MAMMOTH TRUMPET

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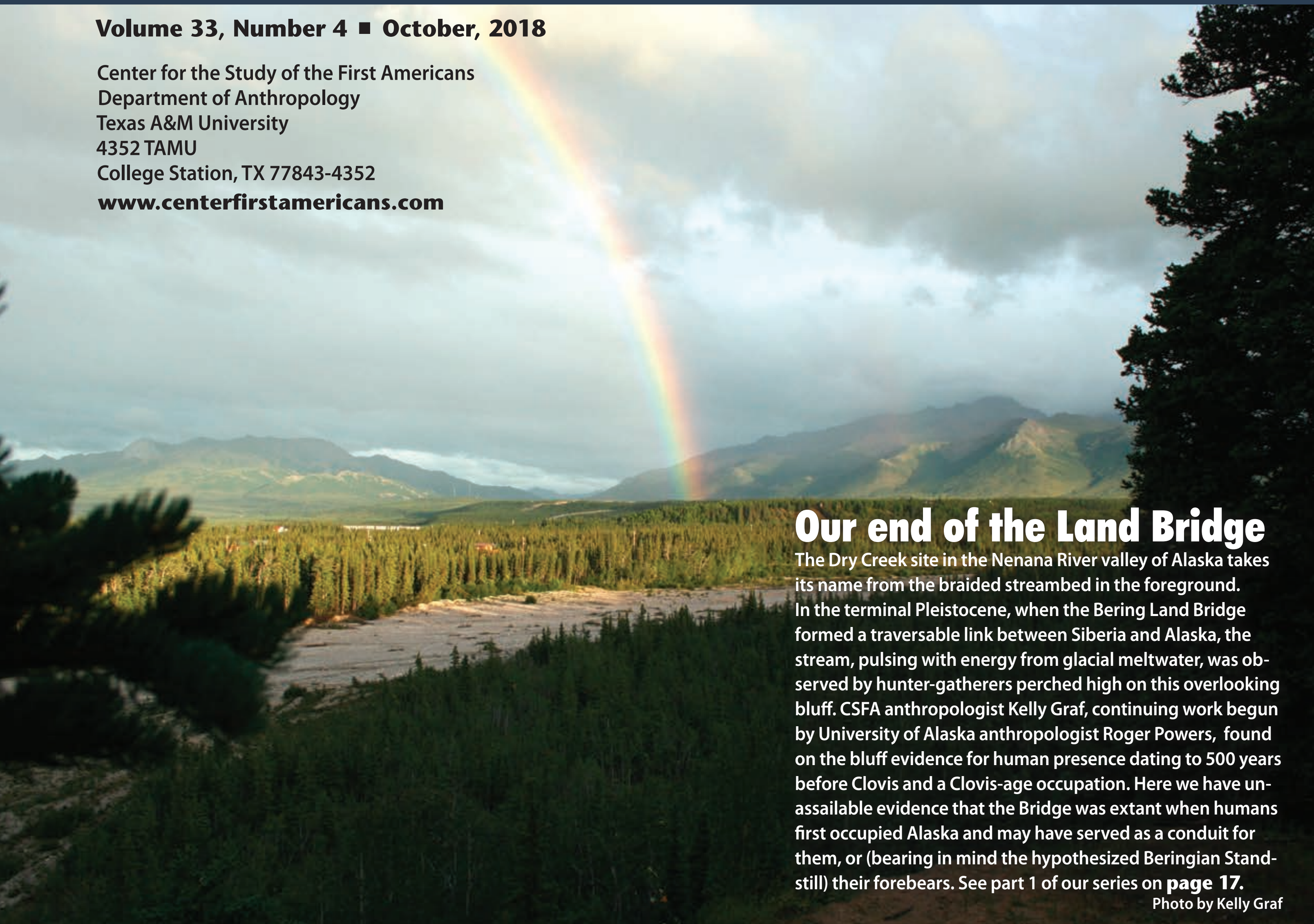

Our end of the Land Bridge

The Dry Creek site in the Nenana River valley of Alaska takes its name from the braided streambed in the foreground. In the terminal Pleistocene, when the Bering Land Bridge formed a traversable link between Siberia and Alaska, the stream, pulsing with energy from glacial meltwater, was observed by hunter-gatherers perched high on this overlooking bluff. CSFA anthropologist Kelly Graf, continuing work begun by University of Alaska anthropologist Roger Powers, found on the bluff evidence for human presence dating to 500 years before Clovis and a Clovis-age occupation. Here we have unassailable evidence that the Bridge was extant when humans first occupied Alaska and may have served as a conduit for them, or (bearing in mind the hypothesized Beringian Standstill) their forebears. See part 1 of our series on **page 17.**

Photo by Kelly Graf

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INSIDE

Technological Revolution

Ancient Human DNA Recovered from Pleistocene Cave Sediments

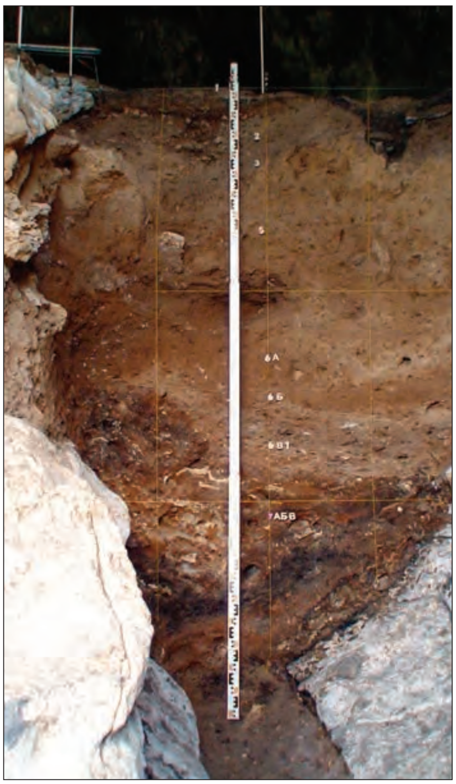
Svante Pääbo and assistant showing the location of a sediment sample at the Caune de l'Arago site, France. A 560,000-year-old human tooth was discovered in the layer in 2015.

CHRISTIAN PERRENOUD

THE SUCCESSFUL recovery and analysis of ancient human DNA has revolutionized our understanding of the First Americans, including timing their arrival in the Americas, identifying their homelands in the Old World, and tracing the routes they followed into and through the New World (**MT 29-2**, "Clovis child answers fundamental questions about the First Americans"; **MT 29-2**, "Ancient Siberian boy reveals complex origins of First Americans"; **MT 30-3**, "DNA links Mexican Paleoamerican to Native Americans"; **MT 31-2** "DNA clarifies prehistory of New World arctic"; **MT 31-3**, "Kennewick Man's DNA reveals his ancestry"). In addition, environmental DNA (eDNA), the fragments of plant and animal DNA deposited and preserved in cold lake sediments, has shed light on the timing of the opening of the so-called Ice-Free Corridor (**MT 32-4**, "Was the Ice-Free Corridor the route followed by the first Americans?").

Human remains of the First Americans are vanishingly rare, so our opportunities to learn directly about the people themselves are few and far between (**MT 31-2** "Who were the people who peopled America?"). Moreover, these human remains when discovered very often end up reburied owing to the provisions of the Native American Graves Protection and Repatriation Act (NAGPRA). The bones of the Anzick child and Kennewick Man, for example, have both been reinterred in accordance with the wishes of American Indian tribes living in the regions where their remains were found (**MT 30-2**, “We are all one: Anzick child reburied”). Molecular biologists successfully recovered DNA from the bones of both of these individuals before they were reburied, but destructive testing of ancient American Indian human remains is never assured, since many tribes have objections to such intrusive scientific studies.

Thanks to the work of an international team of researchers, however, these issues may no longer be obstacles to recovering the stories of the First Americans contained in their DNA. The research team, led by Viviane Slon and Matthias Meyer of the Max Planck Institute for



IAET SB RAS/SERGEI ZELENSKY

Stratigraphic profile of the East Chamber in the Denisova Cave, Russia, from which sediment samples were collected.

Evolutionary Anthropology, included 29 other scientists working at institutions in nine countries. Their results, published in April 2017 in the journal *Science*, have been hailed by *Archaeology* magazine as one of the top ten discoveries of 2017. In short, Slon, Meyer, and their colleagues have found a way to recover and study ancient human DNA without having to find or disturb burials—and even at sites where there never were any burials.

DNA in dirt?

We shed our DNA into the environment all the time. Dry skin particles, hairs, blood, saliva, and other bodily fluids all contain our DNA. If you happen to live in a confined and protected space, such as a cave, that DNA tends to accumulate. Slon, Meyer, and their team wondered whether this kind of DNA could survive for long periods of time. If so, could it be recovered and identified? So they collected 85 samples of sediment from seven archaeological sites ranging in age from 14,000 to 550,000 years ago and examined the samples for preserved fragments of DNA, which they then attempted to identify by comparing the bits with DNA sequences of known species. The team was unable to identify the vast majority of DNA they

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Mammoth Trumpet, Statement of Our Policy

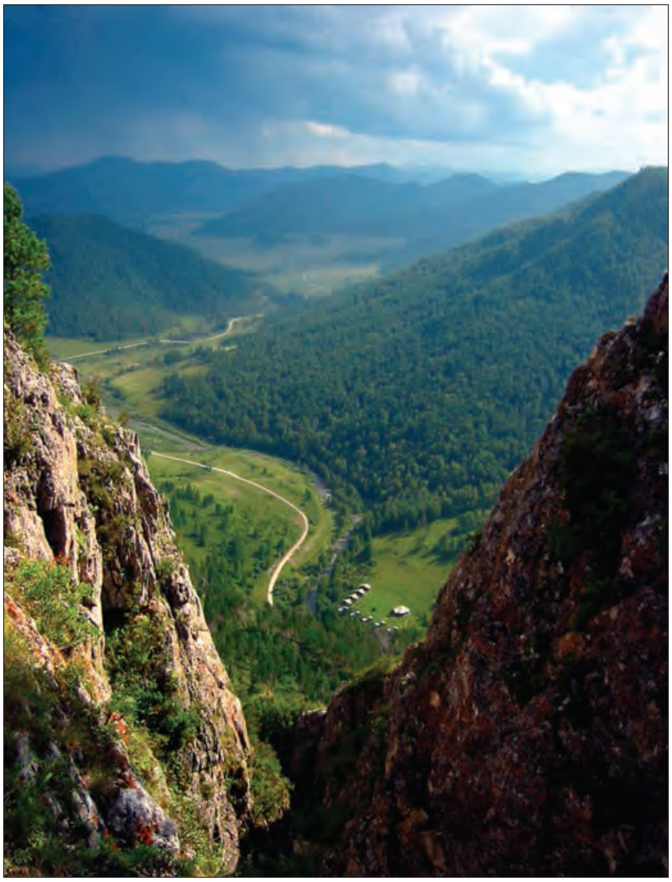
Many years may pass between the time an important discovery is made and the acceptance of research results by the scientific community. To facilitate communication among all parties interested in staying abreast of breaking news in First Americans studies, the **Mammoth Trumpet**, a science news magazine, 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

recovered, and most of the DNA they could identify came from microorganisms, such as bacteria, that live in the soil. But between 0.5% and 10% of the DNA they recovered came from mammals.

