her hopes had been thwarted and that disappointment was unavoidable. It meant, she explains, "that instead of the elk being associated with a time period that fascinates me, it would be associated with another time period—one much closer to us in time." It also meant, she adds, that since "the elk would not be shedding light on Paleoindian life, the Paleoindian portion of the site [as indicated by finding the fluted point] was much more ordinary."

She writes in this year's edition of *Current Research in the Pleistocene* that it now appears the elk kill occurred in a separate "and far more recent hunting event than did the loss of the fluted point, and the two items came to rest near each other on the bottom of Middle Eau Claire Lake by independent means."

Reflecting on a plausible scenario

What happened at the twilight of the Ice Age that left the fluted point on the lake bottom to be found thousands of years later near an elk skeleton? Dr. Hudson has some thoughts about that. "Well, sometime between 10,000 and 11,000 years ago," she says, "somebody lost a fluted point out there, maybe during a hunting episode, or maybe they were retooling. . . . The point had a broken base and damage to the tip so maybe it wasn't worth keeping." Then, some 10,000 years later, "somebody else was hunting, and they were successful, and they killed their elk and left butchering marks on it." Possibly they killed the elk near the edge of the expanding lake, or possibly they killed and butchered the elk on the frozen lake, took only part of the animal and planned to return for the rest, but never did. When the water level rose, or the frozen lake melted, the elk remains sank to the bottom in a spot that happened to be close to the fluted point deposited millennia earlier.

As she looks back over the site and its suggestive clues, one fact puzzles Hudson: Why did Paleoindian hunters—or the hunters of 500 years ago, for that matter—leave the antlers behind? Antlers are a valuable commodity for hunter-gatherers, frequently used to make general-purpose tools and as soft hammers to produce stone tools. "I still don't know why they would have left the antlers untouched," she admits, "or why they would leave one front limb and one hind limb behind, as it is all good meat." Maybe, she suggests, "it was very cold and they decided to do a quick butchering job and take home only

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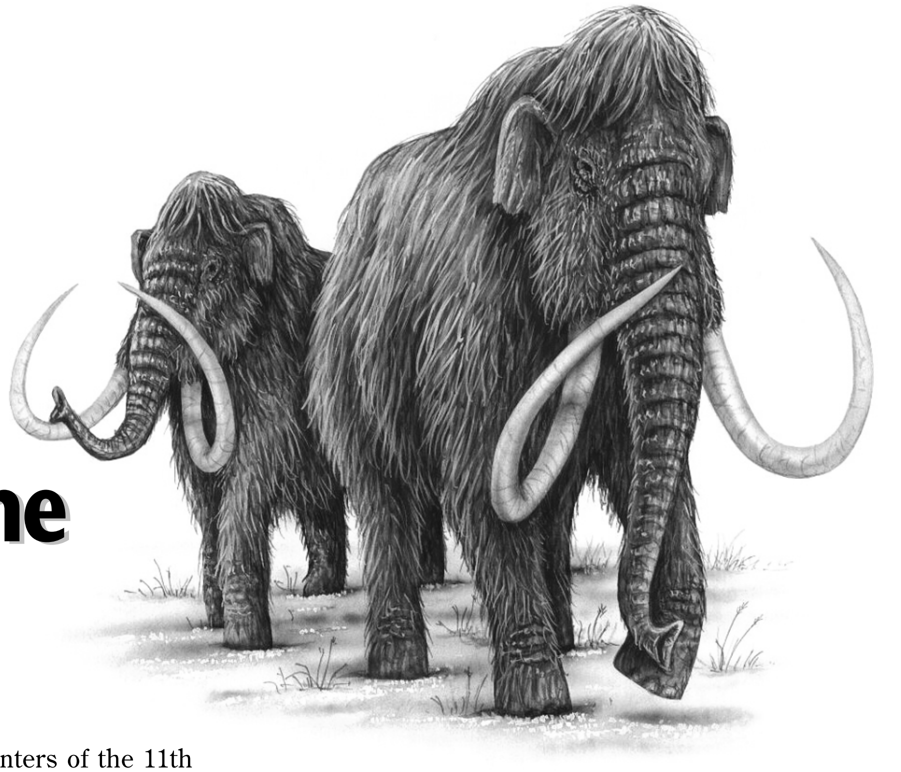
Chemical Studies Reveal the Lost World of Pleistocene America



Mammoths in snow, an illustration by Phil Wilson ©2006 from *After the Dinosaurs: Mammoths and Other Fossil Mammals,* published by HarperCollins. Hoppe (under the pen name of Charlotte Lewis Brown) wrote this book, one of a 3-part series, to excite children about science.

KATHRYN HOPPE, like the Clovis hunters of the 11th millennium B.C., is an expert at tracking mammoths and mastodons. Dr. Hoppe, a geologist with the Burke Museum of Natural History and Culture at the University of Washington, studies the chemistry of fossil teeth. Her research has shed light on the migration patterns of mammoths, mastodons, and other Ice Age animals, as well as the roles climate change and hunting by humans may have played in the extinction of these megafauna.

In several papers published between 1998 and 2007, Hoppe and her colleagues have examined the relative proportions of different isotopes, or chemical varieties, of the elements carbon, oxygen, and strontium in fossil tooth enamel and used these subtle clues to reveal details about the lives and deaths of these animals that would astonish Sherlock Holmes.

"Isotopic ecology"—How it works

Hoppe's methods rely on the fact that mammals construct their teeth over the course of many years using various elements as building blocks. Many of these elements have isotopes that occur in relative abundances relating, more or less directly, to various aspects of the environment in which the animal lived.

B. MUENCHAU, 2003

Hoppe collecting teeth and bones from modern bison (*Bison bison*) for chemical analysis and correlation with results from mammoths and mastodon.

Carbon, or C to use the chemical symbol, is a key component of tooth enamel. Two of its isotopes are ^{13}C and ^{12}C. The relative proportions of these two isotopes in a layer of tooth enamel are determined by their relative abundance in the food consumed by the animal. Plants with a relatively low amount of ^{13}C include trees, most shrubs, and those grasses and herbs that grow in cooler climates. Plants with a relatively high amount of ^{13}C include grasses, sedges, and herbs growing in warmer or dryer climates. Therefore grazing animals, which eat mostly grass, have enamel with relatively high amounts of ^{13}C, whereas browsers, which eat mostly shrubs and bits from trees, have relatively small amounts of ^{13}C in their tooth enamel. Working backwards, researchers can use the relative abundance of ^{13}C in tooth enamel to determine whether an animal was predominantly a grazer or a browser.

Oxygen, or O, is another constituent of tooth enamel. Two important isotopes of oxygen, ^{18}O and ^{16}O, are found as the O in H_2O of rainwater, and their relative proportions in the water that animals drink largely determine their proportions in the developing enamel. The proportions are correlated with temperature, so rainwater in colder climates (and during colder seasons) has relatively less ^{18}O than rainwater in warmer climates (and warmer seasons). As a result, layers of tooth enamel incorporating higher proportions of ^{18}O grew during periods when the animals lived in colder regions and/or during colder seasons of the year.

T. FURUTANI, 2002

Hoppe processing mammoth sample for analysis of strontium isotopes in the Thermal Ionization Mass Spectrometer Lab at the University of California, Santa Cruz. A sample, first dissolved in acid, is purified by adding it to specialized resin in one of the columns, which separates Sr from other elements. Researchers working in the lab must wear protective equipment to avoid contaminating samples.

Strontium, or Sr, is a component of rocks. Different kinds of rock include varying proportions of two isotopes—^{87}Sr and ^{86}Sr. As rocks break down through weathering and erosion the strontium becomes incorporated into the soil. Plants that grow in the soil draw the strontium into their structure. When herbivores eat the plants, the strontium makes its way into the animal's developing tooth enamel. The relative proportions of ^{87}Sr and ^{86}Sr in teeth, therefore, are a reflection of the bedrock in the region in which the animal lived during the years in which the teeth were growing. If the animal moved across a wide area with diverse kinds of bedrock, then the ratio of ^{87}Sr to ^{86}Sr in its teeth will be a sort of average of the ratio of these isotopes in the bedrocks of all the regions in which it lived. If it lived in a more restricted area, then its $^{87}Sr/^{86}Sr$ ratio will be a simple reflection of the $^{87}Sr/^{86}Sr$ of the bedrock underlying that region.

The relative proportions of these various isotopes of carbon, oxygen, and strontium in tooth enamel are isotopic signatures of the climate, geology, and diet of animals. In the case of extinct animals, these data can open a window onto the ecology of species that otherwise would be forever closed to us. For archaeologists, these data provide insights into how these animals may have been exploited by ancient hunters and whether they might have been more or less vulnerable to extinction through either over-hunting or climate change.

Diet

Hoppe, with Dr. Paul Koch of the University of California and Dr. David Webb of the University of Florida, analyzed oxygen and carbon isotopes in 72 fossil teeth from 6 sites in Florida. They published their results in the journal *Chemical Geology* in 1998 in an article titled "The isotopic ecology of late Pleistocene mammals in North America, Part 1. Florida." They determined that mastodons had oxygen and carbon isotope percentages in their tooth enamel similar to those of known browsers, such as deer and tapir. Mammoths, on the other hand, had the isotopic signatures of grazers, such as bison and zebra. Moreover, oxygen isotope variations across several layers of enamel in the molar of an individual mammoth indicated that its diet had not changed significantly from one season to the next.

