MAMMOTH TRUMPET

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Center for the Study of the First Americans
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Unlocking the secrets of Early American toolmakers

Using this calibrated bow, Anthropology professor Michelle Bebber launches shafts at a precise velocity to test the performance of projectile points on impact. Bebber and co-director Eren Metin have made Kent State University a powerhouse of research into Early American technology—they found, for example, that the iconic Clovis fluted point is more resistant to shattering on impact than unfluted points. See our story on **page 5.**

Photo by Kent State photographer Bob Christy

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What Does the Y Chromosome Tell Us about the First Americans?

Part 2: Insights from South America

IN PART 1 OF THIS SERIES, we reviewed recent studies of the Y chromosome that shed light on the Eurasian origins of the First Americans and considered their implications for the Beringian Standstill hypothesis as an explanation for the diversity in Y chromosomes in the Americas. Here in part 2, we look at South America, a vast and understudied geographic region.

The Y chromosome, as readers of part 1 will know, is passed only from father to son, so it provides a record of only the paternal line of inheritance. The Y chromosome nevertheless has the potential to provide important insights into the origins and history of the First Americans.

In 2016, Chris Tyler-Smith, Senior Group Leader at the Wellcome Sanger Institute in the United Kingdom, Stanford University geneticist Carlos Bustamante, the 1000 Genomes Project Consortium, and an international team of 41 other geneticists presented the results of their analysis of 1,244 Y-chromosome sequences from around the world. Their conclusions, published in the journal *Nature Genetics,* with David Poznik from the Program in Biomedical Informatics at Stanford University cited as first author, estimate that the most recent common ancestor of the Y chromosomes they studied lived around 190,000 years ago.

They also determined that humans first entered the Americas around 15,000 years ago, which is consistent with the conclusions of geneticists Shuhua Xu, Hui Li, and their team discussed in part 1 of this series (**MT 35-1,** "What does the Y chromosome tell us about the First Americans?").

New study focused on South America

In 2019, Tyler-Smith, along with Fabricio R. Santos, a Professor of Biology and Evolution at the Universidade Federal de Minas Gerais in Brazil, and a team of 23 other scientists from 9 additional countries studied Y chromosomes from across the Americas and Eurasia to shed light on the genetic history of South America. This previously understudied region is key to understanding important aspects of the peopling of the Americas as a whole. The results were published recently in the journal *Cell* with young and enthusiastic Brazilian scientist Thomaz Pinotti cited as first author.

Tyler-Smith and the team sequenced 20 Native American Y chromosomes from across South America, including 19 selected from haplogroup Q, one of the previously

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The trend of travel, we find, was north to south—but complicated by splits and double-backs.

documented founding male lineages of Native Americans, and one from haplogroup C3, a much rarer haplogroup in the Americas thought to be another founding lineage. They then compared these sequences with 65 Native American Y-chromosome sequences already published, 137 sequences from around the world, and 82 drawn from the literature. These data shed new light on our understanding of the peopling of the Americas.

Tyler-Smith and colleagues identified four principal Y-chromosome lineages: Q-M3, Q-CTS1780, C3-MPB373, and C3-P39/Z30536. Such a small number of lineages may be a result of genetic drift. This would mean that the relatively few individuals who crossed Beringia in small groups carried only a small subset of the haplogroups represented in the source population. These variants would therefore have become the ancestors of all the indigenous American Y chromosomes—not necessarily because the variants conferred any special advantage to the men possessing them, but simply because, by the luck of the draw, they were the variants that happened to be among the small sample of Asian Y chromosomes carried by the men who made the journey to America.

Score a point for the Beringian Standstill Hypothesis

Tyler-Smith and colleagues determined that all the Y chromosomes in their study sample that belonged to distinct C3 haplogroups in America share ancestry with some Siberian C3 samples. They estimate that the Siberian-American part of the C3 lineage formed around 23,100–38,000 years ago.

Whereas Y chromosomes belonging to haplogroup Q are found "in many indigenous peoples of Asia and the Americas," most Native American Y chromosomes belong to the subgroup Q-L54. This subgroup, which also included some Siberians and some northern Eurasians, appeared around 19,000 years ago. Tyler-Smith and his colleagues estimate the "split date of the Native American Q-M3 lineage from the Northern European Q-L804" at 17,000 years ago. They therefore conclude that the population from which the First Americans emerged became isolated sometime prior to 19,500 years ago. Corroborating this timeline, they also identified the purely American lineage, haplogroup Q-CTS1780, which appeared around 17,000 years ago and which includes the Anzick Child (**MT 29-2,** "Clovis child answers fundamental questions about the First Americans"). Consequently, the hypothesized Beringian Standstill likely began at around this time.

Tyler-Smith and his team found that, within the Q-M3 lineage, another previously identified Native American subgroup designated Q-M848 diverged around 15,000 years ago and rapidly diversified into 24 branches, one of which included Kennewick Man (**MT 31-3,** "Kennewick Man's DNA reveals his ancestry"). For Tyler-Smith and his colleagues, this episode of rapid diversification provides "a compelling end date for the Beringian Standstill" and the initial surge of

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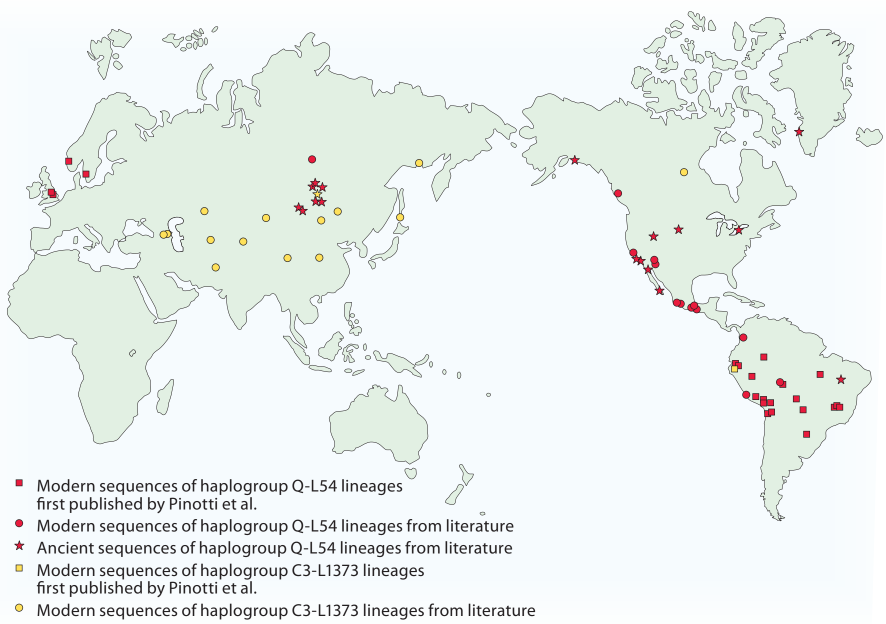
–Michael R. Waters, Director

people into the Americas "perhaps via the ice-free Pacific coast." They characterize this event as "the largest-scale and most rapid demographic expansion in human history after the original out-of-Africa event."



AFTER WEI ET AL. 2018

Geographical distribution of Eurasian and American samples used in this study.

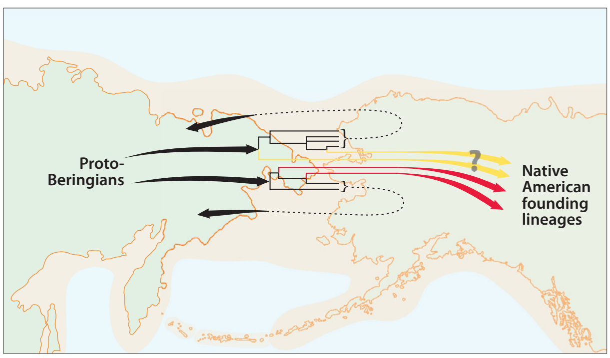
Asia. This scenario finds support in the distribution of some mitochondrial-DNA lineages and in some interpretations of the development and spread of certain languages in Siberia and northern North America.

Swift spread of hatchlings

As the founding population expanded into and through the Americas, they diversified remarkably rapidly into numerous differentiated subpopulations. Tyler-Smith and his colleagues found that between 14,000 and 10,800 years ago, more than 24 Q-M848 sublineages appeared throughout Mexico and South America. This suggests that as a colonizing group settled in its chosen region, it soon became isolated from other groups and began to develop its distinctive genetic identity and culture. Tyler-Smith and his coauthors suggest this may partially explain the "huge diversity of linguistic families" in South America "and the difficulty of establishing relationships between them."

A possible twist in the migration story

Tyler-Smith and colleagues acknowledge another possible sequence of events that could explain the observed Y-chromosome data. They refer to this alternative explanation as the "out-of-Beringia hypothesis." In this scenario, the population isolated in Beringia split. Some groups moved eastward and became the First Americans. Other groups, which migrated westward into Asia, are represented by some of the Q lineages now living in northern Eurasia. This east-west parting supposes an earlier period of diversification in Beringia, corresponding to the divergence of the American, northern Siberian, and European Q lineages at around 19,000 years ago. It also infers that Eurasian lineages Q-L330 and Q-L804 arose in Beringia. The Eurasian Q-L804 and the American Q-M3 lineages split around 17,300 years ago; according to this scenario, that was when they diverged in Beringia or perhaps eastern



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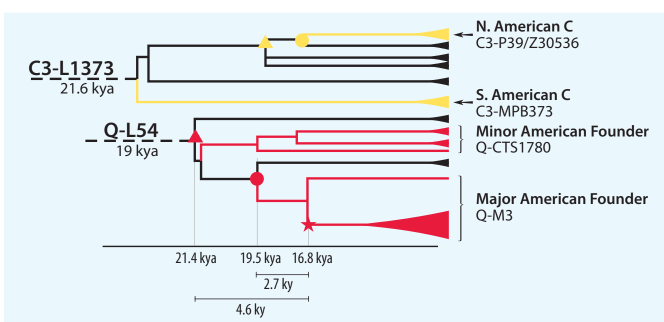
Proposed model for male-lineage expansions out of Beringia. The westward-bound, back-from-Beringia migrations infused altered lineages into the source region, which accounts for very rare paternal lineages now found in Siberian Kets and some northern Eurasians.



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Phylogeny of founding Paleoamerican paternal lineages. The range of confidence intervals for the relevant split dates yields the estimated duration of the Beringian Standstill (2700–4600 yr).