In their search for human DNA among the other mammals, Slon, Meyer, and their colleagues focused on mitochondrial DNA, or mtDNA, principally because it occurs in much higher numbers than nuclear DNA, and also because it makes it easier to distinguish different species owing to the rapid rate at which it accumulates mutations.

An important hurdle Slon, Meyer, and their team had to clear was determining whether the mtDNA they recovered was truly ancient or whether the sediment sample had been contaminated by modern DNA. Fortunately, there are clear chemical clues to the age of DNA. When DNA degrades over a long period of time, cytosine, one of the bases that make up the steps of the ladder-like DNA molecule, is replaced by thymine when it occurs near the end of a DNA fragment. So when you find DNA fragments with these substitutions, it's a good indication of great age. Remarkably, the team reports that "of the 52 sediment samples from the Late Pleistocene, 47 contained mtDNA fragments from at least one family [of mammals] showing evidence of ancient DNA-like damage." And from the older, Middle Pleistocene, samples, 14 of 33 samples showed this same pattern of damage. Overall, Slon, Meyer and their colleagues "detected ancient mtDNA fragments from 12 mammalian families, of which the most common were hyaenids [hyenas], bovids [bison], equids [horses], cervids [deer] and canids [wolves]." All these species are known to have been present at the sites because their bones were recovered from the same sediment layers that yielded the DNA.



BENCE VIOLA, MAX PLANCK INSTITUTE FOR EVOLUTIONARY ANTHROPOLOGY

View of the valley from above the Denisova Cave in Russia.

Found: ancient human DNA

Initially, Slon, Meyer and their team found human mtDNA at only one site, El Sidrón Cave in northwestern Spain. At the other sites investigated, the abundance of mtDNA from other mammals might have swamped any human mtDNA that was present, but at El Sidrón there was an "almost complete absence of animal remains at the site."

Slon, Meyer, and colleagues decided to test whether the abundance of non-human mammal mtDNA at other sites made it too difficult to detect small traces of human mtDNA. So they repeated their analyses "using probes targeting exclusively human mtDNA." Using this method, they successfully recovered "between 10 and 165" human mtDNA sequences "showing substitutions typical of ancient DNA" from 15 sediment samples from four sites. After further study of these mtDNA sequences, the team was even able to tell whether the human mtDNA recov-

MAX PLANCK INSTITUTE FOR EVOLUTIONARY ANTHROPOLOGY)

Meyer at work in the clean laboratory at the Max Planck Institute for Evolutionary Anthropology.

ered from a site came from a single individual or from multiple individuals. Using methods analogous to the way bone analysts determine the Minimum Number of Individuals (MNI) represented at a site, Slon, Meyer, and their colleagues found that the variability in DNA sequences from multiple fragments of DNA indicated that there were "at least two mtDNA genomes" present at both El Sidrón and at Denisova Cave in Siberia.

The next question the team considered was, How much DNA can be recovered from sediment compared to skeletal elements?

SYLVIO TÜPKE, MAX PLANCK INST. FOR EVOLUTIONARY ANTHROPOLOGY

Slon (*above*) preparing a sediment sample for DNA extraction.

This is important because if DNA is only rarely preserved in sediment, then the techniques developed by Slon, Meyer, and their team will be of only limited usefulness. Using samples of bone and sediment "originating from the same layers at three archaeological sites," they found that the number of human mtDNA fragments retrieved from bones ranged between 28 and 9,142 per milligram, whereas the number of mammalian mtDNA fragments retrieved from sediment was between 34 and 4,490. Slon, Meyer, and colleagues concluded that "surprisingly large quantities of DNA can survive in cave sediments"—particularly for relatively large mammals. In addition, instead of being concentrated the DNA is "spread evenly within the sediment."

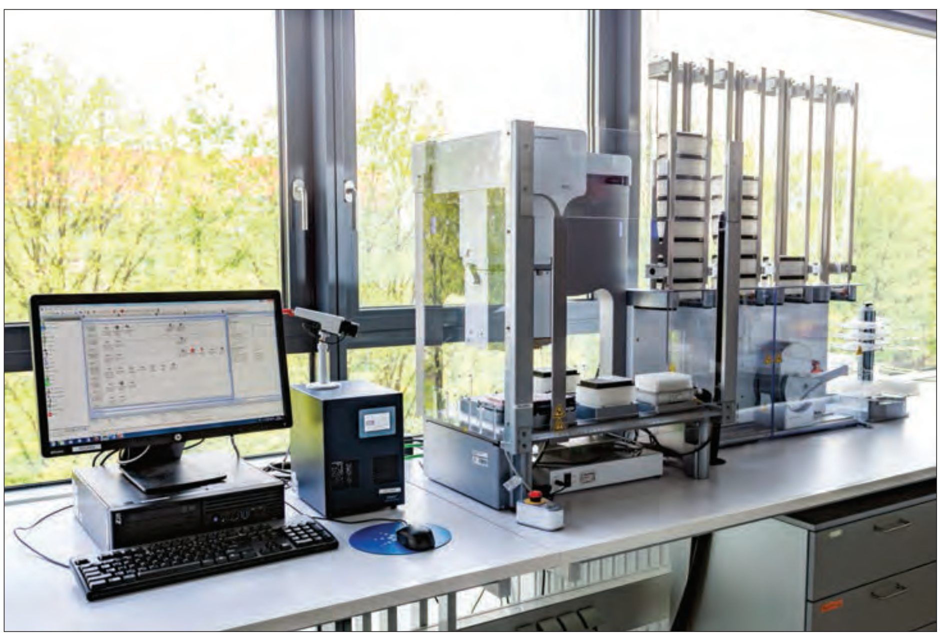
But is the DNA confined to the particular layers that accumulated during times when humans occupied the sites, or does it get spread across layers, thereby making it difficult to associate particular DNA sequences with specific time periods? Slon, Meyer, and their colleagues considered this question and concluded that there was enough consistency between the species of mammals represented by their bones and the species represented by their DNA to support the argument that DNA was largely restricted to the layers in which it was originally deposited. For example, in Chagyrskaya Cave in Siberia, the team recovered abundant ancient mammalian DNA fragments from layers that were also rich in artifacts and bones, but no DNA in the underlying layers with no artifacts or bones. And at the same site, Slon, Meyer, and colleagues recovered DNA from woolly mammoth and woolly rhinoceros in layers dated to the Late Pleistocene period, but no megafaunal DNA in later levels. Together, these observations indicate that, at least at this site, there was little or no downward or upward movement of mtDNA fragments through the sediment layers.

A real revolution in technology

Slon, Meyer, and their colleagues have shown that "mtDNA can be efficiently retrieved from many Late and some Middle Pleistocene cave sediments." Even sediment samples stored in laboratories for several years still may yield positive results, which means that "samples collected for dating, site formation analyses or the reconstruction of ancient environments at sites where excavations are now completed" potentially could be repurposed for genetic studies.

Most of the news articles reporting the results of this study have emphasized the team's remarkable recovery and identification of Neanderthal and Denisovan mtDNA at four of the six sites with layers old enough for these early humans to have been present. However, as these early human species appear never to have made their way into the Americas, that accomplishment, although remarkable, is perhaps less relevant to the interests of archaeologists studying the First Americans.

Of greatest significance for American archaeologists is that this technology makes it possible to reliably retrieve genetic information from cave sediments and, given improvements in technology, possibly at other kinds of sites as well. David



SYLVIO TÜPKE, MAX PLANCK INSTITUTE FOR EVOLUTIONARY ANTHROPOLOGY)

Multiple sediment samples are processed in parallel to generate DNA libraries and isolate DNA by hybridization capture.

Reich, a genetics professor at Harvard University, told the *New York Times* that "there's been a real revolution in technology invented by this lab. Matthias is kind of a wizard in pushing the envelope." It's "an amazing, amazing thing," Adam Siepel, a population geneticist at Cold Spring Harbor Laboratory, told the *New York Times*, "a bit like discovering that you can extract gold dust from the air."

The impact on research methods

This technological revolution means that we no longer must find human bones to learn something about the people who actually occupied Late Pleistocene archaeological sites. Moreover, all the controversy regarding studying ancient Native American human remains can be avoided by recovering ancient human DNA from sediment instead of from bone. The terms of NAGPRA don't apply to "remains or portions of remains that may reasonably be determined to have been . . . naturally shed by the individual from whose body they were obtained." Of course, archaeologists and molecular geneticists aren't relieved of the ethical obligation to consult with potentially descendant communities when engaged in this sort of research. Ideally, the obligation would be observed regardless of the potential for retrieving DNA from sediment layers. But eliminating the necessity of procuring human skeletal remains would avoid inflammatory "grave robbing" rhetoric from the dialogue and could lead to more productive collaborations between tribes and scientists.

MATTHEW WILSON

◀ Marie Soressi collecting sediment samples at Les Cottés site, France.

EL SIDRÓN RESEARCH TEAM

▼ Excavating at El Sidrón site, Spain.