One surprise revealed by the study was that Ice Age horses ate both grass and browse. Modern horses and zebras tend to be grazers, so it had been anticipated that ancient American horses would be as well. Feral horses in North America, however, have a more diverse diet, so perhaps the fact that their Pleistocene predecessors did as well shouldn't have been so surprising.

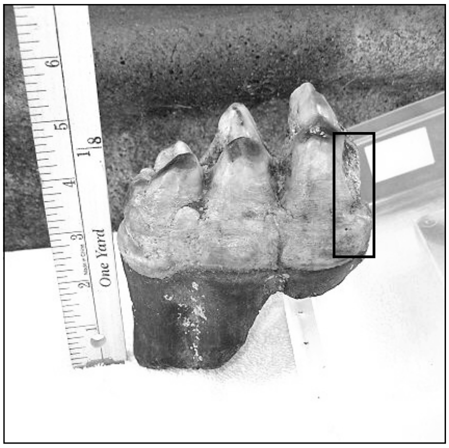
Migration patterns

Hoppe, Koch, and Webb, along with Dr. Richard Carlson of the Carnegie Institution of Washington, examined the strontium-isotope ratio of tooth enamel from 58 individuals from 5 sites in Florida. The sample included 16 mammoths, 17 mastodons, 6 tapirs, 18 deer, and one rabbit. The results were published in the May 1999 issue of the journal *Geology*. In 2007, Hoppe and Koch published a follow-up study in the journal *Quaternary Research* adding data from 11 mammoths, 14 mastodons, 6 tapirs, 3 horses, and 13 deer—also from Florida sites.

Much of central and southern Florida is underlain by ocean-deposited carbonate rocks, mainly limestone. These have relatively low $^{87}Sr/^{86}Sr$ ratios. In contrast, northern Florida and much of neighboring Georgia have relatively high $^{87}Sr/^{86}Sr$ ratios due to the igneous and metamorphic bedrock of the Appalachian Mountains. In general, therefore, Floridian animal species that didn't migrate over great distances would have tooth enamel with low $^{87}Sr/^{86}Sr$ ratios, whereas migratory species would have higher $^{87}Sr/^{86}Sr$ ratios reflecting the ratios of the plants consumed in these distinctive regions.

Hoppe and her co-investigators determined that bulk samples of tooth enamel, which, because they combined many years of enamel accumulation represented an average of the plants consumed by an animal over the period in which the tooth was growing, showed that mammoths, tapir, and deer all had relatively low $^{87}Sr/^{86}Sr$ ratios. Mastodons, on the other hand, had high $^{87}Sr/^{86}Sr$ ratios. These results indicate that Floridian mammoths, tapir, and deer all had small home ranges, whereas mastodons likely migrated over long distances to the north. Hoppe and her co-authors suggested one-way distances of up to 500 km.

Hoppe and her colleagues caution that mammoths also could have moved equally large distances along the broad Florida coastal plain, but since the plants throughout southern Florida share the same $^{87}Sr/^{86}Sr$ ratios, these movements would not be recorded in their tooth enamel. The evidence for mastodons, however, is unequivocal. According to Hoppe and Koch, a sequence of microsamples of enamel, spanning approximately two years in the life of an individual mastodon from the Page-Ladson site, demonstrate that at least this individual "moved repeatedly back and forth between regions with high and low strontium, and are consistent with the interpretation that it migrated on a seasonal basis."



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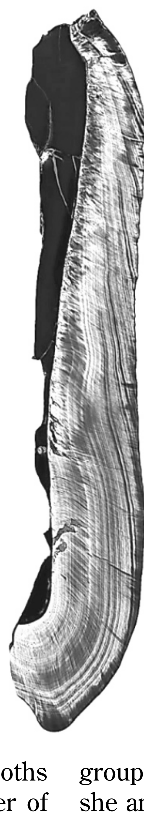

K. HOPPE

This mastodon tooth (*left above*) was found on a beach in southeast Texas by a *Mammoth Trumpet* reader. The box shows the location of the sample Hoppe cut from the cusp of a similar tooth from a Florida mastodon (*left below*). Backlighting shows up growth bands in the enamel, similar to the annual rings in a tree trunk, as light and dark strata. Each band retains materials that were mineralized simultaneously. By analyzing the composition of the bands, scientists can read the record of chemical variations in the animal's diet and thereby reconstruct seasonal variations in migration patterns. This sample measures about 2½ inches high.

Tapir and deer, as expected, had small home ranges, but horses gave Hoppe another surprise. Horses that lived before the last glacial maximum (about 20,000 years ago) had high $^{87}Sr/^{86}Sr$ ratios, indicating they migrated long distances north into Georgia. Horses that lived after the last glacial maximum, however, had low $^{87}Sr/^{86}Sr$ ratios and so did not migrate outside of Florida. These changes in migration patterns over time likely are related to the changing climates of the late glacial period.

Mammoth herd structure and Clovis hunting strategies

In 2004, Hoppe used her data on mammoth isotopic ecology to shed light on Clovis-culture hunting strategies. In a paper published in the journal *Paleobiology*, she studied mammoths from several Clovis kill sites as well as natural-death assemblages.

The Dent site in Colorado and the Miami site in Texas previously had been interpreted as places where Clovis hunters had ambushed and killed entire family groups of mammoths. Hoppe realized that a comparison of the carbon isotopes in the skeletons of these mammoths could provide an independent test of whether the mammoths were a family group killed in a single event or a number of unrelated individuals killed over an extended period of time.

Hoppe used data from the natural catastrophic death of a family group of mammoths at the Waco site in Texas and an accumulation of deaths of unrelated mammoths from the Friesenhahn Cave in Texas to show that mammoths from the same family group had similar ^{13}C values, whereas the values of unrelated mammoths preserved together varied widely.

Hoppe reasoned that if the Dent and Miami sites represented single events in which Clovis hunters had slaughtered a family group of mammoths, then the variability in the isotopic signatures should be low, like those recorded for the Waco site. On the other hand, if the Clovis sites represented separate events that took place at different times in one location, then the variability in the isotopic signatures should be high, such as she had observed at Friesenhahn Cave.

Hoppe's analyses revealed that "the individuals at each of the Clovis sites display highly variable [^{13}C] values. In fact, the . . . values of mammoths at every Clovis site have greater variability than those of mammoths at Friesenhahn Cave." Therefore, the Dent and Miami sites each contained "a mixture of unrelated individuals rather than a family group assemblage."

These data suggest that Clovis hunters did not, at least in these two cases, slaughter entire family groups of mammoths. Instead, they hunted, or possibly scavenged, single mammoths. Hoppe concedes that "further work is needed to resolve whether other mass accumulations of Clovis mammoth (i.e., Lehner, Arizona . . . and Colby, Wyoming) likewise represented the deaths of unrelated individuals."

The notion that spear-wielding hunters could drop entire family groups of mammoths in their tracks always has seemed more than a little far-fetched. George Frison described the modern process of culling family groups of elephants in his 2004 book *Survival by Hunting: Prehistoric Human Predators and Animal Prey*. It requires first shooting the matriarch of the herd with a large-caliber bullet to the brain, killing her instantly and throwing the rest of the group into confusion. If the matriarch was only wounded, then she and her sisters could attack the hunters or flee—possibly traveling a great distance before dying. Frison concluded that Clovis point–tipped spears certainly could kill mammoths, but not reliably with penetrations of the brain or even the heart. Therefore, if mammoths behaved anything like modern elephants, directly attacking a family group with spears likely would have had disastrous consequences for any hunters bold enough or stupid enough to try.

Climate change and extinctions

If Clovis hunters were not capable of killing family groups of mammoths en masse, then perhaps their role in the late-Pleistocene megafaunal extinctions has been exaggerated. Other researchers have proposed climate change as the driving force in these extinctions. Can Hoppe's data be used to refute or substantiate this hypothesis?

According to Hoppe and her colleagues, one alternative explanation for the mass extinctions is that climate change caused a "nutritional 'bottleneck' " by disrupting the unique, highly diverse plant communities of the late Pleistocene. This would have presented the most difficulties for those species with specialized diets. Koch, Hoppe and Webb, in their paper describing the isotopic ecology of Florida's Ice Age mammals, demonstrate that mammoths and mastodons "exhibit more focused feeding . . . than modern elephant populations." While these results cannot prove that nutritional stress caused the extinction of the megafauna, they do establish that one necessary condition of that model was present. Florida's proboscideans appear to have been vulnerable to extinction due to climate change.

Conclusions

The research of Hoppe and her colleagues on the elemental isotopic ecology of fossil animal teeth has made an immense contribution to our understanding of extinct species. Knowing what mammoths and mastodons ate, whether and how far they migrated, whether these migrations were seasonal or not, and details of the structure of herds allow us to characterize the paleobiology of these animals, reconstruct aspects of their paleoenvironments, and test hypotheses relating to whether their ultimate extinction was tied to human predation or changing climates.