Do the Northern European Q lineages support the Solutrean hypothesis?

Shuhua Xu, Hui Li, and numerous colleagues, writing in the *European Journal of Human Genetics* in 2018, suggested that the "restricted distribution of Y-chromosome lineage Q1-L804 in Northwest Europe might support the Solutrean hypothesis" (**MT-35-1**). I asked Santos what he thought about this possibility. He and first author Pinotti replied that they considered it highly unlikely. For one thing, the distribution of the Q-L804 haplogroup doesn't correlate with the modern distribution of Solutrean archaeological sites. And although no ancient DNA has yet been recovered from a Solutrean individual, ancient genomes obtained from individuals from the preceding Aurignacian and Gravettian cultures as well as the succeeding Magdalenian culture show “no connections to modern or ancient Native Americans.” Finally, since the Q-L804 haplogroup is extremely rare, Pinotti and Santos think it’s likely present as well in northeastern Eurasian populations, but hasn’t yet been documented simply because genetic testing is much less common in this region. Consequently they conclude that “the most parsimonious explanation for the presence of Q-L804 in Northwestern Europe is through gene flow that brought chromosomes from Siberia to Europe.”

Genetic footprints trace the First Americans’ route

Because the Y chromosome is carried only by men, it can’t tell the complete story of the First Americans. Tyler-Smith and his colleagues’ detailed analyses of a large number of Native American Y chromosomes, both ancient and modern, nevertheless yield important insights into the timing of the arrival of the First Americans in this hemisphere. Their results support the Beringian Standstill Hypothesis and fine-tune the duration of the period of isolation to between 2,400 and 4,600 years. This timeframe is perfectly consistent with the estimate of 3,000 years proposed by Xu, Li and their colleagues discussed in part 1 of this series.

Coauthors (*left–right*) Pinotti, Xue, and Tyler-Smith at the Iguaçu Falls in Brazil (visible in the background), September 2018. The coati would love a banana from the green bag.

Most Native Americans belong to the Y-chromosome haplogroup Q and, more particularly, to subgroup Q-L54, which appeared around 19,000 years ago. This lineage includes some Northern Europeans, so it may also include a population that arose in Beringia just prior to the opening of the coastal route into North America. The Q-M3 branch of the Y-chromosome human family tree, which Tyler-Smith and team regard as “most certainly” the lineage “carried by the population that first expanded beyond the glaciers into the Americas,” appeared around 15,000 years ago. Tyler-Smith and his coauthors further propose that the rarer and purely American haplogroup Q-CTS1780, which appeared around 17,000 years ago, might identify a separate movement of people out of Beringia that followed the melting of the Pleistocene glaciers. Perhaps these lineages represent the divergence of Beringian groups, some of which followed a coastal route of entry into the Americas while others chose an interior route (**MT 34-1, -2,** “Along the coast or down the Ice-Free corridor—how did the First Americans get here”).

Finally, beginning around 15,000 years ago, the South American population of Q-M848 haplogroup rapidly dispersed into regionally distinct subpopulations, which over the subsequent millennia developed the distinctive languages and cultures that have been documented by anthropologists.

Large-scale migrations, such as the movement of humans out of Africa and later out of Asia and into the Americas, are turning points in human history. Tyler-Smith, Bustamante, and the coauthors of their 2016 study, in considering factors that may have precipitated such epic expansions, offered a number of possible explanations: technological innovations, such as the introduction of metal tools, that gave human populations new capabilities; social changes, such as the creation of inherited leadership roles, that focused the efforts of larger and larger groups on particular initiatives; or new ecological opportunities afforded by the discovery of large areas of previously unoccupied lands. The expansion out of Africa 50,000–60,000 years ago is the most striking example of populations expanding rapidly into previously unknown territory; and the initial discovery and colonization of the Americas is the second most significant.

The conclusions that Tyler-Smith, Santos, and the coauthors of their 2019 study reached regarding the distribution of Y-chromosome variants in the Americas will be useful in further research on the pre-Columbian history of South America. They are confident that the continued study of ancient DNA “will undoubtedly further change our understanding of the deep history that shaped the present-day biological and cultural diversity of the South American continent.”

–Brad Lepper

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Suggested Readings

Pinotti, T., B., et al. 2019 Y Chromosome sequences reveal a short Beringian standstill, rapid expansion, and early population structure of Native American founders. *Current Biology* 29(1):149–157.

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Clovis toolmaking

To flute, or not to flute

THE BEAUTIFUL FLUTED PROJECTILE POINT, the icon of the Clovis culture, has stirred much controversy over the years among archaeologists searching for the answer to the question, Why was it fluted?

One conjecture argued that flutes sped the bleeding of speared prey, but that evoked the counterargument that fluting was largely overlaid by the shaft and hafting material. Fluting made it easier to haft a point to a shaft, ran another contention, which ignored the fact that toolmakers successfully hafted unfluted points on spears for millennia before and following Clovis. Or perhaps it was just a way of jazzing up the weapon, a sort of artistic frill without any functional purpose.

Although Metin Eren, Assistant Professor of Anthropology at Kent State University and Research Associate at the Cleveland Museum of Natural History, can't disprove this final supposition, that fluting was purely decorative or served some arcane role in pre-hunt ritual, as co-director of the experimental archaeology lab at Kent State and himself a master flintknapper, he has demonstrated that fluting was functional. Moreover, his discovery sparks our enormous respect for the intuitive skills of Clovis toolmakers.

Adapting weapons to new circumstances

Although we have learned much about the speed and scale of human migration into North America, we know little about the technological processes at play. On arriving in unfamiliar territory, early humans could have used or modified tools they developed previously, or they may have found it necessary to develop new tools to deal with new challenges.

Hunter-gatherers of the Clovis culture fall in the latter category. The earliest Clovis projectile points date to 13,000 years ago and are distributed across the south-central and southwestern parts of the continent. "As they spread, Clovis spear points start to change," Eren says. "What we don't know is if they intentionally designed them to adapt to different environments or prey."

Fluting, a risky business

Despite some morphological differences, all Clovis points bear the distinctive flute. A fluted point is a work of art, and the harrowing fact is that detaching flute channels is one of the last operations the toolmaker performs. If the point breaks during fluting, all the time spent shaping the piece is wasted. "I've mastered Clovis technology, and it can take me an hour or hour and a half to make a fluted point," Eren tells us. "That's a big chunk of your day if your point breaks. Time is lost. So why would you risk fluting?" Why, indeed, waste precious time when you're simultaneously colonizing a new landscape—searching for food, learning the terrain, locating toolstone resources, and traveling great distances?

It took Eren and his colleagues, and the advantages of 21st-century engineering expertise, abetted by an arsenal of sophisticated test equipment, to prove that, for Clovis toolmakers, gambling with possible failure was worth it.

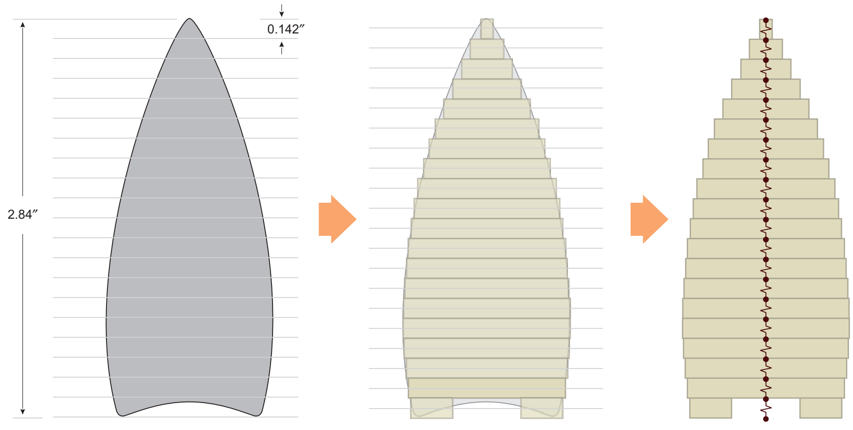
Flutes, a shock absorber

The purpose of the flute, the shallow channel that extends from the base of the point toward the tip on both faces, is to thin the proximal end of the point, especially its base. In theory, a thin stone-tool edge is weaker and more brittle than a relatively thick one. But given the widespread use of Clovis points across time and space, Eren and an interdisciplinary group of colleagues wondered whether that weakness in fact conferred an advantage.

Eren explains that when the point impacts a tree or a mammoth bone, compression between the object it hits and the 8-ft shaft behind it imposes enormous stress on the point. "You're going to get a lot of breakage, but then the very thin

View of the Kent State experimental archaeology lab.

For computer analysis, the model of the point is discretized into 20 slices of equal height and the cross-sectional area of each slice is calculated. Each slice is interpreted as a spring. Load is applied to the simulated model, and stress is calculated in every spring. When a spring is subjected to calculated failure stress, a new simulated model is created with the failed spring deleted, the load is distributed among the remaining springs, and analysis continues. As springs are deleted, the stiffness of the remaining material is affected. In a fluted point, progressive spring deletions are relocated from the tip of the point to the base. In contrast, in an unfluted point the greatest stress always occurs at the portion of the remaining material closest to the tip. Consequently, under stress a fluted point suffers less damage to its tip than does an unfluted point.



base will start to break as well, acting as a shock absorber, sort of like a bumper." Think of collapsing panels in automobiles designed to spend themselves while absorbing the force of collision.

Some crumpling still occurs, which absorbs some of the compression stress and thereby prevents the point from breaking in the middle. The overall effect of fluting is to increase the resilience of the point and extend its lifespan. "That'd be the first North American invention, that shock absorber," says Eren. What's remarkable to him is that it took 21st-century engineering to figure out something that people 13,000 years ago had already figured out.

The benefits of fluting, examined mathematically

For science, it's not enough just to observe things. You have to prove them quantitatively, statistically. Eren's experimental archaeology lab routinely deals with extremely complex concepts like stress distribution and modeling. "We have to collaborate with engineers and physicists because they have a language that describes what we think we're observing," Eren says. "This interdisciplinary work is something archaeologists should have been doing from the start." To understand artifacts as much as possible, he insists that archaeologists "need to understand material science because that's what it is."

Eren flintknapping a Clovis point.

A material object under load—in this case, a Clovis point upon impact—experiences stress. Once stress has reached the failure threshold at a particular location, that portion of the object breaks, or experiences crumpling, and the stress is redistributed.