Does this scientific breakthrough mean that archaeologists and biological anthropologists need no longer study actual ancient American human remains? Chris Tyler-Smith, of the Sanger Institute in the UK, tells *The Guardian* that he would "advise any young scientist interested in this to give up the struggle to find bones of ancient humans and instead study ways to extract DNA from soil. You will get a lot more science done." Chris Stringer, with the Natural History Museum in London, disagrees. He tells *The Guardian* that while "ancient genome studies are a magnificent addition to the tools we use to study our past . . . we still need the physical evidence to tell us what they looked like. How they lived. Whether they buried their dead or painted caves. And there are many human and human-like species for which we don't have DNA. We need to get the whole picture." Indeed, studies of the physical remains of Kennewick Man, for example, revealed a great deal about his life and times, very little of which would have been evident in the man's mtDNA (**MT 30-1**, "Ambassador from our ancient past").

The methods developed by Slon, Meyer, and their international team to extract DNA from sediment mean that a wealth of genetic information about the people who occupied caves is now available to scientists. As techniques improve, we may be able to recover DNA from many different kinds of sites and perhaps also recover nuclear DNA in addition to mtDNA, which will add a tremendous amount of detail to our understanding of the people and their biological relationships both to their contemporaries and potential descendant communities. Reich is certainly correct in seeing this breakthrough as the beginning of a real revolution in technology and in our understanding of human history.

– Brad Lepper

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Suggested Readings

Kolata, G. 2017 No bones about it: Scientists recover ancient DNA from cave dirt. *New York Times*, 27 April 2017.

McKie, R. 2017 How a DNA revolution has decoded the origins of our humanity. *The Guardian,* 18 November 2017; https://www.theguardian.com/science/2017/nov/19/human-evolution-dna-revolution-mapping-genome.

Slon, V., C. Hopfe, C. L. Weiss, F. Mafessoni, M. de la Rasilla, C. Lalueza-Fox, A. Rosas, M. Soressi, M. V. Knul, R. Miller, J. R. Stewart, A. P. Derevianko, Z. Jacobs, B. Li, R. G. Roberts, M. V. Shunkov, H. de Lumley, C. Perrenoud, I. Gušić, Ž. Kućan, P. Rudan, A. Aximu-Petri, E. Essel, S. Nagel, B. Nicke, A. Schmidt, K. Prüfer, J. Kelso, H. A. Burbano, S. Pääbo, and M. Meyer 2017 Neanderthal and Denisovan DNA from Pleistocene sediments. *Science* 356(6338):605–08.

DEEP WITHIN the Siberian permafrost, the remains of lost giants of the mammoth steppe have lain for thousands of years, preserved to near perfection. The shaggy beasts that roamed northern Siberia during the late Pleistocene died off about 12,000 years ago, though isolated populations lingered on islands to the north and east (**MT 33-1,** "Isolated: The not-so-ancient extinction of a relict mammoth population"). Now mammoth tusks, some more than 4 m long, are emerging from the permafrost and fueling a trade that benefits the people of Arctic Siberia, including the native Yakuts, an Asiatic ethnic group that speak a language of Turkic origin.

Tusk hunters slog over icy tundra 18 hours a day in hopes of discovering a tusk, which may be worth upwards of $30,000.

"This is not just trade, but illegal business," warns Vladimir Pitulko, a Stone Age archaeologist based in the Paleolithic Department of the Institute for the History of Material Culture (part of the Russian Academy of Sciences) in St. Petersburg. He has researched the Siberian Arctic for 40 years. The race to collect valuable mammoth ivory is jeopardizing archaeological sites, both known and unknown to researchers. "This is not *collecting,*" he emphasizes, which was always common in these territories. "This is real mining, with high-pressure water pumps washing away sediments and everything that is in there." The result is wholesale destruction of the landscape similar to that wrought on the American West by placer mining for gold.

Ancient humans valued the tusks for a more pressing reason—their very survival.

OF MAMMOTHS AND MEN

ELENA PAVLOVA

Pitulko with mammoth skull found in the upper portion of the ice-complex deposits exposed in Sop-Khaya icy bluff, summer 2014.

Rising temperatures helped seal the fate of the mammoths at the end of the last Ice Age by shrinking and drowning their grassland habitats. Today their thawing and eroding permafrost graveyard has created a rush of tusk hunters. The tusk rush is driven not by ancient callings but by powerful modern forces: the collapse of the Soviet Union and the ensuing flurry of frontier capitalism; the international ban on trading elephant ivory and the search for alternatives; even global warming.

Mammoth hunting on the mammoth steppe

During the last Ice Age, the mammoth steppe was the largest biome on Earth. It stretched from modern-day Spain across Eurasia to Canada, and from the Arctic as far south as China. During this cold, dry period, grasslands—a landscape of grasses, herbs, and willow shrubs—were home to large herbivores—mammoth, woolly rhinoceros, bison, horse, and musk ox. The mammoth steppe thrived in cold climate for roughly 50,000 years but died out about 12,000 years ago.

For as long as mammoths and humans coexisted in Arctic Siberia, the giant creatures provided the wherewithal for human survival: bones and tusks for use as toolstock and framing members for houses, and fiber for making ropes and snare tackle. Because mammoth meat is tough compared with that of other prey animals that abounded in the mammoth steppe—bison, horse, and reindeer—humans valued mammoths as a source of raw material rather than a food source. Ivory seemed limitless in supply and function. The appearance of bone and ivory tool production is, in fact, one of the hallmarks of Early Upper Paleolithic culture in the mammoth-steppe belt of Northern Eurasia and is one key to unlocking the vault of early human material culture during the period Mikhail Anikovich calls "the Bone Age."

Hunters valued female mammoths for their long, straight tusks, which toolmakers fashioned into spears. Mammoth hunters aimed their spears at the animal's shoulder bones and ribs to cripple the animal before finishing it off with a blow to the upper part of the trunk.

The manufacturing of ivory shafts, points, and spears was indispensable in the treeless open landscapes of the Eurasian mammoth steppe belt, and these technological skills peaked shortly before the Last Glacial Maximum (LGM) and persisted into the Holocene across northern Eurasia in all areas populated by mammoths and men, both in Europe and eastern Siberian Arctic.

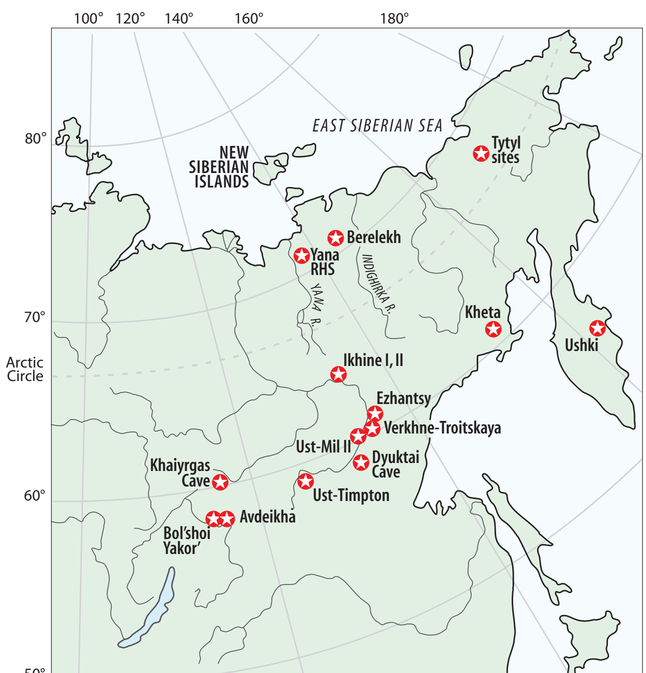
ELENA PAVLOVA

Pitulko sampling ice wedges at Sop-Khaya icy bluff on the bank of the Yana River at the Yana site, summer 2014.

Pre-LGM human activity in Arctic Siberia

Siberia, which occupies about 9% of Earth's dry land mass, covers about 5.2 million square miles, an area almost half again as large as the United States. It's bounded by the Ural Mountains in the west and by the Bering Strait in the east. To the south lies central Asia, Mongolia, and China, and to the north the Arctic Ocean. This vast area is sparsely populated and comprises immense swaths of untouched land called *taiga,* a brutally cold subarctic forest that teems with wildlife. Arctic Siberia was even larger in the Upper Pleistocene, when receding sea levels exposed the coastal shelf, but shrank during the post-LGM transgression that began after 15,000 years ago.

For decades, scientists have been trying to locate evidence for early human presence on the Taimyr Peninsula, the area that constitutes a significant bulk of this great Arctic expanse. Many radiocarbon-dated remains confirm that fauna survived here into the Holocene, but not until recently has clear evidence been found of human presence during this time period.



Until the 1970s, settlements in Scandinavia and the Kola Peninsula, the spur of Russia that forms the northwest boundary of the White Sea, were the point of reference for human occupation in the Far North of Europe and Asia. People couldn't settle there until after these territories became deglaciated about 10,000 years ago. Then Russian paleontologist Nikolai Vereschagin discovered the human component of the Berelekh "mammoth graveyard," which added a single pre-Holocene site to the archaeological record of Arctic Western Beringia.

The Berelekh mammoth graveyard was well known to locals for years, even centuries before it was scientifically described for the first time in the late 1940s by geologist Nikolay Grigoriev from Yakutsk. About 20 years after Grigoriev published his findings, Vereschagin decided to study the Berelekh mammoth site. He didn't expect to find evidence for human involvement. His interest lay in the site as a reference for evaluating other archaeological sites with numerous mammoth remains in Eurasia, central and eastern Europe, and in Urals. Vereschagin's goal was to distinguish differences in bones from natural death accumulations (presumably Berelekh) from those of mammoth remains in archaeological sites, which possibly resulted from hunting, scavenging, or collecting. "Although Berelekh easily (and mostly) finds association to Vereschagin's name," Pitulko explains, "he was not the first to discover it."

Although mammoth remains dated to 13,000–12,500 RCYBP (about 15,800–14,800 CALYBP), human habitation episodes near the graveyard are no older than 12,100–11,800 RCYBP (about 14,100–13,800 CALYBP). Until the end of the 20th century, nothing was known of human occupation of the Upper Pleistocene Arctic Siberia except for a few temporary human habitation episodes during the Terminal Pleistocene. The question of LGM and pre-LGM occupation remained unanswered.