The fruitfulness of this avenue of research is amply demonstrated by the several papers reviewed in this brief article. Additional research on a broader range of species from a wider geographic compass certainly will go a long way towards recovering the lost world of late Pleistocene America and potentially solving one of the most vexing problems of American archaeology and paleontology: What caused the extinction of the megafauna? Stay tuned for further developments from this scientific frontier.

–Bradley Lepper

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The Silver Beach Elk Site

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enough meat to feed the family, figuring the lake would stay frozen and they could return later for the rest, but never did. I just don't know."

Could hunters of 500 years ago have killed the elk with a fluted point they either made or found? Hudson doesn't buy into that explanation. She contends that Native Americans of the period since European contact probably wouldn't have been taught the skills needed to make or use a fluted point as a weapon. If they had had a fluted point, she considers it more likely they would have used it as a knife, possibly for butchering animals.

Building on dashed expectations

The fluted point itself may yet yield valuable facts about the Paleoindian period. Hudson would like, for example, to see the point analyzed for microwear and blood residue; additional information may tell us something about the game of its time. Soil samples taken during site excavation, which have yet to be fully analyzed, may provide interesting data as well.

Despite her elation at the possibilities initially offered by the Silver Beach Elk Site, and the dismay felt when those possibilities were dashed by radiocarbon dating, Hudson believes the site provides scholars with considerable knowledge. "I still have work to do," she says, "and I am trying hard to get over my disappointment and remind myself that the remains still have value, the elk for its time, the fluted point for its time."

And, she adds, science owes a debt to the residents around the lake. The Silver Beach Elk site never would have been found if the local residents hadn't stumbled across the bones and the fluted point, set about finding an archaeologist to come and look at them, and then provided money for expensive testing required to answer questions the site posed.

Hudson is confident that there are other sites in submerged situations. She declares with stoic optimism, "Even though this one didn't turn out to be the dream I had about it, it could still be out there somewhere, and we just have to keep looking at lake bottoms. Sometimes it's just good to have our imaginations sparked like this."

–George Wisner

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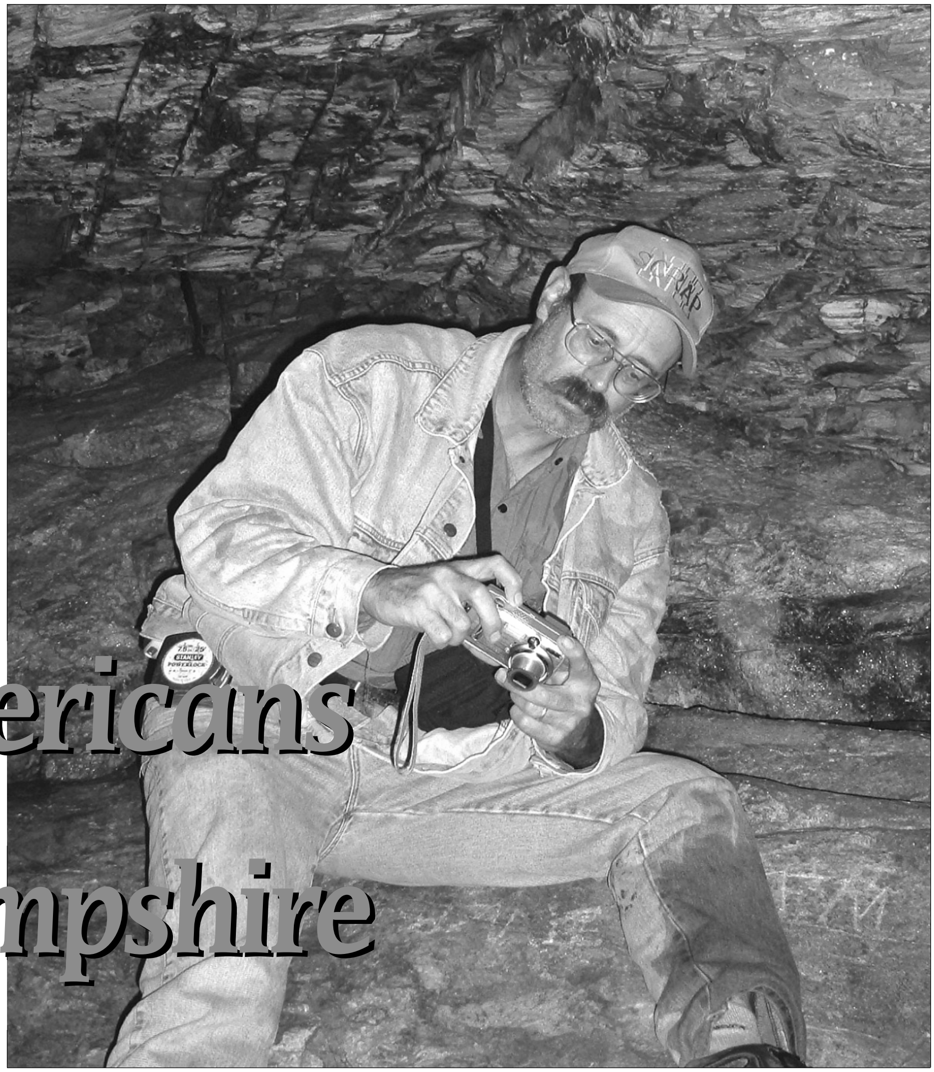
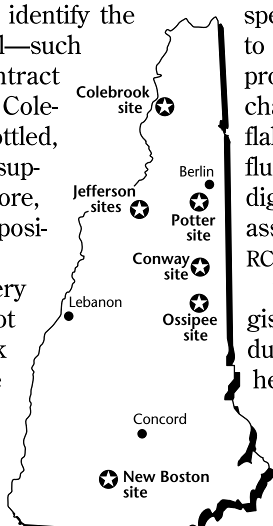
Boisvert, SCRAP, and the Paleoamericans of New Hampshire



ALL PHOTOS: NH STATE CONSERVATION AND RESCUE ARCHAEOLOGY PROGRAM

Dick Boisvert at the Mount Jasper rhyolite quarry in Berlin, New Hampshire, which was exploited from the Paleoamerican period forward.

WHEN IT COMES TO UNDERSTANDING even the simplest aspects of Paleoamerican culture, archaeologists don't have it easy. It's difficult to infer behavior from the meager scraps of stone and bone most of our efforts are rewarded with, so it's a red-letter day when we identify the preserved remains of something more ephemeral—such as the ancient post-molds discovered by contract archaeologist Edna Feighner at New Hampshire's Colebrook site a decade ago. Those patches of mottled, organic-rich soil, all that remained of structural support posts that had rotted away 11,000 years before, offered the opportunity to flesh the skeleton of supposition with firm behavioral data.



While the credit for the Colebrook discovery rightly belongs to Feighner and her crew, they got an assist from Richard Boisvert. When Colebrook came to light, Dr. Boisvert was the Deputy State Archaeologist of New Hampshire, which also made him director of the State Conservation and Rescue Archaeology Program (SCRAP). Several of Feigner's crew members had previously worked as SCRAP volunteers for Boisvert, a lithics specialist whose emphasis is on teaching his charges how to do field archaeology the right way. Rigorous training probably helped sharpen their alertness in recognizing channel-flake fragments in their shovel tests. Channel flakes are a sure indicator of fluted-point manufacture, and fluted points are exclusively Paleoamerican. A little extra digging at Colebrook turned up the post-molds and an associated hearth, which all dated from 10,300 ± 170 RCYBP—a rare find indeed.

Today Boisvert is New Hampshire's State Archaeologist, and Edna Feighner works with him directly. They've dug again at Colebrook, pulling out more data that are helping them "write that part of the story for New Hampshire," as Boisvert puts it. But Colebrook is only one of the pies Boisvert and his crew have their fingers in.

When an entire state is your archaeological bailiwick, you've got an excellent opportunity to get a lot of quality research done—and Boisvert has taken advan-

The 2006 SCRAP field school excavations at the Colebrook site.

tage of that opportunity in spades. His state may not be the biggest in the Union, but it's archaeologically rich, with a cultural time depth extending back to the Clovis era.

Big responsibilities

As New Hampshire's top archaeologist, Dick Boisvert oversees much of the archaeological research in the state. He considers this one of his biggest responsibilities; consequently he regularly has to sit in judgment on other archaeologists and often must assess the quality of their work without ever setting foot on the sites in question. Boisvert's office also handles Native American repatriation issues, which can be unusually complex in New Hampshire, since the state's requirements are significantly more demanding than federal requirements, as outlined in the Native American Graves Protection and Repatriation Act (NAGPRA). That there are no state or federally recognized native tribes in New Hampshire, just a myriad of small bands, makes the work even more difficult.