If the redistributed stress is less than the overall failure threshold, then the object remains intact. If, however, the threshold is exceeded, the object fails. The geometry of the object under stress determines how stress from damage relocates from one place on the object to another, such as from the tip to the base.

Eren's team hypothesized that fluted points withstand higher energies and last longer than unfluted points because stress relocates from the tip to the thinner, brittle basal edge created by fluting.

To test the hypothesis, they conducted analytical and experimental analyses. The results showed that the tip of a point is initially subjected to the greatest stress. As the point deteriorates from crushing, a larger percentage of the maximum stress in the point is redirected from tip to base.

In another analysis, a Clovis point is modeled as tiny springs arranged in series the length of the point. In a computer simulation, each spring represents a portion of the point as it is compressed. When a part of the point is subjected to its predicted failure stress (the stress at which crushing fracture occurs, about 250 megapascals), destroyed material is simulated by deleting a single spring.

In these simulations, spring deletion always occurs at the tip of the point first, which agrees with the predictions. In a fluted point, however, spring deletion is relocated from the top to the base of the point sooner than in an unfluted point. Thus fluted points preserve more of their distal portion under stress than do unfluted points.

By assessing three variables associated with the resilience of fluted versus unfluted points—energy at failure, time at failure, and point length at failure—the team realized that the presence of fluting significantly increases the likelihood of relocating damage occurring on a point. Because damage relocation increases overall resilience of a point in terms of energy absorbed, the time before point breakage, and remaining intact until that moment of breakage, fluting indeed contributes to increased durability.

Was fluting worth the trouble?

The benefits conferred by Clovis lithic technology would have compensated for the steep learning curve and production risks involved in the fluting process. Moreover, Clovis colonizers ranging far from their toolstone sources and in need of sustainable resources benefited from reliable weaponry during the hunt.

Eren hopes that further experiments will consider peripheral variables untested by current models. For instance, Eren's team assumed that the mechanical direction of force on the point is head-on to the tip, but future studies could examine glancing blows or the effect on breaking if the point is rotating in the air. They also plan to examine varieties of Clovis point shapes, like the Debert-style, Vail-style, and Lamb-style fluted points from far northeastern North America, with deeper basal concavities than Clovis points from other parts of North America.

Evolving technologies

Over the centuries, simple fluting evolved into the intricate and riskier process of full-faced fluting. "We haven't tested full-faced fluting yet," Eren says. "I have some hypotheses, though. One is that the manufacturers of these tools were simply showing off. It's the same thing with feathers: When they first evolved, they allowed dinosaurs and birds to glide and fly, but sexual selection can sometimes take over. You get something like a peacock, where the feathers aren't functional; they're just for attracting mates. In that sense, fluting could be governed by sexual selection, where knappers are showing off. It's very difficult for knappers to make full-faced flutes. It shows you're worthy as a mate because you have this skill many don't have. It's costly because it takes a lot of time to get there. I do think there's probably some function to full-faced fluting we haven't yet figured out. You can have functional and sexual selection working simultaneously as well; the two aren't necessarily mutually exclusive."

By late-Paleoindian times, fluting was abandoned altogether, perhaps because later Paleoindians using lanceolate point forms were much more familiar with their landscape and toolstone resources and could afford to design their weaponry for maximum killing potential. "By that point, people have been on the landscape thousands of years. They're no longer colonizers," Eren says. They know where prey is going to be and where the toolstone sources are. In contrast, if you're a colonizer like Clovis, you're in a new landscape, and although you want to make a kill, if your point breaks and you don't know where to find toolstone to make a new point, you're at a severe disadvantage. Clovis had to ensure their points were as durable as possible.

Thousands of years after Clovis, people are "less concerned about preserving their points because they know where the toolstone is. Now they're more concerned with ensuring they're going to make a kill by causing more damage to prey." Owing to the shrapnel effect, a point inflicts more severe injury to prey if it breaks inside the animal. Think of the modern soft-nose bullet for firearms and the dread dumdum bullet of World War I, with an X incised on the tip to ensure its breaking apart on impact. Eren reminds us that sometimes "there's an advantage to having your point break. They don't always need to be durable."

KENT STATE PHOTOGRAPHER BOB CHRISTY

Bebber in the pottery workshop of the experimental archaeology lab.

An exciting way to study technological evolution

Eren and colleagues recently received a National Science Foundation grant for collaborative research on "The role and function in traditional weapon design." The goal of this project is to understand the role that function plays in traditional weaponry design. It will investigate the evolution of Ice Age stone-tool weaponry, dated to 13,500–12,500 years, used by hunter-gatherers in colonizing North America.

Eren's team is looking at Clovis as it moves from west to east across the continent. As the culture moves, the points change in size and shape. Do the changes offer a functional advantage? Are people adapting hunting technology to the specific environment they're in? The team can test that in the Kent State experimental archaeology lab because they have replicas of all the different Clovis styles and can determine how well they shoot, how well they cut. Eren boasts that "in our experimental archaeology lab, we can reverse engineer these things and see whether these different Clovis point shapes endow some sort of functional advantage."

In the experimental archaeology lab, Eren and his team, many of them students, test replicate Clovis points by using them, shooting them, crushing them, all to see if functional differences exist within the technology. They even haft points onto arrows, which they then fire at clay targets with a high-tech projectile launcher while measuring the velocity of different shapes and materials with a speed-timer.

"We can test nearly anything about prehistoric technology in this lab," Eren says. "We can recreate and then reverse engineer virtually any artifact from the last 3 million years of human technology from stone, ceramics, metal, or other material, and figure out how it was made or how it functions." Researchers can't use real artifacts in their tests because they're priceless. The replicas they make, however, are expendable.

The lab contains an impressive ballistics range, a pottery studio, flintknapping area, metal forge, an $80,000 Instron Universal Materials Tester, microscopes, biomechanics equipment, and the list goes on. "We are essentially a materials-science and technology lab that is 100% dedicated to prehistoric technology," Eren says.

Michelle Bebber, co-director of Kent State's experimental archaeology lab, focuses on pottery and metal. "In the lab, I am responsible for the ceramics area, metal-forging area, and for setting up the Instron to run various tests," Bebber says. "Plus, I conduct my own research and advise students interested in pottery or metals research. Most recently, one of my students did a ballistics study comparing Neo-Assyrian bronze arrow points." Between Eren and Bebber, they can cover the full spectrum of ancient tools.

Bebber and student using the Instron Universal Materials Tester.

In a recent article published in *Journal of Archaeological Science,* the two compared the efficiency of copper versus stone projectiles, considering the old copper culture in North America. In this study, they looked at how well a copper point versus a stone point penetrates a target. They have compiled a profile of ballistics data, weight-of-pull of a calibrated bow vs. performance. "We can shoot the same target over and over again to see which tool works better," Eren explains. "So we can do that not only with copper versus stone, but with different styles of stone points. Once we understand how well this stuff works, we can go back to the archaeological record and say 'ok, this group here made this style of stone point. In the next period, they make a point that functions better. Why?'"

Then the team looks to the environmental record and imagines the possibilities; for instance, perhaps there was suddenly a big drought, so there wasn't as much prey on the landscape, and that must explain why points were suddenly better. Necessity is the mother of innovation. Early humans had to make sure they definitely made a kill. But sometimes evolution isn't progressive; it can go the other way.

"They're making one style of tool, and in the next period the style decreases or disappears completely, and then we can say, 'Hmm, why is technology suddenly getting worse?' And we look at the number of sites. Maybe there was suddenly a plague or environmental downturn, with fewer people there, and because of the demographic change, knowledge just wasn't sticking in the population as well," Eren says. Of course, researchers can only make these kinds of inferences if they first understand how the artifacts work.

Returning to the roots of archaeology

For Eren, experimental archaeology brings archaeology back to its roots. He believes that archaeology's principal strength —artifacts—is getting overlooked by sub-disciplines like geoarchaeology and ancient DNA archaeology. He insists that "our strength should be material culture and how technology evolves. I'm not saying we shouldn't have other sub-disciplines, just that our ultimate focus should be artifacts, and the best way to understand them is through experiments."

Although not every archaeologist is doing experimental archaeology, Eren believes every archaeologist should be doing it. "Todd Surovell published a paper in *American Antiquity* about how the archaeological record is a finite resource and we're running out of sites," Eren says, "so the most sustainable way for us to understand artifacts is through experiments. It really is the future." MT

–Katy Dycus

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A Talented Team

Beck & Jones

CHARLOTTE BECK AND GEORGE ("TOM") JONES came to the field of archaeology by very different routes. When their paths finally crossed, perhaps that's why they became such a talented team.

Jones found his fascination early. "I suppose like many archaeologists, my interest in the field began with a broader interest in the past—in other words, an interest in dinosaurs, other strange creatures, and the earlier Earth," Jones explains. "I thoroughly enjoyed my introduction to Earth science in grade school, though we received far too little of it. I've long felt it was a mistake not to place more emphasis on Earth science, because it is that area of science that deals with processes at a scale that everyone can understand, unlike, say, molecular biology. It also introduces children to the world of classification, and for some kids there is nothing more satisfying than knowing the name of something—what to call a substance or some kind of rock."

He remembers that with merely a tantalizing taste of the study of science and particularly anthropology in his early education, a fact he thinks should change for schoolchildren, "when it came time to give college serious consideration, my father and I discussed what I might like to study. I offered a set of conventional options. He reminded me of my interest in anthropology. I never looked back."

Jones admits that he wasn't a great college student. "I've since learned from 30-odd years of teaching that the greatest contribution I can make toward student learning is to place most of the learning in the student's hands. And the best way I can do this is to emphasize writing. Trying to explain yourself on paper is a more assured way of learning than to place the entire burden on 'thinking something through.' "

Beck, Jones's wife of 38 years, tells us that, unlike Tom, she was nearly 30 when she discovered archaeology. She had no idea what to do with her life and quit college after two years. Shortly afterward she went to work for Eastern airlines, although the glamour of being a stewardess wore off fairly quickly. In her sixth year with Eastern she decided to give college another try, juggling two classes a quarter and her flying schedule. As she states in a paper in an upcoming edited volume called *Women in Great Basin Archaeology,* "In the fall of 1973 I enrolled in two classes at Georgia State University, one of which was Introduction to Physical Anthropology. I loved it! I made an A in that class, and when I finished I knew exactly what I was going to do: I would go to graduate school and get a Ph.D. in Physical Anthropology! And from that time on, I was on a mission!" But then, "The next quarter I took Introduction to Archaeology. I loved archaeology!" In the end she chose archaeology and entered graduate school at the University of Washington in 1976. It was there she met Tom Jones, and the rest is history.