The question was answered spectacularly in 2001, when Pitulko's expedition discovered the Yana site, which became the oldest archaeological dig in Arctic Siberia and the entire Arctic region. Its main component, about 32,000 years old, *doubled* the period of known human habitation in Western Beringia and sparked further investigation of the area. Pitulko, a Stone Age archaeologist based in the Paleolithic Department of the Institute for the History of Material Culture (part of the Russian Academy of Sciences) in St. Petersburg, has researched the Siberian Arctic for 40 years.

ELENA PAVLOVA

Yana complex of sites: excavations of the cultural layer embedded in permafrost deposits that compose the second alluvial terrace of the Yana River.

He recalls with delight the day his team located the cultural layer of the Yana site in 2002. They were racing the clock, having only 10 days to discover "if there was something to excavate, or if it was already eroded by the Yana River in full." The team discovered human-modified mammoth bones in addition to jewelry and artifacts. Not only did humans use mammoth ivory in technologically innovative ways, they labored intensively to fashion pendants of animal teeth as well as beads, bracelets, and headbands from mammoth tusks. Pitulko believes these artifacts weren't simply decorative, but served to communicate important social information such as tribal membership.

ELENA PAVLOVA

Screening material excavated from the cultural layer at the Northern Point locality of the Yana site, 2009. ▲

ANDREI IVANOV

Screening cultural material on the coast of the East Siberian Sea, August 2000. Sea water had to be used after freshwater sources became frozen. ▶

With support from the Russian Science Foundation, Pitulko plans to revisit the Yana site in the near future. "We're going to look at a new area," he explains. "It's of the same age as the main part (about 32–31 ka) and the same culturally, but slightly different in function or season. In short, it has much more mammoth-related activity (tusk processing), and also more mammoth remains. Surprisingly, it doesn't have personal decorations very common for the Northern Point locality (which is presumably the living site), so this new locality is basically the working area." Pitulko is unquenchably optimistic about what the future holds: "After 15 years of work on the site, I know that this is not the end of the story. More good surprises are coming, I hope."

Bunge-Toll/1885 and the SK mammoth

Pitulko cites as undeniable proof of human existence in the Arctic as early as 45,000 years ago two archaeological sites, the Bunge-Toll site/1885 on the Yunigen (a minor tributary of the Yana River), and a mammoth site in the mouth of the Yenisei River in western Taimyr, near the polar station of Sopochnaya Karga.

In 1885, the Russian government sent an expedition led by Alexander von Bunge, with polar explorer Baron Eduard Toll, to the lower stretches of the Yana and New Siberian Islands. Toll described a pile of bison skulls found at the site. (He mounted a bronze plaque on a larch tree with the name of his expedition and the date. In 2012, when more faunal remains were discovered, a lo-

(72° N latitude), on the Yana (69° N) and even farther to the east and north, and probably on the New Siberian Islands, which in the period of reduced sea level then formed part of the continent.

Both the Bunge-Toll/1885 and SK site are evidence for human occupation in the Arctic much earlier than previously thought. Unfortunately, however, today we have no information on their culture or ancestry. So, as Pitulko says, "We all have more to admire when it comes."

Possibly an earlier passage into the Americas

As early as 45,000 years ago, when mammoth, bison, horse, and other animals freely grazed the

Pitulko studying organic-rich frozen Pleistocene deposits containing mammoth bones on the bank of the Balyktakh River on Kotelnyi island, New Siberian islands, August 2002.

cal resident found Toll's plaque.) Pitulko, to commemorate his predecessors, named the site Bunge-Toll/1885.

Pitulko believes the pile of bison skulls was probably constructed by humans. Additional evidence for human presence at the site was found by Aleksey Tikhonov, director of the Zoological Museum in St. Petersburg). His field crew found the shoulder bone of a wolf that had been punctured by a sharp object. Aided by computer tomography, Pitulko's team reconstructed the spear used. The shoulder bone dated to 45,000–47,000 years ago.

Approximately the same age, Pitulko estimates, are the remains of a mammoth killed by humans from Sopochnaya Karga, its age confirmed by dating sediments accumulated above the remains themselves. The SK mammoth is a nearly complete mammoth skeleton with traces of soft tissue. The rib bones bear cutmarks, similar to those seen on remains at the Yana site, caused by stabs of a spear. Archaeologists also identified signs of injury to the cheekbone, caused when hunters delivered a fatal blow. Pitulko notes that this method of slaughtering is today practiced by elephant hunters in Africa, who target the base of the trunk to cut major arteries and cause mortal bleeding of a disabled animal.

For Pitulko, these findings indisputably confirm that this Arctic region was colonized around 45,000 years ago. Humans had probably moved there even earlier because by that time they had already settled extensively around the mouth of the Yenisei

Pitulko and Stanislav Remezov sample permafrost sediments of the floodplain terrace of the Yana River at the Yana site to retrieve the paleoenvironment proxy record, summer 2009.

mammoth-steppe biome, no obstacles prevented humans from settling in Arctic Siberia. Humans also likely explored north of west Siberia, as suggested by a 42,000-year-old Ust-Ishim human hip bone found 2,000 km south of the Sopochnaya Karga mammoth, near Tobolsk, by Pavel Kosintsev of the Academic Institute in Ekaterinburg. No other human remains have been identified to this early period, understandably, because natural processes over thousands of years have dramatically transformed and distorted the landscape, sediments, and topography.

Pitulko estimates that 45,000 years ago migratory people inhabited the area between the Yenisei and the Yana rivers as well as other ice-free areas. These early humans were almost certainly anatomically identical to us. The Ust-Ishim hip bone, for example, contains the genome of a modern human. No Neanderthal remains have been found north of 56° N latitude and dated to this period (the last 50,000 years).

The early occupants of Arctic Siberia were sparsely distributed, but their descendants successfully survived throughout the middle MIS 3 (marine isotope stage 3, ca. 57–24 ka). By the end of this epoch, they had settled westernmost Arctic Western Beringia, in the lower reaches of the modern Yana River valley. They weren't completely preoccupied with mammoth hunting, as indicated by a paucity of mammoth mass-kill sites. Their diet was varied and based on bison, horse, and reindeer. The chief aim of mammoth predation was to acquire tusks. The abundant food source ensured the survival of the developing population and their diffusion across the Siberian Arctic.

Humans arriving early in the area bordering the Bering Land Bridge may have seized the opportunity to enter the New World before the Last Glacial Maximum. Pitulko believes humans were present at the Asian entrance to the Land Bridge before the LGM, although the evidence is sparse. He cites lithics found at so-called Kymynei Mount in Vankarem depression, northern Chukotka, by Quaternary geologist Stanislav Laukhin. The findings were retrieved from a drill core of a level overlaid with moraine deposits. "Presumably they are older than LGM, but there is no dating, so the evidence is sort of weak and rarely mentioned," Pitulko admits, "but perhaps this is what we are talking about."

Studying ice-complex deposits on the bank of the Yana River in the western Yana-Indighirka lowland, Sop-Khaya icy bluff, summer 2014.

Alternatively, people may have stayed in the area, according to the Beringian Standstill hypothesis. According to Pitulko, however, the newest archaeological findings that demonstrate successful human occupation in Arctic Siberia beginning about 50,000 years ago put this hypothesis into question.

"The Bridge was certainly smaller than at the LGM," he explains, "but it was wide enough to provide a good connection between the continents, as the Arctic Ocean level was still lower than today." Before the Last Glacial Maximum and before the Laurentide and Cordilleran ice sheets coalesced (**MT 32-4,** "Was the Ice-Free Corridor the route followed by the First Americans?"), glacier margins could have exposed a passage accessible to humans. Sites of pre-Clovis age far south of the extent of the Laurentide ice sheet at LGM are of unknown ancestry. Perhaps, according to Pitulko, they bear witness to a pre-LGM population whose presence has yet to be archaeologically recognized.

He further elaborates on possible early migrations: "Coastal lowlands of east Siberia (Yana-Indighirka-Kolyma lowlands) were stretching northward for hundreds of kilometers. This is indicated by multiple finds of radiocarbon-dated Pleistocene fauna remains (terrestrial species such as mammoth, bison, etc.) on the present-day islands." Bathymetric estimates of the sea level prior to the LGM, 50–30 ka ago, coupled with glacial retreat in North America, confirm the presence of a passageway for human migration in a southerly direction to unglaciated regions. "Possibly some coastal regions were ice-free, too," he supposes, "and then humans would have used them also. I do not see any reason why humans would have been prevented from doing this, as they were living close to the Bering Land Bridge, being fully equipped to live in the Arctic and sub-Arctic regions with an unlimited food source provided by the late Pleistocene mammoth steppe biome."