Another of Boisvert's top priorities is finding ways to do archaeological research on a shoestring. "We don't have a lot of resources to commit to doing archaeology in New Hampshire," he points out, "so what we do have, we spend very carefully." He depends heavily on his SCRAP volunteers to help him get the work done, and despite his busy schedule, he still finds time to work with them frequently. In fact, they're a source of pride. "I'd put them up against any professional crew in the business in terms of quality," he says. "Some of our SCRAP volunteers have worked with us since the early 1990s; they're solid, reliable, and highly skilled."

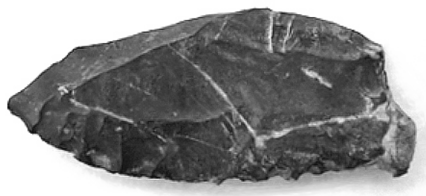
Bob Potter, owner of the Potter site near Randolph, holding a point fragment from a failed fluting attempt.

Although the size of the group has varied over the years, SCRAP generally consists of a core of 50–60 dedicated volunteers. The whole point of the SCRAP program is public education; nonetheless about a third of the participants do end up either becoming professional field archaeologists or going on to graduate school, which helps spread Boisvert's brand of careful, detail-oriented archaeology unto the next generation. "We're quite proud of the SCRAP program," he says. "We do first-quality work, and we've contributed a great deal to the archaeology of New Hampshire."

The secrets of Colebrook

Serendipity can't be ignored as a major player in archaeological discovery, but the truth is that most finds are the result of careful study, the development of complex models, and lots of field testing—which involves hard slogging through all kinds of terrain, and the physically demanding work of shovel test after boring shovel test. Of course, all that's useless if you don't recognize what you've got when you find it. The Colebrook site turned up during a routine gas pipeline survey in 1997. Thanks partly to their SCRAP experience, when several of Edna Feighner's crew identified channel-flake fragments in their shovel tests, they knew they'd found something special. Further excavation uncovered the 11,000-year-old post-molds and hearth that made the site especially interesting.

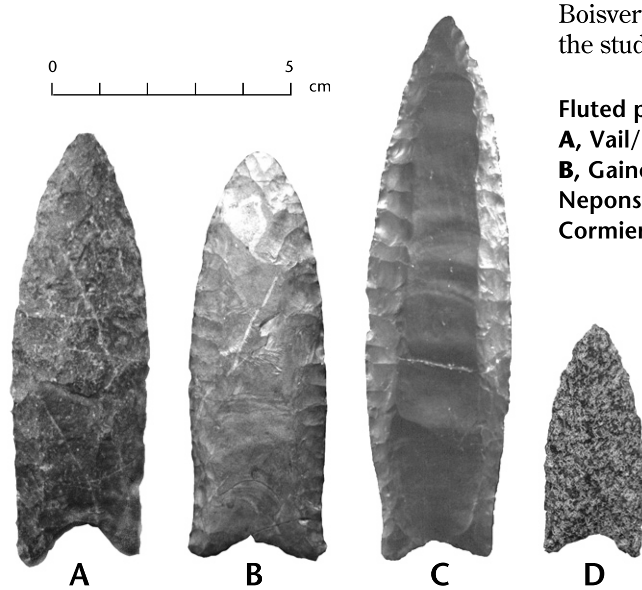
As a result of their findings, the pipeline was rerouted, and the landowners decided to preserve the Colebrook site undisturbed—until 2006, when they allowed Boisvert and Feighner to return and conduct further excavations during that year's SCRAP field school. In the 25 m^2 SCRAP excavated, they found evidence of extensive fluted-point production, including a biface fragment and 73 channel-flake fragments, some of which could be refitted to form whole flakes. No points were recovered; they were apparently carried away for use elsewhere.



An extensively reworked Michaud/Neponset fluted point from the 2004 excavations at the Jefferson II Israel River site, evidence that even 11,000 years ago the occupants adhered to the venerable New England maxim, "Use it up, wear it out, make it do, or do without." The point is 57.73 mm long, 25.33 wide, and 17.59 mm thick.

Colebrook is a small site, perhaps 8 m in diameter, but its value far exceeds its size. "We're reasonably certain that we have four identifiable episodes of tool manufacture here," Boisvert reflects. "Two distinct heavy ones, a pretty good concentration, and a dispersed episode. We're getting down to reconstructing individual behavior 11,000 years ago. I think that's cool, to use technical terminology."

While it's difficult to tell when these different episodes of tool manufacture occurred in relationship to one another, Boisvert suspects that they all took place over a relatively short span of time; in fact, Colebrook may represent a single-occupation site. The lithic technology is clearly post-Clovis, of a subtype called Michaud/Neponset (after sites in Maine and Massachusetts, respectively). The Colebrook people manufactured what Boisvert calls "the Eastern equivalent to Folsom"—long, narrow points with extremely thin, lengthy flutes. "The thing that's really interesting is that you get this multiple fluting—flutes on top of flutes. They were very interested in getting very, very thin bases, driving off thin channel flakes on both sides and then going back for second tries."



Fluted points from New Hampshire: **A**, Vail/Debert style, New Boston; **B**, Gainey style, Ossipee; **C**, Michaud/Neponset style, Conway; **D**, Nicholas/Cormier style, Jefferson.

Impressive as the evidence of fluted-point manufacture is, it's not so unusual for stone artifacts to survive 11,000 years in the ground. What's more exciting is the fact that structural remains survived, specifically a total of 20 post-molds. Finding post-molds is exceedingly rare in the East, given the cool, relatively wet environment, not to mention the opportunity for mechanical destruction due to factors like root growth and animal burrowing. "The post-molds give us some perspective on both behavior and the structure of the site," Boisvert says. Unfortunately, it's hard to point to specific domestic structures based on the post-molds. "Essentially," he says, "post-mold interpretation should be a connect-the-dots operation—but I don't feel like we can connect the dots yet to point toward a particular type of structure. The post-molds may represent something besides domestic structures; say, more on the lines of roasting spits or drying racks. Some are close to hearths, and may be for cooking props or supports. I'd prefer not to come to any judgment until we've conducted more in-depth analysis."

In any case, the presence of the post-molds suggests that people were doing something besides just making stone tools at this riverbank encampment 11,000–11,300 years ago, and it gives Boisvert and his crew something to work with besides the lithics. In addition, some of the features contained identifiable botanical remains, including seeds; a student at Northern Arizona University is writing his thesis on them at the moment. This research is still in its preliminary stages, however, and Boisvert prefers to keep mum about it until the student publishes his results.

Other Paleoamericans in New Hampshire

As intriguing as Colebrook is, it isn't the be-all-and-end-all of Paleoamerican sites in the Granite State; in fact, it represents just one of a number of Paleo sites on Boisvert's plate. For example, since 1996 he and his SCRAP associates have been working at five Paleoamerican sites on the Israel River near Jefferson, New Hampshire, all of which are crowded into a strip of land about half a kilometer wide and a kilometer long. Local archaeologist and SCRAP alumnus Paul Bock identified the first three sites in this archaeologically rich area in late 1995 while searching tree throws for artifacts after an especially fierce storm. The sites, which cover areas from one-half hectare to about four hectares in size, exhibit the full range of Paleoamerican remains known for New Hampshire, starting with post-Clovis Gainey points and continuing on through 1,500–2,000 years of occupation. Oddly enough, none of the sites is located near a water source; Boisvert suspects the occupants were ambushing caribou.

Since 2003, Boisvert has also directed fieldwork at the Potter site near Randolph, New Hampshire; it's located about 12 miles from the Israel River Complex and appears to be related to them,

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Largest-ever Survey of Native American Genes Sheds Light on First Americans

YOUR GENES ARE THE CODE that determines much of what makes you who you are. When interpreted they also can be read as a map revealing the routes followed by your ancestors across the globe and through history.

Sijia Wang, a biologist at University College London, and Cecil Lewis and Mattias Jakobsson of the University of Michigan (Lewis is now at the University of Oklahoma), along with 24 co-investigators, have completed what the group terms the "largest continent-wide Native American population-genetic survey performed to date." The team examined 678 *autosomal microsatellite markers* in 422 individual Native Americans representing 29 distinct populations from the Canadian Chipewyan to the Huilliche of southern Chile as well as a Siberian group. These observations were combined with comparable data obtained from a worldwide DNA sample of more than 1,000 individuals from 53 populations collected by the Human Genome Diversity Project and maintained at the Centre d'Etude du Polymorphisme Humain (Center for the Study of Human Polymorphism).

Autosomal microsatellite markers are short bits of distinctive genetic code, typically consisting of 5–20 copies of repeated sequences of short motifs with a length of only three or four DNA "letters." The variation among individuals in the number of repeated copies of the motif of a microsatellite provides a relatively simple way of gauging relationships between populations and tracking lineages across the ages.

This study of Native American DNA sought to answer a number of questions about the peopling of the Americas: Where did the first Americans come from? Did they originate in Siberia and cross the Bering Strait as the traditional model suggests? Or did they come across the Atlantic Ocean from Europe, or island-hop across Polynesia? Was there a single wave of migration, or were there several, possibly from a variety of different parts of the world? Did the original colonists follow a coastal route spreading rapidly across the Americas, or did they move slowly and methodically through the interior of the continent, perhaps following major rivers?