"Charlotte and I met in graduate school," Jones explains. "Knowing that we spent seven days a week working together in the lab, people often asked how we could stand to see so much of each other and to work as closely as we did. I can't imagine it any other way. Having a life partner who not only shares your research interests, but also takes responsibility for keeping research projects on track and on pace has been essential for my scholarly development (and I hope for Charlotte's)."

After Beck and Jones received their Ph.D.s, they interviewed for and accepted a split position at Hamilton College in Clinton, New York, a picturesque small town with lots of charm, snow on the ground in winter, and Christmas lights on the square. This should have been an idyllic first teaching job, but the first few years were challenging to say the least. Hamilton students had certain expectations of faculty, and initially their teaching evaluations were mediocre. To make things worse, it was extremely cold that first winter (getting down to -25 degrees), and the adorable little Victorian house they bought, built between 1850 and 1865, had no insulation. Because they had only one salary between them, turning up the heat on their crumbling furnace wasn't an option!

But a small liberal arts school like Hamilton turned out to be the best

ALL PHOTOS: CHARLOTTE BECK AND GEORGE JONES

Charlotte and Tom on San Juan Island off the coast of Washington State, where they taught a joint University of Washington and Hamilton College field school, 1985.

option for these two. "We may not have made it at a major university" Beck says, "because it took us a while to get something published." While at Hamilton, Beck and Jones created an archaeology program that ended up being more like a graduate than undergraduate program. They focused their students on research, eventually giving papers and publishing with some of them, and sending many on to graduate school.

"I was a student of Tom and Charlotte's at Hamilton College in the late 1990s and early 2000s," says Amanda Taylor, now with Willamette Cultural Resources Associates in Seattle. "They shaped my approach to archaeology by immersing a group of us in original research on transporting toolstone in the central Great Basin, interweaving landscape, site, and technological data. They both brought so much excitement and humor to field and lab research and gave just the right amount of support and freedom to engage students in the work. Particular memories that stand out—Tom encouraged my idea to walk the hypothetical route between a Paleoarchaic quarry on an alluvial fan to a habitation site on the valley bottom with the entire field school. Back at Hamilton when we conducted lab work for that project, I remember listening to the radio and talking and laughing with Charlotte while she also taught us the importance of careful, rigorous analysis. One of the most important things Tom and Charlotte taught me was the power of collaboration."

Charlotte gathering seeds from a Joshua tree near Tonopah, Nevada, ca. 2000.

Going against the tide

In 1986, with $2,000 from Hamilton and fees from eight students, Beck and Jones began their research project in Butte Valley in eastern Nevada. "Things were a bit rough," says Beck. "We had to haul in our water and food; the latter was kept in coolers and often spoiled before the week was out. But we made some great dinners on our Coleman stove." The archaeological record in Butte Valley turned out to be of the Late Pleistocene/Early Holocene Western Stemmed Tradition (WST), and it was at that point that Beck and Jones began their focus on Paleoindian archaeology in the Intermountain West.

Tom and their dog, Silas (rescued in Canyon de Chelley when he was four weeks old), at the Sunshine Locality, 1993.

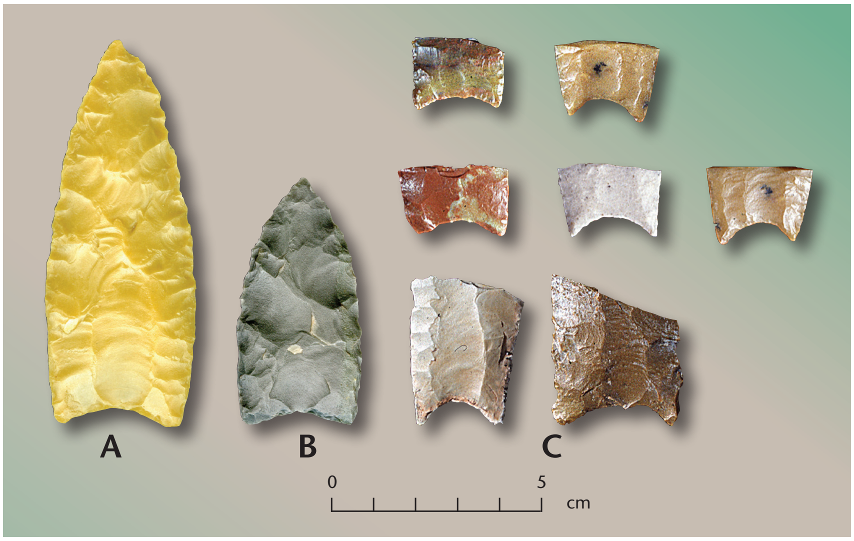
After more than 20 summers of field research on the sagebrush flats of central and eastern Nevada, Beck and Jones have found that the greatest part of its archaeological record of the last 12,000–14,000 years rests on the surface. Only in Long Valley at the Sunshine Locality (**MT 19-4,** "When the camel died, did anyone hear it?") have they recovered materials in stratified context below the surface. Consequently, dating the earliest occurrence of the WST has been a challenge. But Beck and Jones have argued for years that this techno-complex is as old as Clovis in the Intermountain West. Fewer Clovis points have been found in this region compared with areas to the east, and in only seven cases have they been associated with radiocarbon dates, most of which are younger than Clovis dates elsewhere. Some scientists question the validity of these younger dates, but Beck and Jones have argued for some time that Clovis in that region was followed by a late-Paleoindian fluted form that would account for them. They believe that the early record in the Intermountain West contains "extensive evidence of a technology quite unlike that of Clovis, one that spans at least 3,000 years," and that when Clovis people arrived in the area, people utilizing Western Stemmed technology were already there. Although not every archaeologist agrees with their argument, Beck and Jones make a compelling case to support the existence of a technology independent of Clovis in the Intermountain West.

They point out that our knowledge of the age of Clovis is based on surprisingly few well-dated sites and that the radiocarbon dates for Clovis sites don't grow progressively younger from north to south, which we would expect if their forebears entered through the Ice-Free Corridor. The pattern actually appears to be in the opposite direction, more consistent with a southern origin, exemplified by the Debra L. Friedkin site in southeastern Texas. Beck and Jones suggest that people carrying Clovis technology moved from the Southern Plains northward along the Rocky Mountain front, crossed over the mountains, and eventually entered the Intermountain West late in the Clovis period. At some point they likely encountered people with a different technology who had been in the region for at least 1,000 years before Clovis evolved.

"The WST techno-complex is quite distinct from that of Clovis," Beck and Jones explain in a paper published in *Paleo-*

american Odyssey, "and appears to have developed from an as yet unknown antecedent. In the nature of biface reduction, toolstone used, and point morphology, it is very different from Clovis." Patterns of land and source use further distinguish fluted-point and stemmed-point users.

Beck and Jones point to differences in the kinds of toolstone used by Clovis and WST toolmakers. Fluted-point makers strongly preferred chert, while WST knappers used chert principally to manufacture tools such as scrapers, gravers, and crescents. Obsidian when present was used for points, but fine-grained volcanics such as dacite and andesite were also used. Thus, it seems unlikely to Beck and Jones that either technology was an outgrowth of the other. "We don't know what happened when these two groups encountered each other," says Beck. "Clovis appears to have had a short history in the Intermountain West, and the people carrying this technology may have merged with the resident population or have simply become extinct. We just don't know."



Clovis and Sunshine fluted points: A, classic Clovis point from Blackwater Draw, New Mexico; B, Clovis point from the Noyes collection; C, Sunshine Fluted points from the Sunshine Locality.

"It wouldn't have taken long for the two populations to become one," Jones explains. "There are certain advantages to that." He goes on to say "with pre-Clovis sites so widely spread and so rare," Jones says, "it's difficult to imagine how we might gain a clear picture of such issues as the routes by which colonists moved across the Americas and the nature of their adaptations until we have more assemblages for comparison."

Charlotte with Gary Noyes and his daughter, Cindy Warwick, on the gravels of Pleistocene Lake Tonopah, Nevada, 2007. Noyes and fellow avocational archaeologist Phil Hutchinson collected at the Sunshine Locality in the early 1970s. Noyes loaned Tom and Charlotte his entire collection of stemmed, fluted, and unfluted points from southern Nevada for analysis. Noyes and Hutchinson donated their collections to the Nevada State Museum.

The Sunshine Locality

Today the ground surface of this site, with its clumps of sagebrush, saltbush, and winterfat, is peppered with scatters of lithic artifacts, all that is left of the people who occupied a once lush landscape, impoverished by heat and drought over the last 8,000 years. Where marshes and streams once provided a home for ducks, fish, horses, and camels, as well as people, the sediments have been reworked by thousands of years of wind and water. The flat valley floor is a wasteland of filled-in river channels and washes.

More than 850 Paleoindian projectile points have been recovered from this site. At least 15 of these are fluted points, which motivated subsurface testing from 1987 to 1990 by a team from the Desert Research Institute, the Nevada State Museum, and the Bureau of Land Management. This work lead to an amazing discovery. Camel teeth and bones were recovered from a deposit several meters below the surface alongside a single piece of stone-tool debitage. The association offered a tantalizing possibility: If confirmed, this would be the first direct evidence that humans may have hunted camels in the Great Basin during the Pleistocene.

Beck and Jones were asked to take over the research after the deaths of two of the scientists working on the project. Beginning in 1992, when they put in a number of core holes in an attempt to locate a buried deposit, they spent five summers at the site. In 1995 they discovered bones of another camel. Two distinctive artifacts, a stemmed point and a scraper, were also found in the alluvium, although not in the same context as the camel. Because the camel bones and artifacts were recovered from alluvial deposits, Beck and Jones had to grapple with the possibility that the artifacts or bones—or both—had been washed into position by a vigorously flowing braided stream. They tested the grain size of sediments in relation to artifact size and found they were strongly correlated. Although they couldn't rule out that some of the artifacts may have been transported by the stream, most of them seemed to come from near the top of the gravel beds, suggesting an occupied surface. They had hoped to find cut-marks on the camel bones but were unsuccessful, thus making it impossible to demonstrate an association between the bones and humans.