The commonly accepted model for the peopling of the Americas, confirmed by well-established archaeology, maintains that the New World was colonized shortly after the LGM, around 15,000 years ago. Although Pitulko doesn't dispute the model, he nevertheless sees an additional open window of opportunity. He maintains that "even if we don't have firm, or widely accepted, evidence for humans in North America prior to the LGM right now, it does not mean that it does not exist at all." Pitulko says. After all, he points out that "50 years ago we did not know anything

Suggested Readings

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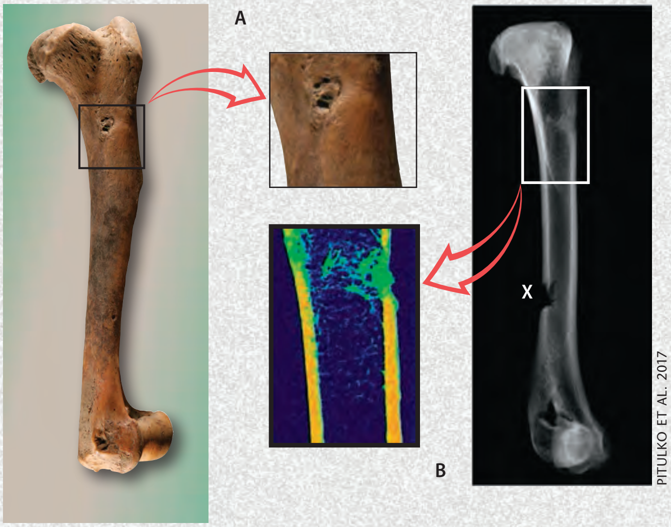
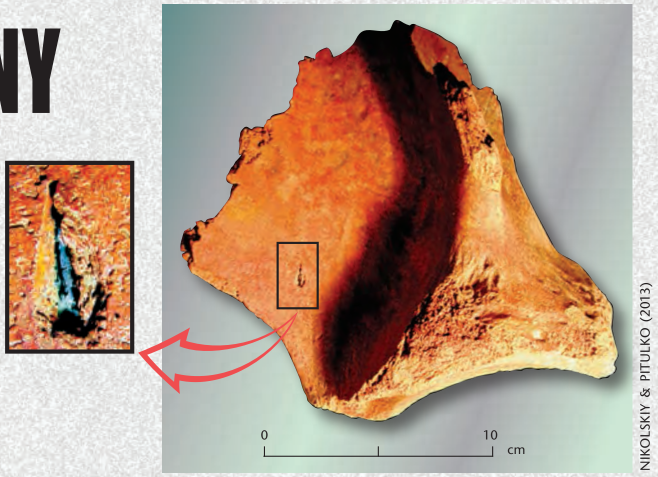
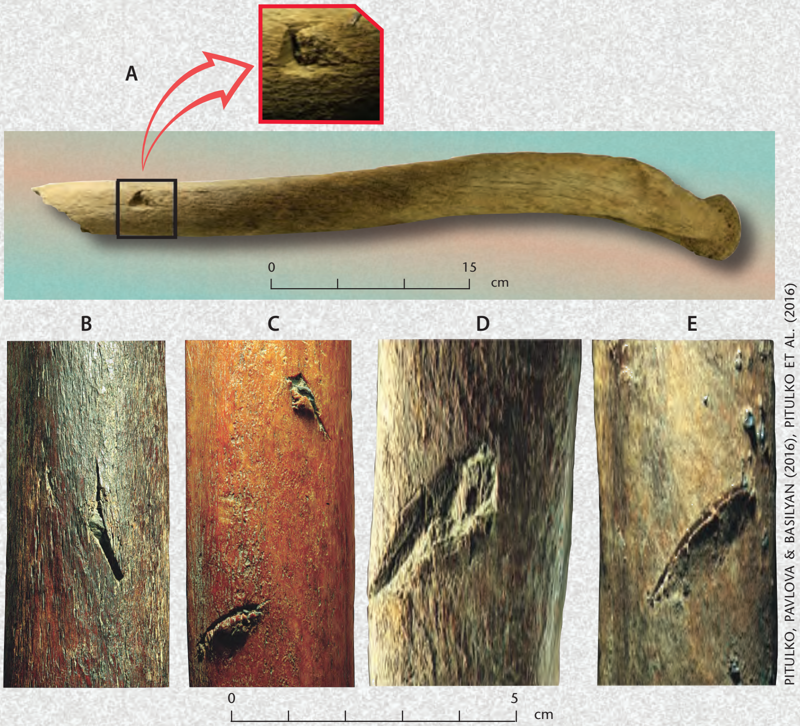
BONE & IVORY MISCELLANY



Pleistocene wolf humerus with human-inflicted lesion from the Bunge-Toll 1885 site. **A,** humerus with pathology and close-up of the sclerotic zone; **B,** X-ray photograph of the humerus and X-ray computed-tomography slice of the damaged part of the bone. A sample of bone was removed from the distal area (**X**) for AMS dating.



Mammoth scapula with embedded fragment of lithic tool, from a site in western Beringia.



Mammoth ribs with hunting lesions. **A,** rib with embedded lithic fragment from Nikita Lake site, arctic western Beringia; **B–D,** from Yana RHS/YMAM; **E,** from Sopochnaya Karga, Yenisei river.

Osseous hunting tools from Yana RHS.
A, D, E, foreshafts; **C,** fragment of a long spear point; **B, F, G,** spear points. **A, D,** woolly rhinoceros horn; **B, C, E–G,** mammoth ivory.

about humans in the Arctic earlier than in the Holocene, but after archaeological material was found by Vereschagin at Berelekh in 1970, we learned that humans were in Arctic Siberia 14,000 to 13,000 years ago, and then their appearance was doubled by the Yana finds to approximately 30,000 years ago, then expanded to 45,000 years ago." Drolly, he asks, "What's next?" He further tantalizes us by observing that the history of anatomically modern humans is becoming longer (it now extends to about 250,000–300,000 years ago).

A technological shift due to mammoth extinction and climate

Even through the coldest and driest period, the Siberian mammoth-steppe biome yielded resources sufficient to support diverse animal life and, consequently, human life. Despite the Paleoarctic anticyclone, which swept Siberia with strong northern and northeastern winds, dry summer periods, severe winter freezes, and fluctuations in animal populations, the environment remained hospitable to humans. Growing bison populations compensated for the decline in mammoth populations in Arctic Siberia during the Last Glacial Maximum. Humans adapted to subsisting with the tuskless bison by altering their toolmaking technology.

Coincident with the looming mammoth extinction in northeastern Asia, microblade technology spread. Microblade and bifacial technologies were introduced throughout northeastern Siberia. They also spread into Alaska during the terminal Pleistocene, as represented in component II of the Dry Creek site in the Nenana River valley of central Alaska. Dry Creek is a valuable timeline that illustrates the interface between Siberian and North American lithic techniques.

VLADIMIR PITULKO

Pitulko at the Yana site, summer 2015.

The major technological shift in the Late Upper Paleolithic of Western Beringia—manufacturing microblades from wedge-shaped cores—likewise coincides with significant environmental changes during the LGM. CSFA Associate Director Ted Goebel defines this phenomenon as the "microblade adaptation" and defines it as a modified subsistence strategy for hunting reindeer during the Sartan cryochron cold maximum, the start of the LGM in the west Siberian plain about 24,000 years ago. He explains that reindeer, as well as bison, horse, goats, and sheep, were hunted by people long before the LGM. It was the lack of mammoth-based toolstock that drove this technological, or adaptive, change.

"We note the appearance of microblade industries in the south (first based on wedge-shaped core technology) and their gradual spread northward," says Pitulko. "This technological shift is one of the most important cultural changes in the late-Pleistocene archaeology of the region." Mammoth extinction and the concomitant northward spread of microblade technology are inexorably linked to the collapse of the mammoth-steppe biome. Dry-cold/dry-warm herb-dominated communities were supplanted by humid-cold/humid-warm communities with less diversity in herbs and a profusion of mosses and lichens. "One of the most impressive and important changes is in the development of the forest belt and moving of the tree line in a northerly direction," Pitulko says. In other words, the cold, dry pre-LGM mammoth-steppe biome that was conducive to a healthy, flourishing mammoth population was replaced by a warm, humid climate post-LGM biome, hostile to mammoth .

Identifying the cause of mammoth extinction

Arctic Siberian hunter-gatherers undeniably contributed to the demise of the mammoth. The extinction event itself, however, was a long climate-driven process. "For thousands of years mammoths lived in Siberia together with humans and that did not affect them," Pitulko tells us, "although there is a negative trend in population numbers seen over time starting at 50 ka ago. Exactly the same trend is observed in xerophilic insect species," he argues, "which in no way reflects human contribution, and so we should conclude that mammoth extinction is a climate-driven process that together with environmental changes led to the fragmentation of the mammoth-populated area forming refugia in the northern territories where they finally became extinct, partly owing to overhunting in the limited areas."

The post-LGM world introduced enormous changes in physical geography, environment and wildlife. Humans had to adapt accordingly. Besides microblade technology, we see innovations in subsistence strategies in the appearance of maritime hunting in East Siberia after the opening of the Bering Strait, and in the use of dog teams that enhanced human mobility about 15,000 years ago. Whether we are looking at the frozen landscapes of Arctic Siberia about 45,000 years ago or at modern-day Manhattan, we are sure to find innovation as one of the keys to our survival. MT

–Katy Dycus

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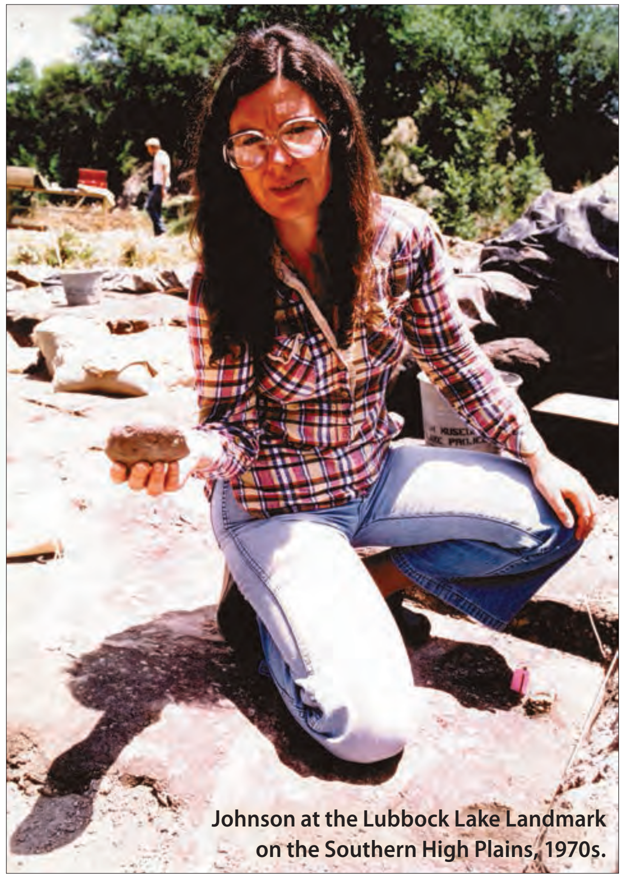
Museum Maven & Grasslands Guru

EILEEN JOHNSON



Johnson at the Lubbock Lake Landmark on the Southern High Plains, 1970s.