The results, published in the November 2007 issue of the on-line journal *PLoS Genetics*, shed light on many of these questions and reveal "several surprising features of genetic variation and population history in the Americas."

Genetic diversity

The authors found that Native Americans, as a whole, exhibited much less genetic diversity than was observed in populations from other continents. They have fewer distinct alleles, or variations of particular microsatellite markers, than are found in other populations and, as a result, lower levels of *heterozygosity*. In other words, since there are fewer alleles for a given genetic marker, there is a higher likelihood that an individual will receive identical alleles from each parent.

The 29 American populations included in the study, ranging from the northernmost (Chipewyan, A) to the southernmost (Huilliche, B). The darkest shades indicate the preferred source locations identified for Native Americans, according to the analysis of heterozygosity patterns in the study.

Our chromosomes are made up of pairs of alleles, which are divided up into the sperm or egg cells, so each parent contributes only one allele from each pair to its offspring. When we receive identical alleles from both parents, we are said to be *homozygous* for that gene. If we receive different alleles for a gene, we are said to be *heterozygous*. Heterozygosity, therefore, is a measure of genetic diversity for a population.

Within native populations in the Western Hemisphere, there is a gradient of diversity, with the highest levels in the north and the lowest in the south. The lowest diversity of any population in the world occurs in the isolated tribes of the Amazon basin. This suggests that America's true founding fathers and mothers were a relatively small group of people, which would have limited the potential pool of genetic diversity available to descendants.

Siberian origins confirmed

America's overall low diversity relative to other world populations, coupled with the gradient of decreasing diversity from the north to the south, is consistent with the traditional migration route from Siberia, across Beringia, and down through the Americas. "At each step in the migration," say the authors, "a subset of the population splitting off from a parental group moves deeper into the Americas, taking with it a subset of the genetic variation present in the parental population."

Continuing this process leads to further reductions in genetic diversity with each split, since a subset of a population cannot possibly contain all the variability in the original population. By the time a descendant group reached Tierra del Fuego, it was a subset of a subset of a subset of a subset, etc., of the genetic variability that characterized the original population that crossed originally into this hemisphere.

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The long-appreciated and well-established fact that this epic colonization began in Siberia is corroborated by the observation by Wang, Lewis, Jakobsson, and colleagues that not only are the Native American populations considered in this analysis most similar genetically to Siberians, but that there is a gradient of decreasing similarity to Siberians with increasing distance from the Bering Strait.

Pre-Columbian contacts?

There has been considerable speculation in recent years that the first Americans came in successive waves, not just from Asia via Beringia, but also from Paleolithic Europe across the northern Atlantic or even from Australia via Polynesia. Others have argued for more recent, but still pre-Columbian, migrations of various seafaring folk from all over the Old World to North and South America.

None of these popular scenarios finds support in the genetic data.

According to Wang, Lewis, Jakobsson, and coauthors, the populations considered in this analysis "have experienced little recent European and African admixture." In the context of their paper, this means that there has been no significant interbreeding in the last century or two. These data also substantially refute the pre-Columbian contact scenarios involving European or African groups.

This is not to say that episodes of isolated contact did not occur. Indeed, archaeological evidence has established that Vikings visited northeastern North America for a brief interval beginning at about A.D. 1000. And Polynesians made landfall on the west coast of South America at around A.D. 1350, evidently exchanging chickens for sweet potatoes. These episodes do not, however, appear to have resulted in any significant levels of interbreeding in the populations included in the study.

Multiple waves of migration?

Regarding the question of whether there were multiple waves of migration across Beringia, the answer again appears to be no. Private alleles are variants of genes that are restricted to populations from only one major geographic region. The presence of a private allele indicates a common ancestry for all the groups that share it. Wang, Lewis, Jakobsson, and colleagues studied a Native American private allele that had been described previously by other scientists (**MT 22-4**, "Genetic Discovery Refines Our View of the Peopling of the Americas"). This allele was found in all 29 Native American populations in the study. It has now been observed in every Native American population examined to date as well as in two groups at the far eastern edge of Siberia. According to the authors of the study, the presence of the private allele, in combination with the other genetic data considered, "can be explained most parsimoniously by a single main colonization event." Moreover, the presence of a private allele in American populations also suggests that the founding population was relatively small and that the colonization event occurred relatively recently.

Migration routes

Once the ancestors of Native Americans arrived in this hemisphere, how did they move from one end to the other? Did they pass through the ice-free corridor and hike across the continental interiors, possibly following the main river val-

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leys? Alternatively, did they glide rapidly in boats along the western coasts of North and South America?

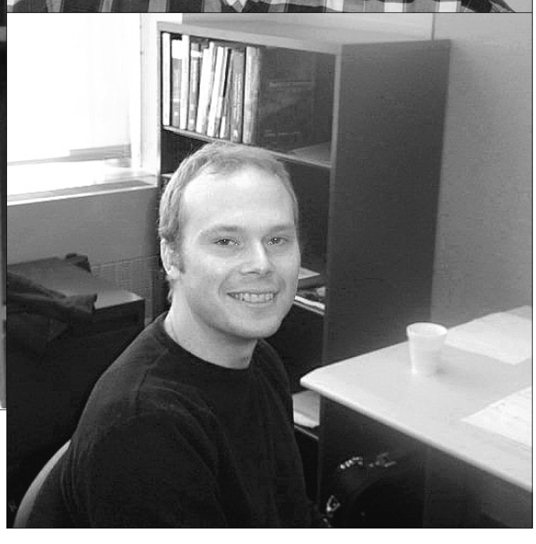
According to Wang, Lewis, Jakobsson and colleagues, there is some degree of correlation between Native American genetic diversity and geographic distance when the model incorporates the higher rate of mobility allowed by coast-skirting watercraft. The authors conclude, therefore, that the genetic data provide some support for the "coastal colonization model."

In South America, the authors conclude that a rapid and early colonization of the coast was followed by a slower dispersal eastward across the Andes Mountains and into the interior by small, less-representative subsamples of the western population. This would explain the close ties between the coastal groups and the gradient of decreasing diversity to the east.

Given this conclusion, it is surprising that the team found no evidence that major rivers similarly channeled early human migrations in the New World. So, while the data are consistent with the idea that boats were used during the early stages of the colonization process, that technology does not appear to have been carried into the continental interiors.

Authors of the survey (*clockwise from upper right*) Sijia Wang, Mattias Jakobsson, and Cecil Lewis.

SIJIA WANG



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Problems and limitations

One limitation of this study is that it sampled only a few hundred individuals from a limited representation of the indigenous peoples of North and South America. It is likely that the data are not fully representative of the genetic variability in this hemisphere. For example, large regions are either poorly represented or not represented at all. The sample included no individuals from groups in Alaska, the western United States and Canada, southeastern North America, or much of eastern South America.

Another limitation of the study is the absence of any effort to incorporate ancient DNA into the sample. Clearly, the living indigenous peoples of North and South America represent only a sample, and likely a biased sample at that, of the biological diversity that existed in pre-Columbian native America. The gene pool became greatly attenuated over time, owing in large measure to European diseases introduced into this hemisphere, which obliterated between 40 and 80 percent of the aboriginal population. For such reasons, it is important to seek DNA from ancient human remains and use these data to supplement what can be learned from living groups. Indeed, the analysis of 5,000-year-old human remains from British Columbia already has disclosed a previously unknown genetic group for America (**MT 22-2**, "Ancient DNA in Canada Reveals New Founding Lineage of Native Americans"). Future work almost certainly will uncover even more variability.

Nevertheless, since the study by Wang and colleagues is the largest investigation of Native American genetic variability conducted to date, its results offer an unprecedented window onto the peopling of the Americas. The broad outlines it reveals aren't likely to be overturned.

Benchmarks of the study

Based on the results of this study, which generally corroborate conclusions drawn from a number of previous analyses of DNA obtained from mitochondria as well as from X- and Y-chromosomes, we are able to draw conclusions about the ancestors of modern Native Americans:

- A relatively small group of Siberians crossed Beringia into North America in the late Pleistocene.
- These people spread rapidly along the west coast of North and South America, possibly using watercraft.
- Daughter groups then appear to have split off from this relatively homogeneous coastal population and moved eastward into the continental interior.
- No genetic evidence was found to support theorized migrations from Polynesia or Europe in Paleolithic times.