Beck and Jones noticed that the collection of fluted points recovered from the surface of this site, as well as one recovered from the excavation, were smaller and thinner than Clovis points, which led them to suspect that they may represent a post-Clovis fluted point as is the case with Folsom in the South-west and Plains and Gainey in the Midwest. They did an extensive analysis of these points, measuring basal width, basal concavity depth, maximum width, maximum length, thickness, and front edge angle, whether flute scars occurred on one or both sides, and the toolstone used. With these comprehensive data in hand, they found that all but one of the points from the Sunshine Locality were narrower, thinner, shorter, and more gracile than Clovis points found in the Great Basin. They recently conducted a much more extensive analysis of 462 fluted points from all areas of the Far West, about half of which turned out to be the more gracile fluted form rather than Clovis. They believe these results demonstrate beyond doubt the presence of a post-Clovis fluted form in the Far West and have proposed the name *Sunshine Fluted* for it.

Excavating the "Deep Pit" at the Sunshine Locality, 1993.

The Future

"From the moment I was introduced to mammoth and bison hunters in a North American prehistory course," Jones says, "I thought there could be no better way to practice archaeology than to learn all I could about the environments of those early people and how they lived their lives. This doesn't mean I didn't explore other topics, other culture histories. But when I took a lunch-break tour of a pluvial-lake terrace during our first field season in eastern Nevada and discovered a scatter of Western Stemmed Tradition bifaces, I was hooked. My enthusiasm for this general topic has persisted because the associated methodological problems are so much fun to work through."

Beck and Jones are now retired and living in Santa Fe, New Mexico. Like many archaeologists of their vintage, they have compiled significant datasets over the years. Their future centers largely on completing monographic treatment of these data and reporting the field research that produced them.

In 2009, Beck was diagnosed with Parkinson's Disease, but she feels fortunate that it is the slow-progressing kind, and she is still doing pretty well. As she states in her *Women in Great Basin Archaeology* paper, "There was a lot of good in my life and I have a lot to be thankful for. For one, I was so lucky to find Tom. He has been, and still is, my soul mate and the light of my life. It has been such a positive thing that we have worked and published as a team in conjunction with our marriage."

Says long-time colleague Donald Grayson, Professor Emeritus at the University of Washington, "Charlotte and Tom have helped to place stemmed-point occupations of the Far West at the heart of debates over the processes involved in the peopling of the Americas. That's a huge accomplishment, based on decades of field and lab work, and represents only a part of what they have done."

– Martha Deeringer

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How Early Were Humans in the Americas?

The View from the Cerutti Mastodon Site

A RESEARCH LETTER in the 27 April 2017 issue of *Nature* introduced the partial skeleton of a mastodon (*Mammut americanum*) to the general public. Even though the bones were well preserved, such a specimen wouldn't normally have caught the attention of Europe's foremost scientific journal. What intrigued the editors was the authors' claims—and the evidence provided to back them up. The authors had documented evidence that some of the remains had been deliberately broken and modified while they were still fresh, interpreting it as the result of human activity. They'd also obtained a firm age for the locality from a U.S. Geological Survey geochronologist (and one of the Letter's authors), using a reliable new dating method. All this would have been palatable to the scientific community, except for one enormous problem, as revealed in the title: "A 130,000-year-old archaeological site in southern California, USA." The site was nearly eight times older than the earliest generally accepted record of human occupation of the Americas.

The ensuing firestorm of criticism was even more scathing than expected.

An intriguing find

The Cerutti Mastodon (CM) first came to light in mid-November 1992, during the routine monitoring of a highway expansion project in San Diego County by paleontologist Richard Cerutti (who sadly passed away at age 78 on November 5, 2019, while this article was being prepared). After spotting bone in a backhoe excavation, Cerutti stopped the project for a closer look. By the time Thomas Deméré, then Curator of Paleontology at the San Diego Natural History Museum, arrived later that day, "Richard had found material he knew was mastodon," Dr. Deméré recalls. "We found tusk material, as well as sharply broken bones with old breaks." A caliche rind that had formed over the bones, including the breaks, indicated the breaks hadn't been caused by construction activity, as caliche typically takes thousands of years to form. The locality was also unusual in that the bone scatter included a large stone cobble in otherwise fine-grained sediment.

Cerutti and others had previously collected Ice Age dire wolf, camel, horse, ground sloth, and mammoth from the general area. "This stood out as something different," Deméré notes. "At that point, we hadn't collected a mastodon. This was actually the first time we'd gotten a great terrestrial Pleistocene fossil with vertebrae, so we were pretty excited."

Among the remains of the sub-adult male was a tusk buried upright in previously undisturbed deposits. That was one of the first hints the CM site wasn't just paleontological. The backhoe had clipped the tusk's upper end, and had damaged a few other skeletal elements as well as the cobble. The equipment-caused damage on the bone was obvious, Deméré reports, and didn't resemble the sharp breaks and notched bones they would later observe; for one thing, the equipment-caused breaks had no caliche rind. Deméré and Cerutti spent the first few days at the site exploring and collecting loose material before sweeping the stratum clean to reveal untouched deposits. They then established a datum-and-grid system, preparing for controlled excavations.

Deméré and his crew were eager to obtain external expertise and opinions to ensure they were doing the work correctly, so they contacted recognized authorities, including archaeologist/paleontologists Larry Agenbroad and Jim I. Mead, both of whom briefly worked at the site. They obtained a National Geographic Society emergency grant to fund the work with Dr. Agenbroad and Dr. Mead; the remainder of the work was funded by CalTrans and a small amount of private funding. The team proceeded to dig back into the undisturbed Pleistocene strata located up to 3 m below the surface. Although all the units in the sandy silt they called Bed E were excavated by hand, on half the site they had to use heavy machinery to remove the overburden to expose that deposit. In all, they excavated about

SAN DIEGO NATURAL HISTORY MUSEUM

Close-up of the femur heads. South is toward the top of the photo.

50 m^2 to a depth of 20–30 cm, the maximum thickness of Bed E.

Ultimately, 14%–15% of the mastodon was recovered. The picture that emerged over the five months of fieldwork was unexpected. Given the nature of the bone breaks, the vertical tusk, and other anomalies, the site looked decidedly archaeological as well as paleontological. “To me,” Deméré explains, “the most dramatic evidence for human presence is the sharply broken, spirally fractured, and in some cases impact-notched limb bones, the vertical tusk, and five large cobbles in this fine-grained stratum.” The andesite and pegmatite cobbles show evidence of impact damage, which the CM team interpreted as use wear, suggesting they were employed as hammer- and anvilstones to break the bone for extracting marrow and preparing bonestock for tools. Two separate cobbles were each surrounded by concentrations of fractured bone and teeth, some of which could be refitted. “Fragments of one rock were found dispersed over a two-square-meter area within one of the bone concentrations,” says Deméré. “We were able to fit some of the broken rocks together with the main clast, which was discovered three meters away.”

A stone cobble (*center*) in situ at the Cerutti Mastodon Site, surrounded by broken and unbroken mastodon bones. Note the detached side-by-side femur heads in the lower right.

SAN DIEGO NATURAL HISTORY MUSEUM

Two detached femur heads were found in the concentration side-by-side, one face up, the other face down.

Finding no signs of abrasion on the breaks, the team excluded fluvial action as the culprit. Furthermore, Bed E was fine-grained and part of a fining-upwards stratigraphic sequence, indicating a low-energy depositional environment. The presence of fragments of bone and teeth of all sizes in direct association with the anomalous cobbles also seemed to exclude fluvial transport. Deméré asserts that “none of it was likely to have happened geologically.” Furthermore, no gnawing damage was observed on the bones. In any case, as Deméré points out, no Pleistocene carnivore could have broken a fresh mastodon femur at mid-shaft. Nor did the bones appear to have been affected by trampling.

The excavators documented the site and its contents thoroughly, aware they would get a lot of pushback when they published. They had an estimated age of 120,000 CALYBP for deposition of Bed E, based on relative dating. Bone samples submitted for radiocarbon dating lacked enough collagen to date, suggesting great age. Later, optically stimulated luminescence (OSL) dating of Bed E sediments conducted in the early 2000s yielded an age of at least 60,000 years. They realized most

Dating the Cerutti Mastodon

Before the advent of radiocarbon dating in 1950, most ages for prehistoric localities were rough estimates because the dating methods used were relative ones. That is, the finds were assigned an age after comparison to geological strata, artifacts, or fossils of a known age, or to a geological process that took a well-established amount of time to complete. Needless to say, these dating methods were sometimes difficult to apply and provided only a general idea of the age of a site.

That changed when we entered the Atomic Age. An unexpected by-product of our new understanding of radioactivity was the realization that all the radioactive isotopes of natural elements decay into “daughter isotopes” at a constant rate. The amount of time it takes for an isotope in a sample to decay to half its initial magnitude is called its “half-life.” The half-life of Uranium-238 (the most common isotope of uranium, with 238 protons and neutrons in its nucleus) is 4.5 billion years. The half-life of Carbon-14 is 5730 years.

This is important because most materials, whether geologic or organic, start out with a specific amount of the isotope in question after the site is formed, and typically will not absorb any more of that isotope. Over the ensuing millennia, the isotope decays at a reliable rate, making it useful as a molecular clock. For living things, the C-14 clock starts ticking the moment something dies. So if an organic sample contains only one-quarter (two half-lives) of its original reservoir of C-14, it's approximately 11,460 radiocarbon years old. Beyond an age of about 50,000 years, however, radiocarbon dating is unreliable because there's not enough C-14 left to measure. This is why it was necessary to use uranium-thorium (U-Th) dating to establish when the Cerutti Mastodon was buried. The CM researchers had already estimated an age of 120,000 CALYBP using relative dating, but wanted to check and fine-tune it.

In years past, U-Th dating was used almost exclusively to date speleothems and corals; only recently has it been sufficiently refined to use on other materials. The method Dr. Paces used measures Uranium-234 content against its Thorium-230 decay product. The process is complex, involving the spiking of the samples with other radioactive isotopes of uranium, a strict purifying process that involves evaporating purified salts onto rhenium filaments, then detecting various isotope ratios by means of mass spectrometry. Ultimately, Paces determined a final age by observing the degree of “secular equilibrium” between Th-230 and U-234. Secular equilibrium occurs when the amount of decay rate of an isotope is equal to its production rate.