ALL PHOTOS: TEXAS TECH UNIVERSITY

SAYS EILEEN JOHNSON of Texas Tech University, "I've known for a long time I'm a grasslands woman." But Johnson is much more than that. She's Director of Academic and Curatorial Programs at the Museum of Texas Tech University, Director of Lubbock Lake Landmark, Curator of Anthropology and Chair of the Heritage and Museum Sciences Program at Texas Tech, and a Paul Whitfield Horn Professor of Museum Science. Whew!

Born and raised in California, she earned a B.A. in Anthropology at the University of California, Berkeley, an M.A. in Anthropology at the University of Kansas, and a Ph.D. in Zoology with a minor in Museum Science at Texas Tech University. She's been at Texas Tech ever since. "The Southern Plains is where I want to be," she says. "Lubbock Lake and the Museum are where I am happiest.

"As a Quaternary research scientist, my interests and experience are in Quaternary paleoecology, taphonomy, paleoclimatology and cultural systems," Johnson notes. "As a museum professional, my interests and experience lie in curation, conservation, preventive conservation, management of collections, and accreditation systems."

IJohnson and colleagues examining late-Pleistocene deposits in Spring Creek valley, upper Brazos River basin, 2017.

The estimable career of a transplanted Texan

Johnson has accrued 47 years of experience investigating the cultural and natural history record of the Great Plains, and for 44 of those years she has concentrated her efforts on the Southern Plains. Lest you think she has been sitting in one place, though, her research experience also includes work throughout western U.S., Mexico, South America, and China. This isn't a woman who rests on her laurels.

"Eileen Johnson has been a very fundamental person in my career since she helped me to decide to pursue a detailed paleontological and zooarchaeological career," says Joaquín Arroyo-Cabrales, Laboratorio De Arqueozoologica, Mexico. "She has always followed my path, both while I was a TTU graduate student and as a professional, and certainly we keep collaborating; furthermore, she supported my wife, Virginia, and me in our early years in Lubbock by having Virginia care for her beloved son, David Ralph. She has a deep knowledge of prehistorical archaeology, especially zooarchaeology, taphonomy, and vertebrate paleontology. She is also a sensitive person with everyone she works with. She is a careful and fair scientist, and she keeps her great work up-to-date."

Johnson's reputation as a careful and confident scientist shines in the incident Arroyo-Cabrales tells his students of a mammoth conference in Yukon. Johnson and Gary Haynes, another Quaternary authority (**MT 32-4,** "Gary Haynes: A predilection for proboscideans"), displayed posters side by side reporting on their studies on the same mammoth sites from northern U.S. into Mexico, but with quite different interpretations. Both scientists, says Arroyo-Cabrales, supported their conclusions with sound arguments. "That is how science is, it has to stand any probe," says Arroyo-Cabrales, "and that is how Eileen is, a complete scientist and presently a great grandmother."

Lubbock Lake Landmark, a treasure in the making

From 1972 to 1981, Johnson directed research at Lubbock Lake while she was completing her Ph.D. at Texas Tech. The site, which is listed on the National Register of Historic Places and was recognized in 1977 as a National Historic and State Archaeological Landmark, was originally considered strictly a Paleoindian site. Johnson soon learned it had much more to offer. She designed a research program to analyze evidence found in deposits up to 8 m thick. Johnson was named Director of Lubbock Lake Landmark in 1981 when the university hired her for a joint staff-faculty position. By 1983, she had developed a master plan for permanent facilities, which were completed and the Landmark opened to the public by 1991. "We are now in another master planning stage for expanded facilities and increased programming," Johnson says.

Johnson directing fieldwork in the Yellowhouse System on the Southern High Plains, early 2001.

Discovered in 1936, this Southern High Plains site boasts an unbroken record of human occupation for more than 12,000 years. Yellowhouse Draw, part of the upper Brazos River basin, has yielded late-Pleistocene and early-Holocene fish assemblages that represent the earliest Quaternary record of fish fossils for the Southern High Plains. Johnson's studies of the fish fauna of the region enrich the vertebrate portion of the record of extensive changes in late-Quaternary climates and ecosystems that preceded today's conditions.

Scientists and students have likely studied Lubbock Lake Landmark more intensely than any other site in the Americas. Water played a vital role in the ancient development of the site as well as its discovery. As the Southern High Plains became warmer and drier throughout the Holocene, much of the region became semi-arid grasslands, but Yellowhouse Draw, fed by natural springs, was an oasis for generations of animals and successive cultures of hunter-gatherers. The sediments that accumulated in Yellowhouse Draw preserved the record of these early inhabitants.

Increased agriculture and urbanization during the 1930s lowered the regional water table and began the depletion of the huge Ogallala aquifer that stretches over several states. In 1935 the Works Progress Administration granted funds to dredge the area and create a lake. Within a few days, some college-age boys examining the dump piles discovered bones of extinct animals and a stone artifact later identified as a Folsom point. After 45 seasons of excavation, Johnson estimates that less than 0.05% of the site has been explored. "We've learned so much more over the years about the extent and depth of the deposits," she says.

Another scientist whose career is inextricably interwoven with Lubbock Lake Landmark is geoarchaeologist Vance Holliday of the University of Arizona. "I met Eileen in the summer of 1973," he tells us. "It was the first season of field work at the Lubbock Lake Project, run under the auspices of the Museum of Texas Tech University. The project would be career-changing and life-changing for both of us. Eileen and I have always remained in touch through our many research collaborations. We still have a lot of writing to do."

Pastores on the Southern High Plains

In a *Historical Archaeology* article of 2000, Johnson and colleague J. Kent Hicks investigated three pastores settlements along the eastern edge of the Llano Estacado in Blanco Canyon and Yellowhouse Canyon. Pastores were a little-known group of sheepherders who migrated from New Mexico into the Canadian River valley beginning in the early 1870s. Their elaborate organization of herd management, brought over from Spain, entitled shepherds to a portion of the flock in lieu of payment, thus enabling them to build their own herds.

With the relocation of the native populations from west Texas and the near extermination of the bison herds, the Southern High Plains became underutilized. Pastores groups established small year-round settlements, commonly referred to as plazas. They favored a distinctive form of architecture, using sandstone or caliche to build substantial rock enclosures as sheltered havens for people and sheep. Some pastores plazas have morphed into Anglo-American towns.

Sister sites, home to Paleoamerican bison hunters

Episodes of drought and wind erosion in the 1950s exposed two ancient bison-kill sites on the Southern High Plains. The sites, separated by less than 500 m, are amazingly similar. Both contain extensive bone beds and scores of unfluted lanceolate Paleoindian projectile points. Both sites yielded bones of as many as 30 bison killed in late fall and early winter.

Johnson overseeing renewed excavations at the Milnesand and Williamson-Plainview sites on the Southern High Plain, early 1990s.

Milnesand in east-central New Mexico was first excavated by Elias Sellards in 1955 and collected by landowner Ted Williamson. Sellards also carried out limited testing at the Williamson-Plainview site (also owned by Williamson) a short distance away. Lithic artifacts at this second site included 152 unfluted lanceolate points, mostly of the Plainview type (**MT 31-3, -4,** "The Plainview site: A bison-butchering site shrouded in mystery"). The combined collection from the two sites constitutes the largest Plainview assemblage recovered from one area.

Johnson and her colleagues reviewed the history of these similar sites and renewed exploration. They concluded that both are bison-kill sites with associated activity areas that involved secondary processing, and both contain unusual pit hearths with V-shaped profiles. Radiocarbon dating indicates that Plainview and Milnesand artifacts are essentially the same age, approximately 11,935–12,180 years old.

Johnson and colleagues discussing the late-Quaternary stratigraphy at Macy Locality 100, upper Brazos River Basin, 2017.

"Regarding Paleoamericans," Johnson tells us, "I've thought for a long time that people were here before Clovis. Given the mounting evidence, First Americans probably were in the New World not too long after the last glacial maximum—18,000 to 15,000 years ago. Coming out of Siberia and crossing Beringia, they seem to have hugged the coastline before the interior corridor was open and hospitable enough to support animal life. Some very interesting research is being done regarding the interior corridor in terms of its timing, how long it took to be hospitable, what animals were traversing it in which direction, and when humans could make it through."

The mutable ecosystem of the Llano Estacado

The Llano Estacado has been a grassland throughout the Quaternary, but the character of the grassland has changed through time, as documented in a 2007 study by Johnson published by the USDA Forest Service. She used different lines of evidence to reconstruct climatic regimes and ecosystems; sediments and soils, vertebrate and invertebrate remains, phytoliths (microscopic silica structures found in some plant remains), and macrobotanical remains. Isotope analysis and radiocarbon dating quantified her data. Bison, pronghorn antelope, and prairie dog were key indicator species whose population densities mapped the changing character of the ecosystem. The modern Llano Estacado is a shortgrass prairie dominated by blue grama, buffalo grass, and patches of honey mesquite. A trader passing through in 1839 described it as "that immense desert region, dry and lifeless." Johnson's research reveals that during the late Pleistocene the area was a tallgrass prairie in a cool, humid climate. The shortgrass steppe emerged gradually around 8,000 years ago, when humid conditions declined and rainfall patterns shifted.

Johnson, a careful excavator, and colleague John Moretti identified the cheek teeth of a jumping mouse, *Zapus,* from the late Pleistocene at a Southern High Plains site, the earliest record of jumping mice in west Texas. "Dr. Johnson personifies the west Texas archaeologist: resilient, steadfast, unrelenting, yet kind and soft-spoken," says Leland C. Bement of the Oklahoma Archaeological Survey. "She's kind of a west Texas candy, hard outer shell, soft center. She holds the bar high, but gives you a sturdy stool to stand on. Of course, that stool might only have one leg if you're from Oklahoma!"

Tracking mammoths into Mexico

During the late Pleistocene, grasslands stretched from the Great Plains through the Basin of Mexico. Along with colleagues Arroyo-Cabrales and Luis Moretti, Johnson investigated a site at Tocuila near the edge of a paleolake named Texcoco and recovered the remains of five mammoths. Samples were radiocarbon dated at 11,300–11,100 RCYBP (about 13,300–13,100 CALYBP).