Wang, Lewis, Jakobsson, and coauthors conclude their paper with the statement that continuing genetic research, "together with accumulating evidence from fields such as

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THE CLOVIS COMET

Part II: What the Data Tell Us

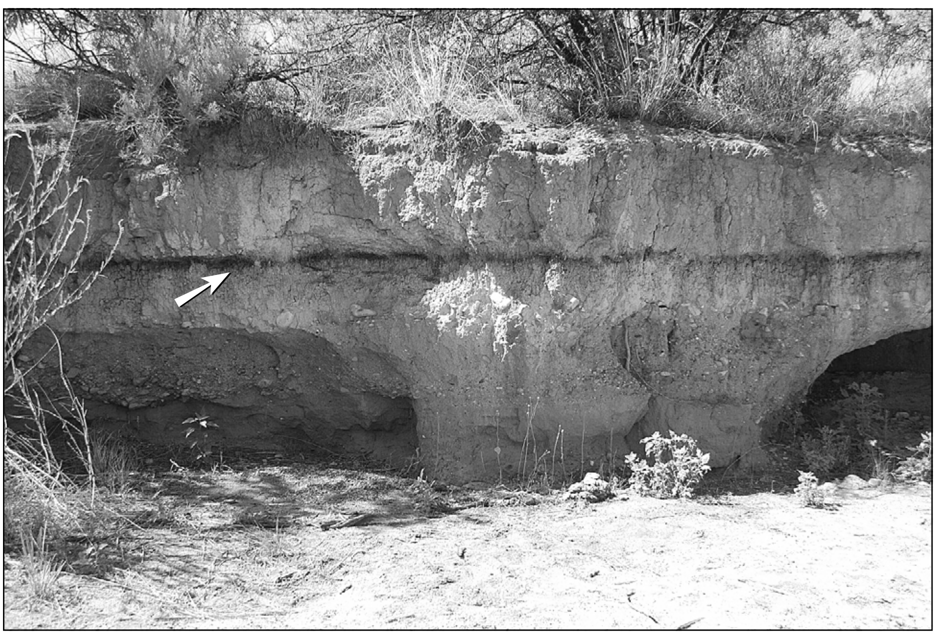
PICTURE AN ENORMOUS DUSTY SNOWBALL tumbling silently through space, broken into thousands of coruscating fragments as it falls prey to another celestial body's gravitational field. Eventually—perhaps thousands of years later—the Earth passes through the densest part of the debris cloud. To observers on Earth, it appears as a nebulous swarm of meteors and comets, inspiring awe and terror in equal proportions—especially when some of the comets fall to Earth. The impacts destroy a human culture that spans the length and breadth of an entire continent, killing most within hours and smothering the rest under a toxic smog that lasts for months. Food becomes scarce, and even when the skies finally clear, it's colder than it was before. It takes hundreds of years for the human population to recover.

That's the grim scenario painted by a multidisciplinary team of researchers who recently published their findings in the prestigious *Proceedings of the National Academy of Sciences (PNAS)*. But despite this cautionary tale, it can't be said that Allen West, Albert Goodyear, and their 24 colleagues are prophets of doom; after all, the disaster they describe occurred during the last Ice Age. If they're correct, it was that event that put an abrupt end to the Clovis people, the first widespread culture in the New World.

In Part I of this series, "The Clovis Comet: Evidence for a Cosmic Collision 12,900 Years Ago" (**MT 23-1**), we introduced you to the Clovis Comet theory. In this installment, we'll take a closer look at some of the lines of evidence that suggest that, for the Clovis people, the world ended in both ice *and* fire.

Clues to doomsday

The evidence that a devastating cosmic event coincided with the beginning of the Younger Dryas cooling interval (and the concurrent Clovis demise) of 12,900 years ago comes in more than a dozen flavors. In Part I of this series, we discussed some of the lines of evidence that



ALLEN WEST

The black mat is clearly visible as a dark band (arrow) running across this exposed profile at the Murray Springs, Arizona, Clovis site.

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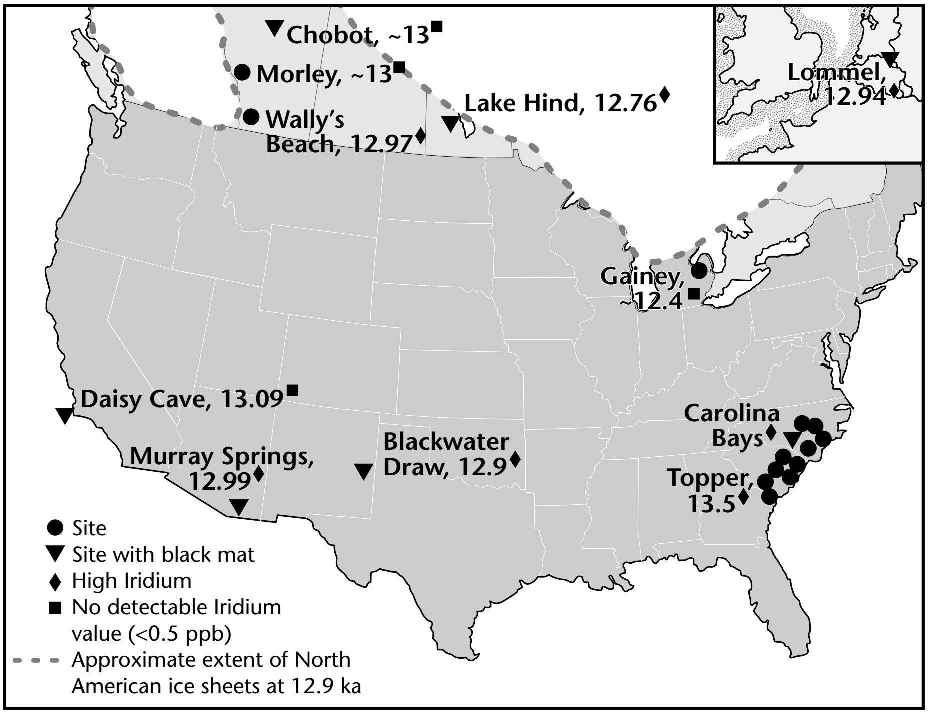
Sites investigated in the study including Lommel, Belgium, with their calibrated Younger Dryas boundary (YDB) dates.



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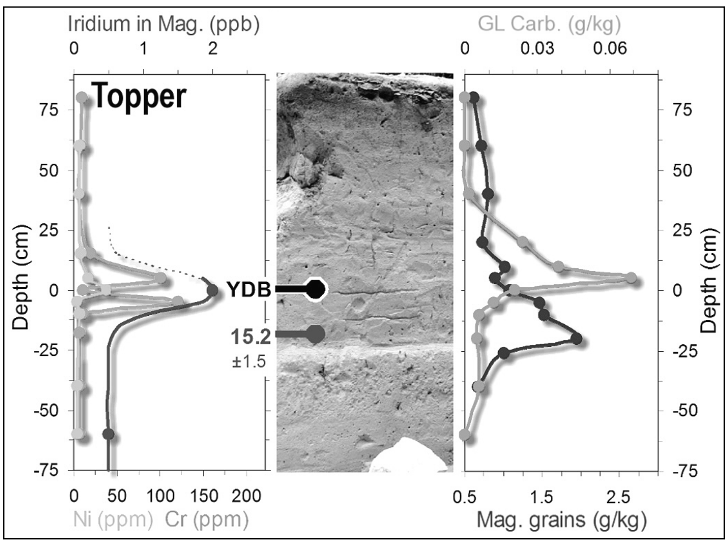
distinguish what the West team calls the Younger Dryas boundary (YDB) at sites scattered across North America. Chief among these are the black mats, dark carbon-rich strata that cap the Clovis sediments at approximately a third of all known Clovis sites (n > 50), as pointed out in a landmark survey by Vance Haynes in 2005.

What the black mats represent isn't entirely clear. Although some or all of them might have been caused by algae blooms, other evidence suggests that the carbon enrichment comes from extensive biomass burning in very hot fires, such as might be ignited by both the thermal pulse and burning ejecta of a cometary strike. Soot, polycyclic aromatic hydrocarbons (PAHs), charcoal, glass-like "vitreous" carbon, and vesicular carbon spherules all peak in the YDB layers of various sites in various quantities; some, like the PAHs and spherules, appear *only* in the YDB layers (though not at all 25 sites examined). Clearly, something caused widespread fires at about the same time across much of North America, and apparently in parts of Europe as well, for there's a black mat of the proper age present in Lommel, Belgium, too. Ice cores from Greenland also yield intriguing evidence of widespread (if distant) biomass burning at the onset of the Younger Dryas. Unusually high levels of ammonium, nitrates, and other chemical burning products have been identified in ice of the appropriate age.

Based only on this evidence, it's easy to conclude that the firestorms might have a variety of explanations, including coincidence. But other key markers suggesting a comet strike have been found in association with the YDB strata at all the sites studied. Among other things, relatively high levels of iridium, nickel, and chromium have been detected in most YDB sediments; there's also iridium and platinum in contemporaneous Greenland ice cores. All four elements are more common in extraterrestrial (ET) objects than they are in the Earth's crust. Iridium alone is present in levels up to 5,000 times greater than background in some of the YDB sediments, whereas it doesn't appear at all in the sediments immediately above or below. While iridium enrichment can occur due to volcanic activity, it does so at much lower levels than have been observed.