Paces processed and studied more than 100 subsamples of CM bone, then calibrated the results using new statistical models that take into account diffusion, absorption, and decay of uranium in bone. In 2015, he reported his conclusions that the Cerutti Mastodon was buried 131,000 ± 9400 years ago, with a standard 95% measure of confidence. MT

– Floyd Largent

scientists would reject the site based on its apparent age alone, so they continued marshalling evidence and biding their time until they got a professional archaeologist and geochronologist on board, and a more precise dating method came along. Meanwhile, experimental research on fresh elephant bones by archaeologist Steven Holen and others, using a large hammerstone and anvilstones comparable to the cobbles found at the CM site, produced very familiar breakage patterns on both the bones and the stones.

SAN DIEGO NATURAL HISTORY MUSEUM

A sharp spiral fracture on one of the Cerutti Mastodon bones after caliche has been removed; internal view above, external surfaces below.

By 2015, the CM team had cracked the dating issue. In 2011, they sent several bone samples to Dr. James Paces at the U.S. Geological Service, withholding the suspected date. The preliminary results yielded an age consistent with what they'd already surmised. Over the next few years, Paces subjected his CM samples to a newly refined uranium-thorium dating method, before concluding the bones were 130,700 ± 9400 years old (see sidebar). The CM team soon began preparing their manuscript for submission to *Nature*.


SAN DIEGO NATURAL HISTORY MUSEUM

Cerutti (*left*) and Deméré at the San Diego Natural History Museum in 2017.

A withering response

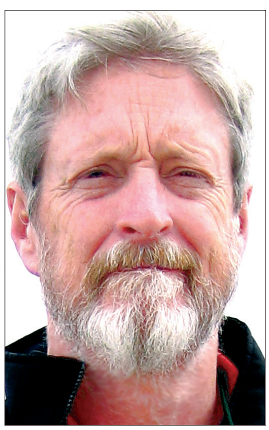
Steve Holen, director of research at the Center for American Paleolithic Research, served as the letter's senior author. In 2017, as it went to press, he told team members to expect criticism, saying, "We want people to be critical." Deméré also welcomed a constructive, scientific debate—which he believes they didn't get. Responses came fast and hard, some downright offensive. The *Los Angeles Times* called the response "archaeology as blood sport."

As expected, many of the critics found the age of the CM site a deal-breaker. Even the late Larry Agenbroad had told Deméré years before that he'd have no trouble accepting the material as archaeological—if it weren't so old. Others rejected the site because it lacked definitive lithic artifacts. Deméré's response: "The insistence that there have to be manufactured stone tools for it to be a human site . . . isn't always reasonable when you're not butchering." (The bones bear no evidence of cutmarks.)

A few commenters have offered alternative explanations for observed phenomena. Although some seem absurd, most seem reasonable to observers on the sidelines. Construction equipment passing overhead and causing damage that mimicked spiral fractures in bones imbedded in moist, malleable strata is a favored hypothesis. One construction engineer also suggested the cobbles were pushed by heavy equipment into Bed E, where they then broke the bones.

One of the leading skeptics of ancient human activity at the CM site is archaeologist Gary Haynes, Foundation Professor of Anthropology, Emeritus at the University of Nevada, Reno. "I was given an advance copy of the article by science reporters from a number of web and print media," he recalls, "so I saw it before publication. My first reactions after reading it were: This isn't well enough thought-out, and who on earth were the peer reviewers who let this slide by?"

In his June 2017 response in *Paleoamerica*, Haynes concluded that while the authors of the Letter did make a "plausible" case for hominins breaking mastodon bones so long ago, the claim needs testing. He went on to note that evidence for human behavior at the site wasn't adequately supported, and that the authors of the original letter needed to provide a much clearer description of the site stratigraphy, while better exploring the potential effects of construction activities on the bones. "The lack of recognizable artifacts or broken bones which had been worked into standardized forms makes me wary of accepting claims about this site," Haynes says. "However, even more of my skepticism comes from the fact the authors didn't try to eliminate all other possible explanations for the bone breakage, and instead ascribed it to human actions." Haynes emphasizes that earth-moving equipment, which can weigh 15 tons or more, has been known to break fossil proboscidean bones in deeply buried waterlogged sediments. "This enormous weight could distort sediments and bend or crush the bones enclosed in them, making spiral fractures, notched edges, and other features mistaken for the results of human actions," he contends. Nor does he believe the CM team ruled


UNIVERSITY OF NEVADA, RENO

Haynes.

out natural breakage caused by fluvial action and mud flows.

Deméré disagrees, pointing out that his team did adequately rule out other hypotheses, including the results of debris flow, animal trampling, carnivore activity, high-energy fluvial action, and more. The remains were found in what the CM team interprets as a low-energy back-swamp area, and all the above factors leave characteristic marks on bone, tend to sort objects by size and density, and damage the smaller ones first. "We don't see that. Heavy bones with cortical thicknesses of up to 1 cm are broken, but lighter bones like ribs aren't. We have both large and small bone fragments in concentrations near the cobbles. The small bone fragments include percussion flakes. A third molar was broken into two pieces separated by two meters and displays a flake scar, with pieces of enamel found here and there—one with a very sharp edge, sharper than bone." He also points out that many of the bones show fracture patterns typical of fresh bone breaks, and that the caliche rinds on the broken surfaces show that this breakage occurred in the past, not recently.

Frustration revisited

For Steve Holen, the Cerutti Mastodon controversy invokes unpleasant memories of an eerily similar predicament in which he found himself ensnarled almost 20 years ago. The bones of contention in that instance were mammoth bones found at the La Sena site in Nebraska and a mammoth skeleton—later found to be two skeletons—eroding out of the bank of Lovewell Reservoir in Kansas (**MT 23-1,** "Early mammoth bone flaking on the Great Plains"). Excavations at the reservoir revealed many pieces of spirally fractured and flaked adult mammoth limb bone. Not only had the bones been broken when green, one artifact of bonestock bore polish from use wear. Holen

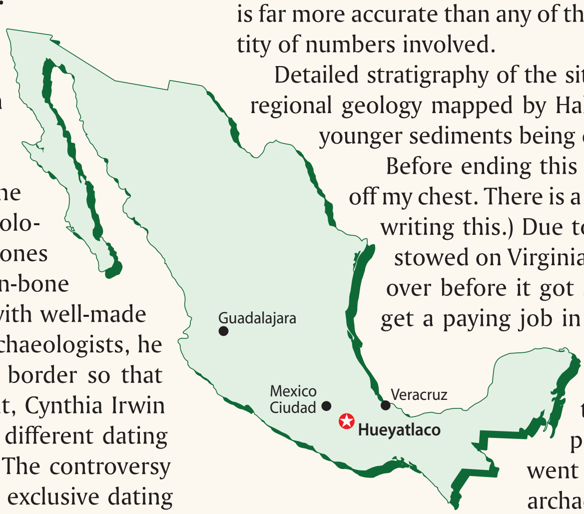
continued on page 20

An Even Older Site?

The Hueyatlaco site in Mexico has long been one of the most controversial sites in the Americas. This site was first investigated by Juan Armenta Camacho and later by Cynthia Irwin-Williams, both now deceased. The site was reinvestigated by Roald Fryxell, Harold Malde and Virginia Steen-McIntyre, and again in 2001 by Harold Malde, Virginia Steen-McIntyre, Marshall Payn and other scientists. Here, Virginia Steen-McIntyre and Marshall Payn, the last surviving members of these later investigations offer their viewpoint on this enigmatic site and point out the need for more work at the site.

We presume that most of you have heard of the Hueyatlaco archaeological site on the north shore of the Valsequillo Reservoir, south of the city of Puebla, east of Mexico City. But perhaps you have not heard the whole story.

Professor Juan Armenta Camacho of the University of Puebla, a self-taught field archaeologist, noticed early on that some of the fossil bones he was collecting showed cut marks, green-bone fractures and inscribed artwork associated with well-made stone tools. Ignored for years by Mexican archaeologists, he was able to interest scientists north of the border so that Harvard sent the promising graduate student, Cynthia Irwin down to work with Juan. Various experts in different dating methods were called upon to date the site. The controversy was when were humans there. Five mutually exclusive dating methods were used.



1 C-14. Which showed nothing but should have shown something had the site been the expected age of 10k–20k years with no extenuating circumstances—but no.

2 Fission- track dating on zircon crystals from overlying volcanic ash layers by Chuck Naeser dated the Hueyatlaco site to be in the lower 200,000's. Chuck was the geologist who dated Africa's Olduvai Gorge, dates universally accepted by both historians and anthropologists. He published his findings in the appropriate journal and waited for the same throng of excitement generated at Olduvai. Nothing.

3 Co-author Virginia Steen-McIntyre developed the new dating technique of tephra hydration which measures the extent of hydration and super hydration and the degree of weathering of a certain heavy mineral. Rough age: 250,000 years.

4 Diatoms. Sam VanLandingham, considered by some of his co-workers to be the world's leading authority on diatoms was invited to examine the site. Many of these microfossils are catalogued to have existed within certain known periods of time, making the Hueyatlaco site at least 220,000 years old.

5 Uranium-Thorium Helium tests by Ken Farley at Cal Tech developed a minimum site age of a shocking 400,000 years! Every person involved in dating Hueyatlaco agrees that this last method is far more accurate than any of the others due to the sheer quantity of numbers involved.

Detailed stratigraphy of the site mapped by Roald Fryxell and regional geology mapped by Hal Malde prevent any notions of younger sediments being deposited at a later time.