The purpose of the study was to determine whether the bones had been fractured by humans. Johnson and her colleagues found ten specimens that bore evidence of human-induced modification—dynamic impact fractures, shaping, and flake removal. Though other vertebrate bones were present, their study focused on mammoth bones. Some, they discovered, had been modified by trampling and carnivore gnawing. Dry-bone fractures were present, but significantly the team also found wet-bone (green-bone) fractures. For Johnson, the helical fractures, which identify a bone broken when fresh (**MT 23-1,** "Early mammoth bone flaking on the Great Plains"), were remarkably similar to fractured mammoth bones from other North American assemblages from which bone cores and large cortical bone flakes had been removed. She concluded that bones had been quarried at Tocuila to produce cores and large cortical flakes.

Johnson overseeing renewed excavations at the San Jon site on the Southern High Plains, late 1990s.

Mammoth localities associated with early peoples in the Basin of Mexico are rare. At Tocuila the well-documented and -dated samples are solid evidence for specialized use of mammoth as bonestock by toolmakers.

Maria Gutierrez, an Argentine scientist who has collaborated with Johnson in the past and continues to work with her on occasion, remembers asking her, "How do you know this is a bone modification?" Johnson replied simply, "Experience." Says Gutierrez today, "Now I know that by experience she meant 'systematicity, persistence, hard work, and especially passion.' "

The big family of bison on the Southern High Plains

Bison migrated into North America across the Bering Land Bridge and became a keystone species of the Plains ecosystem. Changes to that ecosystem and evolutionary forces modified the species and have been of interdisciplinary interest and debate for decades.

Northern and southern bison populations diverged 83,000–64,000 years ago and remained separated by ecological barriers. Steppe bison (*Bison priscus*) persisted into the terminal Pleistocene, but DNA evidence shows they weren't the ancestor of modern bison *(B. bison*). That distinction belongs to the ancient *B. antiquus,* which for 10,000 years was the largest herbivore on the Great Plains. In the early to middle Holocene *B. antiquus* became extinct and was replaced by its descendant, the modern bison. Although the great herds of *B. Bison* greatly outnumbered the earlier *B. antiquus* population (until they were nearly slaughtered to extinction in the 19th century), *B. Bison* is about 20% smaller than its ancestor, with horn cores much smaller and differently oriented.

Hypotheses to explain these changes generally focus on adaptation to warmer Holocene temperatures or human predation, although the transition is a poorly understood event. Bison were a critical resource for hunter-gatherers through time. Studies of the natural history and evolution of North American bison have generally centered on the Northern Plains, although Southern Plains bison remains have also been studied. New data based on morphometric analyses by Johnson and her colleagues of bison metapodials (long bones of the feet) have improved our understanding of the pattern of morphological change in the late Quaternary. Now it's possible to analyze changes in element size and shape, robusticity, and rate of change of size with a geochronological scale. "Bison evolution is a focus of mine," Johnson says, "particularly the driving factors for the changeover from the ancient to modern form in the Bison bison lineage."

A study done by Johnson and colleagues and published in *Quaternary International* compared the chronology of the emergence of late-Quaternary modern bison of the Southern Plains with that of bison of the Northern Plains. Using material preserved at Lubbock Lake Landmark and other assemblages on the Southern Plains, they weighed the relative contributions of the environment and human behavior on morphological changes in late-Quaternary bison. That bison indigenous to more northern latitudes are larger than their contemporaries from southern latitudes has been well established for both modern and fossil bison. Johnson showed that all species were prey to human hunters, and she found no obvious differences in tool technology and hunting strategy. Changes in bison appear

continued on page 20

IN SPRING, residents of Nenana, Alaska, guess when ice will break up on the Tanana River. Every February since 1917, a 26-ft-tall black-and-white tripod is set on the frozen river and connected to a clock on shore. When the tripod has moved about 100 ft, the cable trips a mechanism to stop the clock. The Nenana Ice Classic draws thousands of participants. Just ante $2.50, and you can submit your guess of the month, day, hour, and minute when the ice will break. Last year, the 100th year of the Classic, winners shared a prize of $300,000. Almost $14 million has been paid to winners over the past 100 years.

Part 1: Digging up Ancient Culture in Alaska

In this region of the Far North, ice is more significant than a mere seasonal source of entertainment, because ice is inextricably intertwined with human occupation of North America in the late Pleistocene. Research in the Nenana Valley has yielded a complex record of Late Glacial settlement in the foothills of the Alaska Range, settlement that occurred thousands of years earlier than we could prove until the Dry Creek site confirmed the very footing on which rests the model that today guides our research in the peopling of the Americas.

Beringia, Ice Age gate to the Americas

Beringia and the Bering Land Bridge are precisely the reason that Dry Creek occupies a position of enormous importance in our understanding of how the New World was colonized.

In the late Pleistocene, about 39,000–12,850 CALYBP (about 35,000–11,000 RCYBP), the immense volume of water bound up in glaciers lowered the sea level and exposed a land bridge that connected Siberia with Alaska. The bridge, with a breadth of 1,000 km at its widest point, covered an area as large as British Columbia and Alberta combined. It was an extension of the mammoth steppe, which stretched across Eurasia and Canada. The unbroken landmass we call Beringia extended from the Lena River in Siberia to the Mackenzie River in the Yukon Territory.

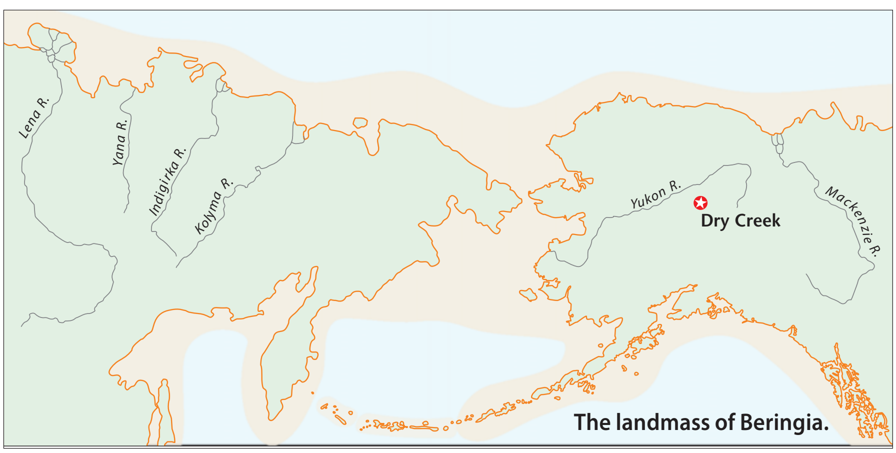
The mammoth steppe, a landscape of grass, herbs, and willow shrubs, was home to megaherbivores—mammoth, bison, horse, and muskox. This much we know. We also know that hunter-gatherers preyed on them.

Scientists assumed, and for more than half a century accepted as an act of faith, that hunter-gatherers discovered in the Bering Land Bridge a convenient passageway to new lands to the east. Farther and farther east they ventured, scientists assumed, until, although they didn't know it, they were occupying North America. Geography renders the intrusion of Asian hunter-gatherers into eastern Beringia by way of the Bering Land Bridge eminently logical. After all, genetic studies prove conclusively that Northern Asians are forebears of Native Americans. What easier method could hunter-gatherers have used to leap from Asia to North America than by traveling the Bering Land Bridge?

All that was missing was prima facie evidence that North America was occupied by humans while the Bering Land Bridge was in place.

Dry Creek furnishes that evidence. It was the first site in the Alaska interior to yield indisputable proof of human presence at the time the Bering Land Bridge was traversable.

Archaeologists are further rewarded by faunal remains found at the site that identify megamammals and smaller game that appeared on the menu. Dry Creek provided the first concrete evidence that early Alaskans exploited Dall sheep, elk, and steppe bison. Dry Creek offers even more prizes to inquisi-



The landmass of Beringia.

tive archaeologists: Artifacts recovered from successive occupations at Dry Creek spanning more than two millennia demonstrate a progression of lithic technologies. The oldest layer at the site contains a small, bifacial projectile-point technology, now known to predate Clovis by nearly 500 years. Dry Creek assures us that archaeologists will be many years unraveling the perplexities of late-Pleistocene Alaska.

Dry Creek bluff (*arrow*), viewed upstream to the southwest. In the foreground is the Parks Highway. In the distance is the Outer Range of the central Alaska Range.

A land of mountains and rivers

A traveler having endured the monotonous expanse of the Bering Land Bridge would have been awed by the rugged terrain of central Alaska. The Nenana River, fed by a glacier in the Alaska Range, gouged a valley through the Alaska Range and foothills that give way to piedmont alluvial fans.

The Nenana River valley is a patchwork of ancient floodplains deeply scarred by Dry Creek and other once-raging waterways. Erosion has created staircases of different terrace surfaces that appear as abrupt steep bluffs (vertical risers) as high as 60 m. The Dry Creek site itself sits atop such a bluff. The site, high up and unprotected from the weather, wouldn't make a good winter campsite, but it was an ideal observation post. Repeatedly it served early Native Americans as a temporary "spike camp," a combination lithics workshop and large-animal processing station. Many sites of the Nenana Complex fit into this pattern of temporary workshops and processing stations.

Central site prior to the 1976 excavations. ▲

Dry Creek bluff during the 1977 excavation. ▶

It appears that Dry Creek was one of a network of spike camps, radiating out of a central, permanent campsite, that were used by small groups on hunting trips. The network could efficiently gather resources from a large area by the collective effort of bands, each numbering perhaps 25–100 individuals, thus reducing the impact of hunting on the entire region.

Its location served Dry Creek well as a hunting outpost, especially in the fall and winter, because winds would have swept the surrounding area free of snow, thereby attracting grazing herbivores. Skeletal remains, although poorly preserved, tell us hunters preyed on mountain sheep (*Ovis*), wapiti (*Cervus*), and steppe bison (*B. Priscus*).

A checkered past leading to triumph

In 1973, Chuck Holmes, discoverer of the oldest dated site in Alaska (**MT 20-1,** "Early Americans in eastern Beringia: Pre-Clovis traces at Swan Point, Alaska"), was a graduate student when he found artifacts on rockfall that littered the slope of the Dry Creek bluff. The artifacts, further investigation revealed, had eroded out of a cultural horizon buried 1.3 m below the surface of the loess mantle that capped the bluff. Charcoal from a supposed hearth found in the horizon was dated to 10,690 ± 250 RCYBP (about 12,540 CALYBP). This was a rare find, a site in North America with microblade artifacts that dated to the terminal Pleistocene.