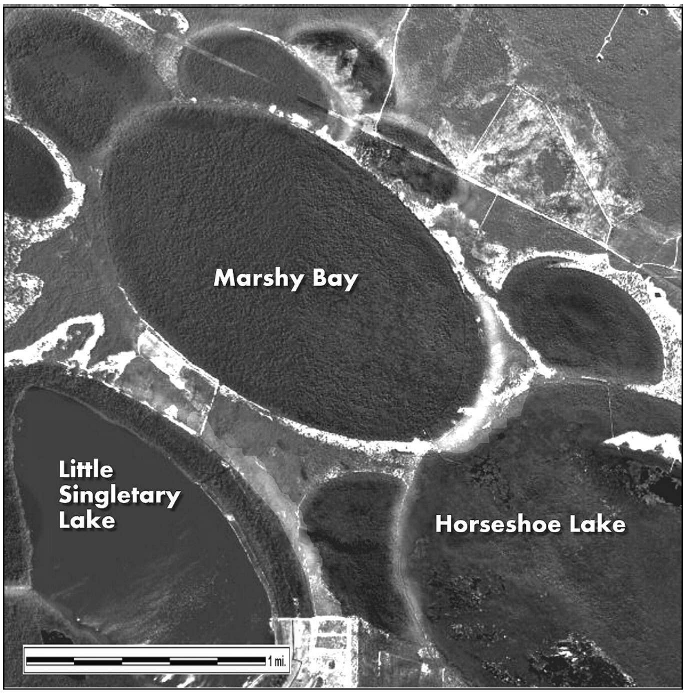
Peaks for several YDB-event markers at the Topper site in South Carolina, including unusually high levels of iridium, nickel, chromium, glass-like carbon, and magnetic grains.



ALLEN WEST

Other markers noted at some of or all the sites include fullerene carbon cages containing helium of a type that doesn't occur on Earth, and a high concentration of magnetic microspherules and grains that are often enriched with titanium compounds. "The spherules can be produced by volcanoes too," West admits, "but those that are don't typically have a lot of iron in them. These spherules are up to 90 percent iron, which is typical of meteorites or cometary fragments that make it thru the atmosphere and burn up." The microspherules have also been identified in the aforementioned Greenland ice cores. And then there are the nanodiamonds—microscopic carbon crystals that are extremely rare on Earth because they're produced almost exclusively by ET impacts. They've been found in substantial numbers in all the YDB sediments tested.

On top of all that, the faunal remains associated with the black mats have, in some cases, been found to be mildly radioactive and slightly magnetized. This was the case for mammoth remains found at the Murray Springs, Arizona, site that were basically "shrink-wrapped" by the local manifestation of the black mat, suggesting that the animal had died no more than a few weeks before the stratum was deposited. The upper surfaces of the bones attracted a magnet and were slightly radioactive, according to West, "but the bottoms were neither magnetic nor radioactive." This is consistent with exposure to a radiation flux, such as might occur when a comet impacts the Earth.



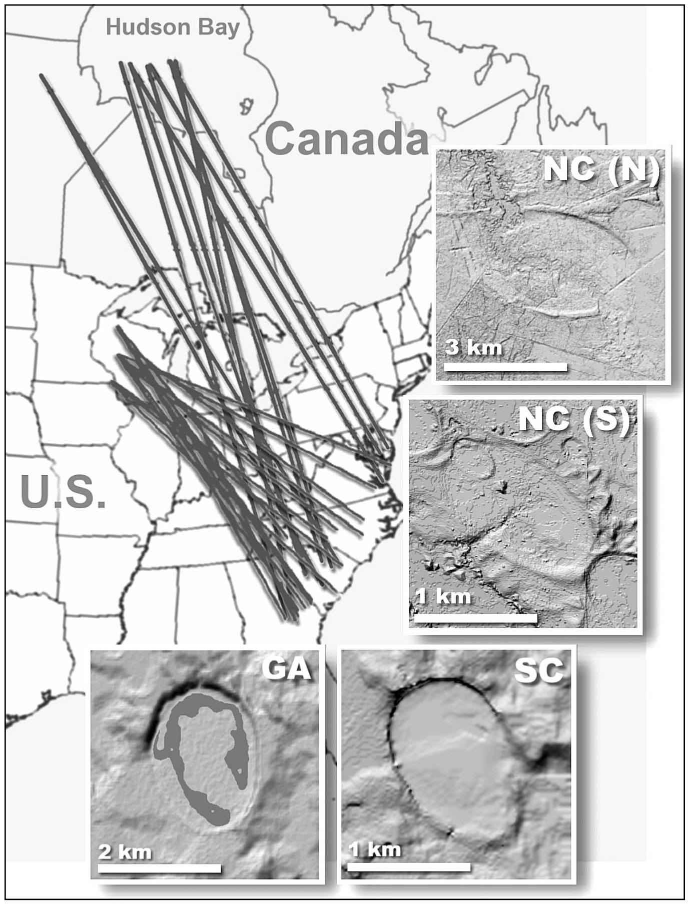
Less convincing, perhaps, are the 15 Carolina Bays that were examined in detail for the *PNAS* study. All yielded impact or thermal markers from sediments of the appropriate ages. These large elliptical depressions on the Atlantic Coastal Plain, all oriented generally toward the northwest, appear to be giant eolian blowout features. While optically stimulated luminescence (OSL) ages collected from the region suggest that the Bays considerably predate the proposed Clovis event, it's possible that the OSL dates are in error and that the Bays may have been scooped out by the atmospheric high-pressure wave resulting from the proposed Clovis impact.

Finally, there's a sudden peak, followed by a well-known minor plateau in the radiocarbon record right around the beginning of the Younger Dryas, suggesting oscillations in the concentration of ^{14}C in the atmosphere. This decrease is generally attributed to a global "overturning" of the oceans that added nonradioactive carbon to the atmosphere, and yet, the "overturning" could have been triggered by the impacts. Also, just before that, there was an increase in the proportion of ^{14}C, which could have been caused by a comet introducing new radiocarbon. "It's not a major uptick and plateau," observes West, "but it makes it difficult to date Clovis and later artifacts, since for a thousand years you get dates that basically look the same."

With the exception of the nanodiamonds (which have only the one known source), none of evidence presented here offers convincing proof of the Clovis Comet theory—at least, not when examined alone. Soot, PAHs, carbon spherules, vitreous carbon, and charcoal can all be generated in hot wildfires, and even the ET items could have been introduced in some other way. But add them all up, apply some deductive reasoning, and you get an excellent (if admittedly circumstantial) picture of an extraordinary cosmic event. "It wasn't necessarily a meteor impact," West admits. "The Earth could have passed through a stream of these microspherules, and the Younger Dryas and the extinctions were a coincidence. There are too many coincidences there, though. People can argue what kind of impactor it was, but we're certain that there must have been one."

◀ An aerial view of a cluster of typical Carolina Bays.

▼ The major axes of more than 100,000 bays in the Southeast all point toward the Great Lakes and Hudson Bay.

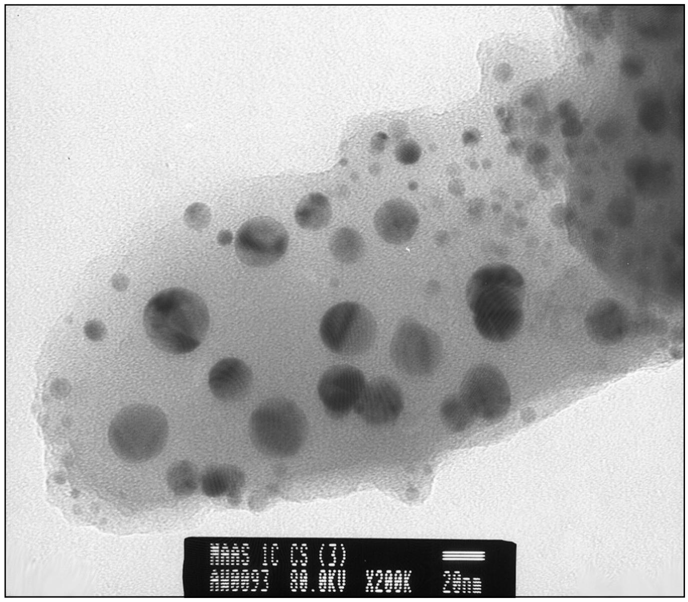


BOTH: ALLEN WEST

What was the Clovis comet?

For their part, West and his colleagues are firmly convinced that the impactor was a large comet; they even have a good idea of the origin of the culprit. The projected orbit passes through the Taurids, a meteor cloud that the Earth encounters every year around late June and early November. The Taurids, Comet Encke, and several known asteroids may all be fragments of a "megacomet" that disintegrated tens of thousands of years ago. "The parent object might have been an icy dustball 4 to 6 kilometers wide before it broke up into thousands or millions of pieces," West speculates. The vast majority of those pieces would have measured 10–20 m across, scaling down to the size of a pea. The fragments have shared the same general orbit ever since, diverging slightly into a cloud of debris that the Earth has periodically plowed through for millennia.