Before ending this note, I'd like to get something off my chest. There is a dark side to archaeology. (Payn writing this.) Due to the smirking and ridicule bestowed on Virginia Steen-McIntyre her career was over before it got started. She was never able to get a paying job in her profession; she was never even able to get an interview. Nothing in writing but the word was out. This was the plight of a young scholar who went against the grain of traditional archaeological thought. MT

–Virginia Steen-McIntyre and Marshall Payn

Suggested Readings

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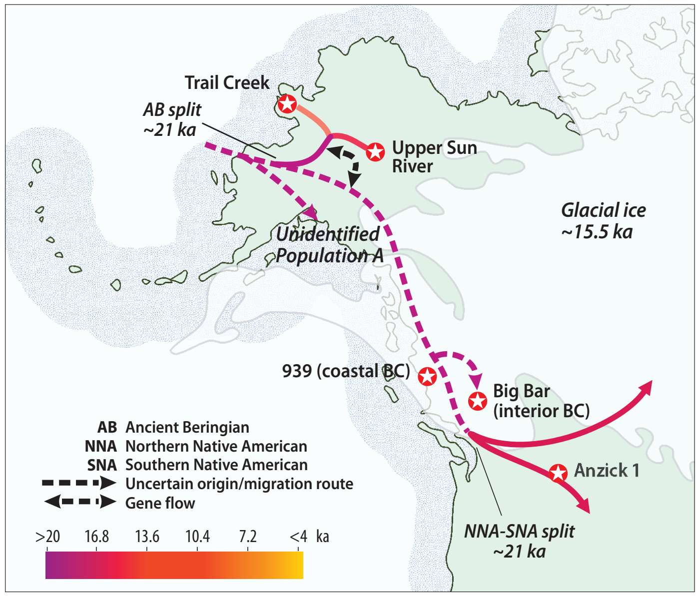


Following the initial entry first into eastern Beringia, then into unglaciated North America ~25 ka to ~13 ka, multiple splits occurred: UPopA and Ancient Beringians split from the NNA+SNA line; the ancestral population of Big Bar in interior British Columbia split from NNA+SNA; the NNA and SNA split south of eastern Beringia. NNA groups remained in northern North America; SNA groups dispersed across the North American continent.

ALL GRAPHICS AFTER J. V. MORENO-MAYAR ET AL., SCIENCE 10.1126/SCIENCE.AAV2621 (2018).

Genetics Studies Reveal Rich History of Ancient America

Part 1

IN RECENT YEARS, studies of the DNA of both ancient and modern Native Americans have given us tremendous insights into the origins and migration histories of the first Americans (**MT 33-2,** "Genetic insights into the First Americans," and **MT 34-2,** "Beringian child's genome reveals the founding population of the First Americans"). It has been established, for example, that Native Americans diverged from Siberian and East Asian populations around 25,000 years ago. In addition, we now know that Native Americans diverged from Ancient Beringians about 22,000–18,000 years ago. Subsequently, the Native American family tree separated into two branches, Northern Native Americans and Southern Native Americans, about 17,500–15,000 years ago. There are, however, many still unanswered questions. Two papers, both published in 2018, go a long way to providing at least tentative answers to many of these questions and clarify our understanding of the earliest chapters of Native American history.

The first paper, published in the journal *Science*, combined the efforts of 54 coauthors representing 11 countries and at least 2 tribal nations, the Shoshone Tribe, and the Stswecem'c/Xgat'tem Band, Dog Creek First Nation. Led by Eske Willerslev with the Natural History Museum of Denmark, David Meltzer with Southern Methodist University, and Yun S. Song with the University of California, this team focuses on understanding the "broad patterns in the dispersal, divergence and admixture of people throughout the Americas."

The second paper, published in the journal *Cell,* reports the work of 72 coauthors from 13 countries. This team, led by David Reich of Harvard Medical School and Johannes Krause with the Max Planck Institute for the Science of Human History, focuses on reconstructing the population history of Central and South America over the last 11,000 years. Together, these papers provide a window of unprecedented clarity and richness into the history of the first Americans.

In this 2-part series, we will review this new research and the insights it provides on the seemingly ever more complicated and dynamic history of the peopling of the Americas. Part 1 is devoted to the paper by Eske Willerslev's team, which looks at the entire hemisphere and has as first author Victor Moreno-Mayar. Part 2 focuses on South America and the paper by David Reich's team, which has as first author Cosimo Posth.

The sample of genomes

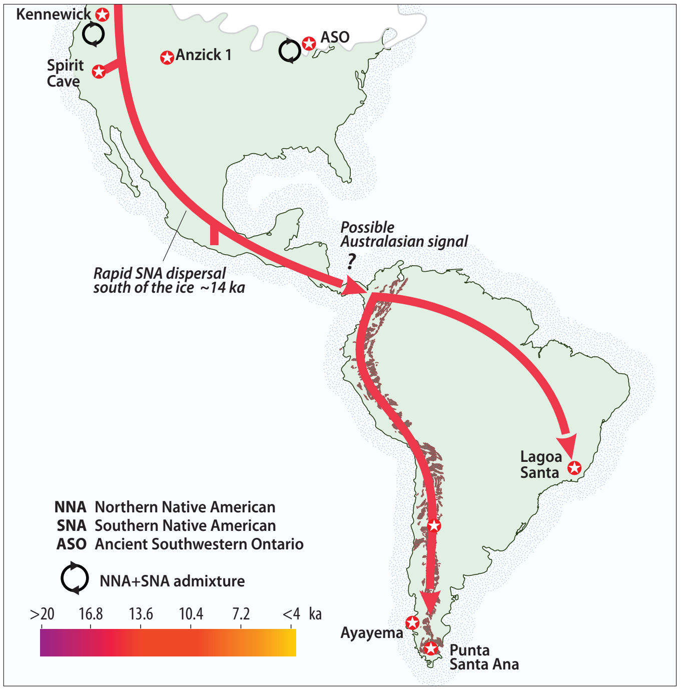
Willerslev and his colleagues obtained genome sequences from 15 ancient human remains from across North and South America. These included, generally from north to south, Trail Creek Cave 2 in Alaska, which dates to about 9000 yr B.P.; Big Bar Lake in British Columbia, about 5600 yr B.P., Spirit Cave in Nevada, about 10,700 yr B.P.; Lovelock Cave, also in Nevada, 2000–600 yr B.P.; Lagoa Santa, Brazil, 10,400–9800 yr B.P.; two individuals from Punta Santa Ana in Patagonian Chile, about 7200 yr B.P.; two individuals from the Ayayema, also in Patagonian Chile, about 5000 yr B.P.; and an Incan mummy from Argentina, about 500 yr B.P.. In addition, they sequenced the genome of a 19th-century Andaman islander to examine the possible Australasian connections to the first Americans documented in previous studies (**MT 32-1,** "Genetic clues answer fundamental questions about the peopling of the Americas). From this large and geographically diverse dataset, Willerslev and his team have given us our clearest picture yet of the peopling of the Americas.

Willerslev and his team recognize that an essential component of all genomic studies involving ancient and modern Native Americans is consultation with the indigenous groups "linked to the ancestral individuals" being studied. It also is important to include, whenever possible, representatives from these groups on the actual research team. In this case, the list of coauthors includes Len George representing the Fallon

Paiute Shoshone Tribe and Harold Harry representing the Stswecem'c/Xgat'tem Band of the Dog Rib First Nation.

Rapid spread of Southern Native Americans through the Americas

The split of the ancestral Native American population into the Northern Native Americans and the Southern Native Americans appears to have occurred south of eastern Beringia. Following the split, the Southern Native Americans spread rapidly throughout the Americas. As part of that rapid movement into an entire hemisphere with varied ecological challenges and opportunities, descendant groups began to diverge both biologically and culturally. Willerslev and his colleagues determined that Mesoamericans, the "most deeply divergent group," populated South America on either side of the Andes Mountains.



During hemisphere-wide dispersal (~14–6 ka), SNA moved rapidly from North America into South America, which accounts for the close affinity between the nearly contemporaneous Spirit Cave and Lagoa Santa individuals. Early South American populations possibly carried an Australasian-related admixture, as seen in the Lagoa Santa individual. SNA colonizers diverged west and east of the Andes. An admixture in North America of NNA and SNA groups prior to 9 ka formed the population that fathered Kennewick/Ancient One. After 9 ka (the age of the Trail Creek Ancient Beringian individual), it appears that NNA groups moved north into Alaska.

Another part of this rapid spread and development of discrete local populations was a series of "complex admixture events between earlier-established populations." This is indicated by the fact that the Lagoa Santa individuals, members of the Southern Native American branch, nevertheless share the same mitochondrial haplogroup as the Anzick child, which means, of course, that somewhere along the line they share a maternal ancestor. Moreover, Spirit Cave Man is also a member of Southern Native American branch, and within that branch, he is most closely related to the Anzick child, whereas the Lagoa Santa individuals are more closely related to the southern Southern Native American branch groups. Statistical analyses indicate, however, that the Anzick, Spirt Cave, and Lagoa Santa individuals are more closely related to each another than to the Mesoamerican Mixe, whose ancestors appear to have interbred with a previously unknown group of ancient Native Americans whom Willerslev and his coauthors refer to "Unsampled population A." This somewhat mysterious group split off from other Native Americans around 25,000 years ago—almost 8000–10,000 years before the split between Northern and Southern Native Americans. Willerslev and the colleagues point out that the timing of this split in the Native American family tree "overlaps with the inferred split of Native Americans from Siberians and East Asians," which occurred 26,000–24,000 years ago.

The fact that these events occurred so close together in time, and apparently before humans spilled out of Beringia southward, suggests to Willerslev and his team that "multiple splits" may have taken place in Beringia and that some of the divergence into separate populations may already have begun by that early date.

Willerslev and his coauthors propose that the Anzick child/Spirit Cave Man branch of the Native American family tree split from the Lagoa Santa/Mixe branch by around 14,000 years ago, perhaps as the Lagoa Santa/Mixe branch of the population was moving southward. Regardless, the expansion of groups southward must have been "very rapid"—at least as archaeologists measure the passing of time—with groups spreading across North America in a "matter of centuries" and on into eastern South America "within a millennium or two."

The Australasian connection and Paleoamericans

The term *Paleoamerican* refers to ancient American human remains that share certain features, such as a long and narrow skull with a small, projecting face that appeared to distinguish these people from modern Native Americans. Examples of human remains that have been identified as Paleoamericans include Kennewick Man, Spirit Cave Man, and the Lagoa Santa individuals. One popular interpretation of these differences has been that the Paleoamericans represent an earlier migration of humans from Australasia, which was largely replaced by the ancestors of modern Native Americans.

This interpretation has a number of problems, but the most daunting is that Spirit Cave Man's DNA contains no Australasian genetic signal. The Lagoa Santa individuals, however, along with the modern Surui from Brazil, who, it's worth noting, don't share the characteristics of "Paleoamericans," do have traces of this Australasian signal. Willerslev and his colleagues write that "the fact that the Australasian genomic signature was present in Brazil 10.4 ka, but absent in all genomes tested to date as old or older and further north, presents a challenge in accounting for its presence in Lagoa Santa." That puzzle, however, doesn't alter the fact that all the Paleoamericans whose genomes have been sequenced "are genetically closer to contemporary Native Americans, than to any other ancient or contemporary group sequenced to date."