It was, however, a site desperately in need of saving. The cultural horizon lay atop a terrace overgrown with spruce. Scattered willow, aspen, and *Artemisia* had taken root in the rockfall slope directly below the horizon, but upstream the terrace was being undercut by a meander of Dry Creek. The edge of the loess mantle that capped the terrace was suffering from severe wind erosion and slumping. Initially cultural remains were found along a 50-m section of the loess mantle. Investigators decided to excavate at the highest point of the terrace, where the greatest density of stone tools and debitage was found. Three test pits dug along the bluff edge confirmed the presence of cultural materials.

In 1973 was launched a five-year program of archaeological and paleoecological studies. Designed to be a truly comprehensive multidisciplinary attack on the secrets guarded by Dry Creek, it addressed all ecological dimensions: geology, paleontology, paleobotany, and palynology The research program was headed by Roger Powers, Professor of Anthropology at University of Alaska Fairbanks.

Powers (*left*) and CSFA Associate Director Ted Goebel, then a beginning graduate student, at the Walker Road site in 1986.

The Powers years, a time of giant strides

The first order of business was to dig a 2-by-15-m test trench perpendicular to the bluff face, which produced a stratigraphic profile that guided future work. The trench revealed that:

- The loess mantle spanned the last 13,000 years and registered environmental changes in the terminal Pleistocene and the entire Holocene.
- The loess mantle contained three and possibly four cultural components. The oldest, CI, contained flakes and retouched flakes, flake cores, triangular bifaces, endscrapers and sidescrapers, and several cobble tools. No products or byproducts of the microblade industry were found in this level. Component II, which yielded an age of about 12,540 CALYBP, was rich in artifacts: microblades and wedge-shaped microcores, burins, bifacially flaked tools (probably knives), choppers, hammerstones and anvilstones, and unworked stones and pebbles. Component III contained 573 waste flakes and several blades, a bladelike flake, and a biface fragment. Although CIII was similar to CII, the artifacts found in CIII weren't of a diagnostic character that could be further classified. The uppermost horizon, CIV, produced two side-notched point bases and flakes.

A problem appeared early in the excavations that would continue to pester investigators over the years: The artifacts were buried in frozen loess, which made excavating difficult. Moreover, loess exposed by a trench refused to dry out. Workers had to wear winter clothing to function in muck. Unless shored, walls collapsed. Eventually investigators learned that by exposing broad areas, sunlight and wind could reach thawing loess and somewhat ameliorate the problem.

By 1976 the Dry Creek project had attracted support from the National Science Foundation, the National Geographic Society, and the Division of Parks of the State of Alaska. Students in an archaeological field school excavated in June and July, and volunteer labor continued the work through August and September.

Midway through the 1976 field season Powers and his crew took stock of their findings. They had radiocarbon dates for CI (11,120 ± 85 RCYBP, about 13,000 CALYBP) and CIV (4670 ± 95–3430 ± 75 RCYBP, about 5500 CALYBP) and had logged 12,951 specimens. Although the same kinds of artifacts were recovered from all components, they realized that the majority were found in CII. CI yielded flakes, sidescrapers and endscrapers, and a triangular point or blank, but no material associated with microblade technology. CII yielded microcore parts, burins, spalls, scrapers, and various bifacial forms. CIV yielded two side-notched points, endscrapers, and flakes. No evidence of CIII was present.

After carefully examining the stratigraphy, they realized that what they had interpreted as CIII was in fact the uppermost part of CII. The solution decided upon was to subsume CIII and its archaeological materials into CII and to eliminate all reference to CIII. (In some early literature describing the Dry Creek site, component CIV is called CIII.)

Graf with the first microblade core found during excavations at Dry Creek.

A milestone achievement

Powers's accomplishments catapulted Dry Creek into importance rivaling that of any Beringian site. When Dry Creek was designated a National Historic Landmark in 1978, it was the oldest radiocarbon-dated site in Alaska. Here are some ways Powers's discoveries have enlarged our understanding.

- Dry Creek is the first site in Alaska yielding late-Pleistocene occupations in a well-stratified context.
- We have irrefutable evidence that humans occupied Alaska before the Bering Land Bridge flooded.
- The earliest occupation, contemporaneous with Clovis, shows us one example of Clovis-age lithic technology.

- Beringian lithic technology assumed much variability in morphology and tool types.

A disaster narrowly averted

Sad to relate, Powers never published his final report on Dry Creek. Except for short journal articles and edited book chapters (and these focused more on the geology of the site than its archaeology), no formal publication was available to the scientific community. In 1983, Powers and his team submitted a report on excavations at Dry Creek to the National Park Service, which had largely funded the project. When a plan to publish the book was stymied by a host of suggested editorial changes, Powers and his students turned their attention to other Nenana Valley sites. Nevertheless he had plans to update and publish the work when he retired from the University of Alaska faculty in 2003. Unfortunately, Powers died just months after retiring.

History records a poignant parallel between the life and career of Roger Powers and of Rob Bonnichsen, founder and former director of CSFA. They were classmates at Idaho State University, and for some of their school years Rob lived with Roger and his father. Rob died in 2004, at an age before he had exhausted his potential contributions to the science of the peopling of the Americas. Roger's untimely death the year before left his definitive work on Dry Creek unpublished.

It fell upon Powers's former students to rescue the irreplaceable document. They included Ted Goebel, Associate Director of CSFA, who describes a conversation in 2013:

> While John Hoffecker, Owen Mason, and I were flying across the Seward Peninsula on a winter consulting trip, our talk inevitably turned to Roger [Powers] and the work in the Nenana Valley we had been involved in as students during the 1970s and 1980s. . . . I said that we owed it to Roger to finish the book for him, and John and Owen quickly challenged me to do so.

Powers's widow, Alicia Powers, was happy to turn over her husband's documents on Dry Creek, including the most recent version of the text and a complete set of illustrations (many of which were water-damaged and unusable). A modest grant from the National Science Foundation helped cover the cost of preparing and printing the book.

–Katy Dycus

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Suggested Readings

Powers, W. R., R. D. Guthrie, and J. F. Hoffecker 2017 *Dry Creek: Archaeology and Paleoecology of a Late Pleistocene Alaskan Hunting Camp,* ed. Ted Goebel. Texas A&M University Press, College Station.

Graf, K. E. , L. M. DiPietro, K. E. Krasinski, A. K. Gore, H. L. Smith, B. J. Culleton, D. J. Kennet, and D. Rhode 2015 Dry Creek revisited: New excavations, radiocarbon dates, and site formation inform on the peopling of eastern Beringia. *American Antiquity* 80.4: 671–94.

Eileen Johnson

continued from page 16

to correlate to the change in grasslands, specifically the rise of the shortgrass ecosystem.

Honors for her work in Quaternary sciences

"Eileen's career as a researcher and mentor has been far reaching and profound in a broad array of subdisciplines and venues," Vance Holliday writes in an article about her soon to be published in *Quaternary International.*

Eileen Johnson has received countless awards and honors, including appointments by the governor to the Texas Historical Commission (1997–2007) and to the chair of the Antiquities Advisory Board (1997–2007). Her 50 years of museum experience began in 1966 at Berkeley and continues uninterrupted today at the Museum of Texas Tech University. Pages and pages of journal articles, 26 book chapters, and three published books bear her authorship. And, as Vance Holliday mentioned, she still has lots of writing to do.

"Dr. Johnson has long championed Paleoindian archaeology, taphonomically oriented research, and curation standards, as is attested by her impressive publication record and cutting-edge contributions," says colleague Alston Thoms of Texas A&M University. "Not only did she undertake very productive Paleoindian studies at a time when the field was held almost exclusively by men, she did so by focusing on bones rather than stones. Furthermore, she successfully averred for decades, often with considerable push-back, for the importance of mandated high-quality curation of recovered materials."

–Martha Deeringer

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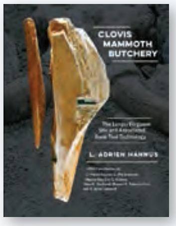

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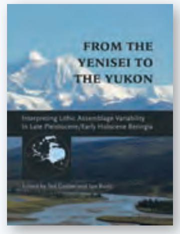

From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia, Ted Goebel and Ian Buvit, editors. 2011. 408 pages. Hardback or e-book (ISBN 978-1-60344-321-0).
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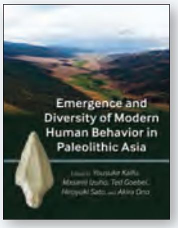

Emergence and Diversity of Modern Human Behavior in Paleolithic Asia, Yousuke Kaifu, Masami Izuho, Ted Goebel, Hiroyuki Sato, and Akira Ono. 2014. 230 pages/ Hardback (ISBN 978-1-62349-276-2).
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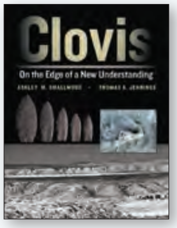

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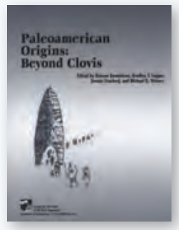

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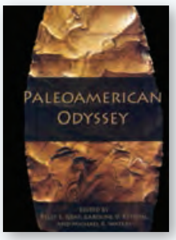

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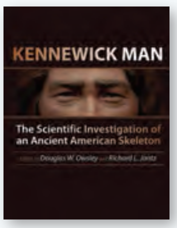

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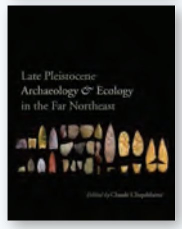

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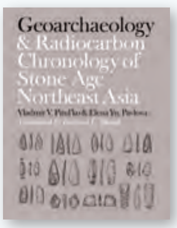

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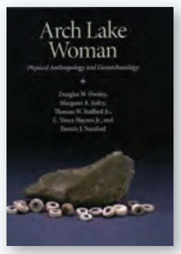

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