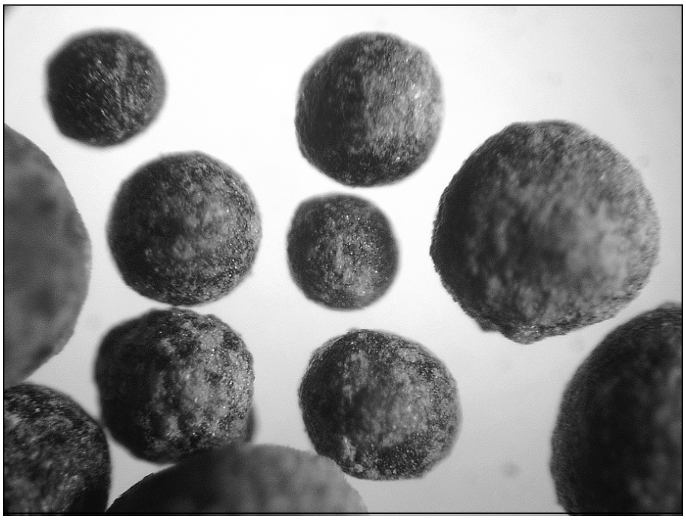
Here's what they think happened 12,900 years ago. As the Earth passed through a particularly dense part of the megacomet debris cloud, it swept up at least one, and possibly several, kilometer-sized fragments. "Some of the fragments might have been like the Tunguska impact, which exploded as an airburst high in the atmosphere, so you might have had a wide area in sky that was on fire, and everything



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.▶

ALLEN WEST

Microscopic carbon spherules from the YDB layer at the Gainey, Michigan, Clovis site. The average diameter is about 50 microns.▼



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under it got cooked," says West. The Tunguska event was apparently caused by a chunk of ice or stone half the size of a football field, which destroyed about 2,150 km^2 worth of forest when it exploded above Siberia in 1908 (see Part I in **MT 23-1** for more details). Multiply that a thousandfold for the YDB event, and it's easy to see that the thermal pulse alone would have devastated the entire North American continent. To compound the injury, some of the fireballs made it through the atmosphere to strike the Earth's surface, apparently on the Laurentide Ice Sheet in eastern Canada; the varying concentrations of impact markers seem to point in that direction (as do the long axes of the Carolina Bays, quite literally), indicating an ejecta cloud that thinned with distance from the impact locality. Any impactor less than 2 km across wouldn't have been able to punch through the kilometers-thick ice sheet, which explains the lack of a detectable impact crater. If it exists, it may lie hidden under the waters of Hudson Bay or the Great Lakes.

The Clovis impact event may have been so traumatic to the survivors that it lived on in human oral tradition for almost 13,000 years. Oddly enough, there's an ancient Native American tradition common to many groups that claims that something (usually a cloud or rock) fell from the sky long ago with disastrous consequences, and that it rained thereafter for up to three months. A comet impact of this magnitude could easily have caused cloudy, rainy weather for months afterward, especially if it impacted the continental ice sheet.

Thank heavens it's over . . . right?

Although the worst danger from the megacomet debris cloud seems to be past—or so we hope—in late 2005 we got a tiny taste of what the Taurids can do to a world. On November 7, two NASA astronomers happened to observe a bright flash on the moon as a Taurid meteor immolated itself. It left a crater more than 10 ft wide. Obviously the impactor wasn't huge, but this proves that sizable chucks of the presumed Clovis comet are still out there—and that we're going to keep encountering them on an annual basis for a long, long time.

Meanwhile, the Clovis Comet research continues. West invites input from other scientists; as he puts it, "We know this theory can be made better, so we're looking for constructive criticism." He also invites skeptics to pay particular attention to the nanodiamonds found at most of the tested sites. As he points out, "No one has convincingly proven that nanodiamonds can form in any way other than by ET impact. While there are some people who are skeptical about the theory, they have to come up with a theory that explains them. "

We'll discuss the further implications of the Clovis Comet impact and its environmental effects in Part III of this series.

–Floyd Largent

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Survey of Native American Genes

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archaeology, geology and linguistics, will surely result in a more detailed picture of the settlement by and differentiation of indigenous human populations in the American landmass."

For more information, check out the original article at **http://genetics.plosjournals.org/perlserv/?request=get-document&doi=10.1371/journal.pgen.0030185**

–Bradley T. Lepper

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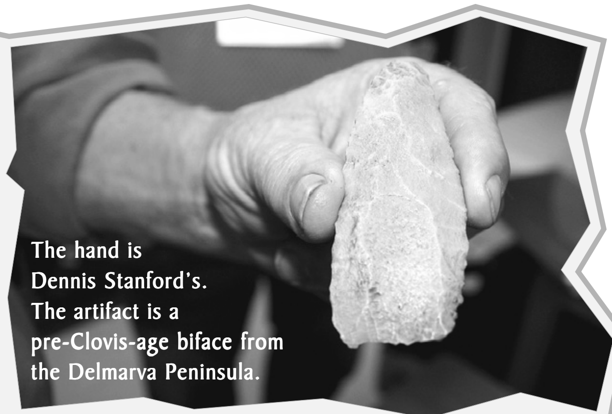
Paleoamerican Origins Workshop



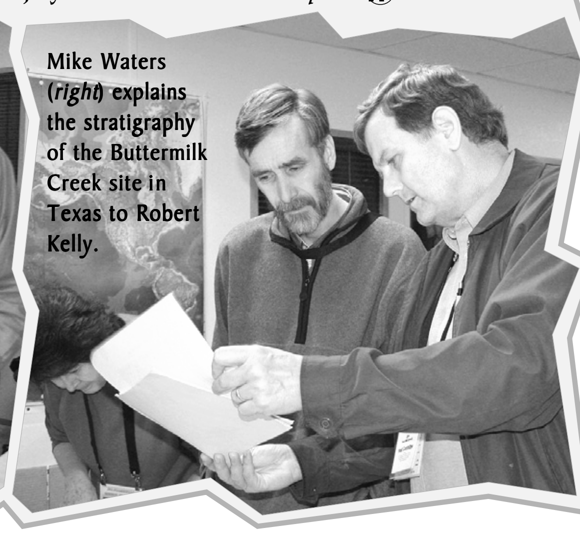
The hand is Dennis Stanford's. The artifact is a pre-Clovis-age biface from the Delmarva Peninsula.

RESEARCHERS FROM AROUND THE WORLD convened February 14–16 at the Texas Archeological Research Laboratory (TARL) in Austin. Their task, made urgent by enormous volumes of data that have accumulated on pre-Clovis discoveries since Monte Verde, was to review existing early occupation sites, to discuss new models for the peopling of the Americas, and to codify rules of evidence for evaluating future discoveries.

During the workshop, sponsored by the Center for the Study of the First Americans, the Southeastern Paleoamerican Survey, TARL, and the Smithsonian Institution, presentations by scientists familiar to *Mammoth Trumpet* readers were followed by intensive and constructive sessions. A galaxy of sites in North and South America fueled discussions, among them Cactus Hill, Hebior and Mud Lake, Manis Mastodon, Page-Ladson, Taima-taima, La Sena and Lovewell Reservoir, Topper, Five Miles Point, Paisley Cave. . . .

Look for the full story on this pivotal 3-day event in the July issue of *Mammoth Trumpet.*

Stuart Fiedel, Ted Goebel, and Al Goodyear (*left–right*) examine artifacts from the Topper site in South Carolina.



Mike Waters (*right*) explains the stratigraphy of the Buttermilk Creek site in Texas to Robert Kelly.

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Boisvert, SCRAP, and Paleoamericans of NH

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at least on a cultural level. Like the specimens from Israel River, dart points found at Potter match those inferred from the channel flakes collected from Colebrook; they all belong to the Michaud/Neponset subtype. Potter is a single-component site, but in this case, single component doesn't mean single use. According to Boisvert, "The Potter site is a patchwork of totally different kinds of artifact concentrations, all located very close together. One reflects woodworking; another biface production, specifically fluting of dart points; and a third, general biface production. We've got three vastly different functions in a site that's basically 100 meters square." In another example of the practical value of the SCRAP program, Boisvert was able to gather a group of 35 volunteers to dig at the site in October 2007—a crew size many field archaeologists would kill for. They were able to complete 1,000 person-hours of work in just 3 days.

Although most researchers don't consider New Hampshire a hotbed of Paleoamerican research—for one thing, the state is exceedingly mountainous, and was still under the ice for centuries after the First Americans arrived—Boisvert is quick to point out that there's still some great Paleoamerican stuff in the Northeast. "People get all excited about the big dead animals in the Southwest," he says wryly, "but we do have some good material here. It's hard to get to—we have these pesky things called trees that get in the way, and we have to work through glacial outwash—but we've got some impressive stuff that we're trying hard to bring to light. There's some first-rate work to be done in New England." Fortunately, Boisvert has the right tools to do the job: an excellent group of volunteers and professionals, with a powerful lever for clearing obstacles: "The asset we have in New Hampshire is the fact that the state is my sandbox. I can direct research anywhere I want in the state. I have to justify it," he says, "but I have remarkable freedom."

Boisvert at the Colebrook site. The dated hearth lies directly in front of him.

He laments, however, that more researchers aren't working in New Hampshire, a fact he attributes to a scarcity of home-grown archaeologists. "We lack graduate programs in northern New England; there are no graduate archaeology degrees to be had in Maine, New Hampshire, or Vermont. Even in the Ivy League schools, the emphasis on local stuff is remarkably thin. Luckily, we've had reasonable success at offering some good data and research opportunities to researchers from elsewhere who want to look at it. It's slow, it's brick by brick, but sooner or later the building gets built." MT

–Floyd Largent

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