The analyses of Willerslev and his team indicate that the genomes of most modern South Americans are a mix of Lagoa Santa and Mesoamerican DNA, with one exception. The DNA of the Ayayema from Patagonian Chile, which dates to 5000 years ago, shares none of the Mesoamerican-related ancestry. This suggests that either the group bearing the Mesoamerican genes didn't arrive in South America until after 5000 years ago, or that the groups and its descendants never made it as far south as Patagonia.

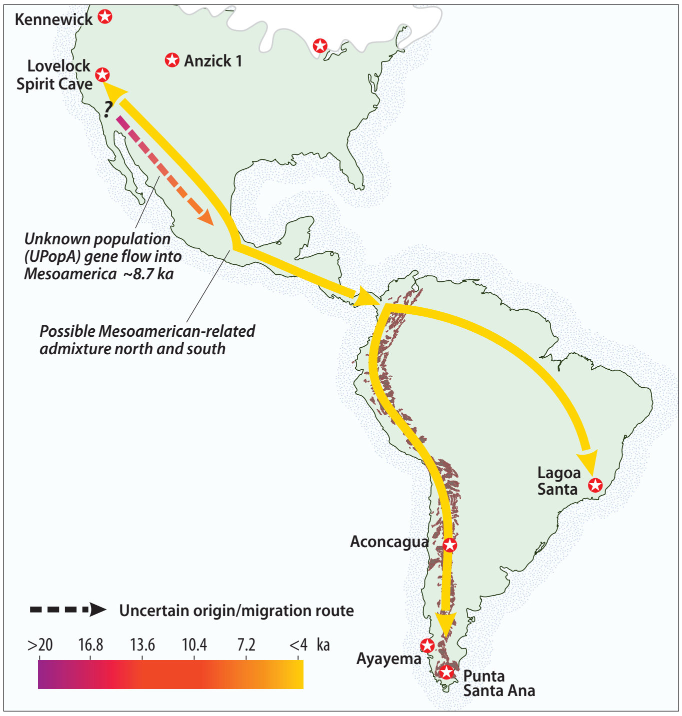
With regard to the Australasian ancestry of Lagoa Santa and the modern Surui, Willerslev and his colleagues suggest that while the Australasian genomic signature may have been more widespread across South America in the Pleistocene, it is now concentrated in eastern South America for reasons that, for the present, aren't understood. One possible explanation offered by the team is that there may have been more Mesoamerican admixture with groups on the western side of the Andes.

The Pacific Northwest—a history of admixture and isolation

In their analysis of ancient and modern Native American populations in the Pacific Northwest, Willerslev and his team observed significant genetic differentiation between these groups and other North American populations; and this differentiation, though established early on, was retained in some cases into the modern era. For example, some long-term continuity is reflected in the fact that the genomes of the ancient individuals from coastal British Columbia clustered with those of contemporary Athabascan and Tsimshian groups. In addition, Kennewick Man was found to be closely related to modern local indigenous groups (**MT 31-3,** "Kennewick Man's DNA reveals his ancestry"), although he derived some of his ancestry from a Southern Native American–related source. Similarly, the Ancient Southwestern Ontario group also was found to have intermixed with a Southern Native American group that diverged after the Anzick-related group split off and before the admixture with a Mesoamerican group occurred.

The genome of the ancient individual from Big Bar Lake was a surprise. Although closely related to Northern Native Americans with no recent Siberian admixture, a detailed analysis suggests that the individuals from Big Bar represent a previously undetected group of Native Americans that diverged sometime after their split with the Ancient Beringians, but before the split between North and South Native Americans.

Willerslev and his coauthors thus characterize the population history of the Pacific Northwest as a complicated tapestry of admixture between the Northern and Southern Native American branches and early isolation between groups living along the coast and groups living in the interior.



In the population expansion out of Mesoamerica sometime after ~8.7 ka, groups moved north into the Great Basin, resulting in a population turnover after 2 ka, attested by the difference between Lovelock individuals: Mesoamerican admixture is absent in the Lovelock 2 individual (~1.9 ka), but is present in the Lovelock 3 individual (~0.7 ka). The expansion southward contributed to the ancestry of most South American groups, but hadn't reached Patagonia by 5.1 ka, the age of the Ayayema individual.

First Americans had a complex and dynamic history

Willerslev and his team's detailed genomic studies of a large number of ancient and more recent individuals from across North and South America provide unparalleled insights into the peopling of the Americas. They showed that once routes out of Eastern Beringia became available, Native Americans rapidly spread through North and South America. This process "gave rise to multiple populations, some of which are visible in the genetic record only as unsampled populations," such as the group represented by Big Bar in the Pacific Northwest and the "Unsampled Population A."

In summarizing their conclusions regarding the peopling of South America, Willerslev's team concluded that, soon after moving into the continent, the ancestral South Americans "diverged along multiple geographic paths," which resulted in several more or less distinctive regional populations. Later, in the middle to late Holocene, another independent migration arrived, reflected in the Mesoamerican ancestry of many South American groups. Subsequent admixture among the first arrivals and later immigrants diluted much of the Australasian genomic signature that may have been present in the earliest populations. The origin of this Australasian contribution to Native American genomes remains something of a mystery.

Willerslev and his team concluded that "overall, the degree of population isolation, admixture, or continuity in different geographic regions of the Americas after initial settlement is poorly understood." They stress that more genome sequences from the late Pleistocene and early Holocene are needed, but the new ancient genomes reported in their paper fill several gaps in time and geography and represent "valuable anchor points that reveal the human population history of the Americas."

The team acknowledges that future research may reveal that this history was even more complicated than it now appears. Perhaps the biggest unresolved questions surround the pre-Clovis occupation of the Americas. Archaeological evidence for these earliest of Americans establishes that they were here, but, so far at least, we have no ancient DNA from any pre-Clovis human remains. Willerslev and his colleagues observe that "how these various population threads may ultimately come together, and how these populations were related to Native Americans past and present, remains to be resolved."

–Brad Lepper

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Suggested Readings

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The Cerutti Mastodon

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was prepared to declare the site the scene of a bone-flaking expedition by Clovis toolmakers collecting bonestock, but that was before a fragment of mammoth limb bone, notched by impact as if by a hammerstone, returned a radiocarbon date of 18,250 ± 90 RCYBP! Likewise, the evidence at La Sena, the completely disarticulated skeletal remains of an adult male mammoth scattered over an area of more than 200 m^2, dated to 18,440 ± 145 RCYBP.

Holen, a careful scientist who was fully aware of the significance of the early dates and of the reception he could expect from the scientific community when he announced his discovery, tried to anticipate every objection that could be raised. Could overlying sediments have splintered the bones? He could point out root etching that confirmed a shallow burial. And even though the La Sena mammoth was once buried under 10 m of loess, only two bones, both ribs, had been broken by sediment loading. How about animal trampling or carnivore gnawing as the agent of breaking? Renowned European archaeologist and taphonomist Paola Villa found all bones "very robust, not brittle and resistance to breakage. . . . I have seen no cutmarks and no gnaw marks."

Holen, himself convinced, failed to convince the scientific community that hunter-gatherers walked the Plains with mammoth 8,000 years before Clovis.

Earlier than we think?

If the Cerutti Mastodon has been correctly interpreted by its advocates, then who were the true First Americans? "I would never make even a wild guess," says Haynes. "I'd first like to see empirical evidence of the kind(s) of hominins potentially entering the Americas so long ago—in other words, taxonomically identifiable hominin bones." The Cerutti Mastodon can't provide such proof, but Deméré and his colleagues remain convinced that only humans could have modified the mastodon remains in the ways observed. If so, the most likely candidates are Denisovans, Neanderthals, or *Homo erectus*. Anatomically modern humans had yet to leave Africa 130,000 years ago.

The evidence remains intriguing. Currently, however, the general consensus is that the CM team hasn't proved the mastodon's association with any branch of humanity. As Haynes puts it, "The claim about this site hasn't been proven completely wrong, but it hasn't been adequately supported—and cannot be accepted as correct."

Deméré and his team realize that one site does not a paradigm make; nor are they out to rewrite the (pre)history books. But they stand by their conclusions. When it came to either hiding their findings or opening them up to public debate, they chose the latter—because as scientists, they knew it was the right thing to do.

– Floyd Largent

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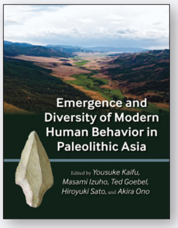

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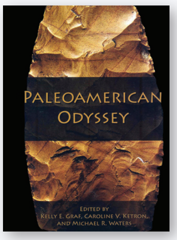

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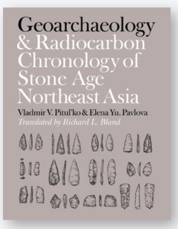

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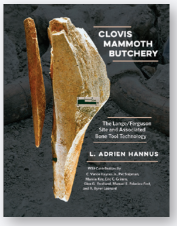

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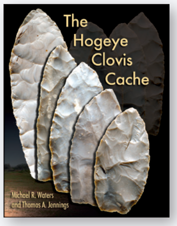

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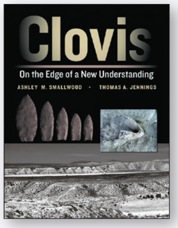

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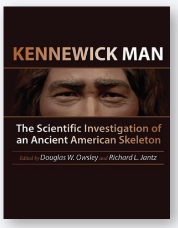

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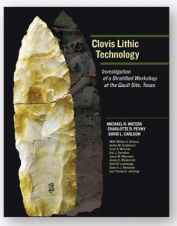

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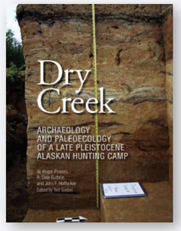

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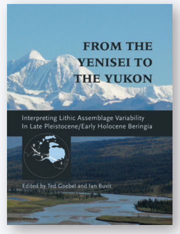

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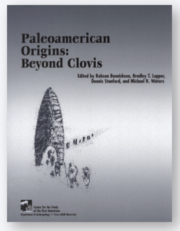

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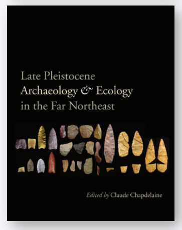

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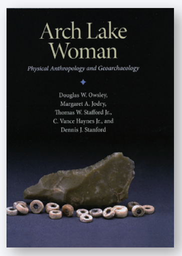

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