MAMMOTH TRUMPET

Center for the Study of the First Americans

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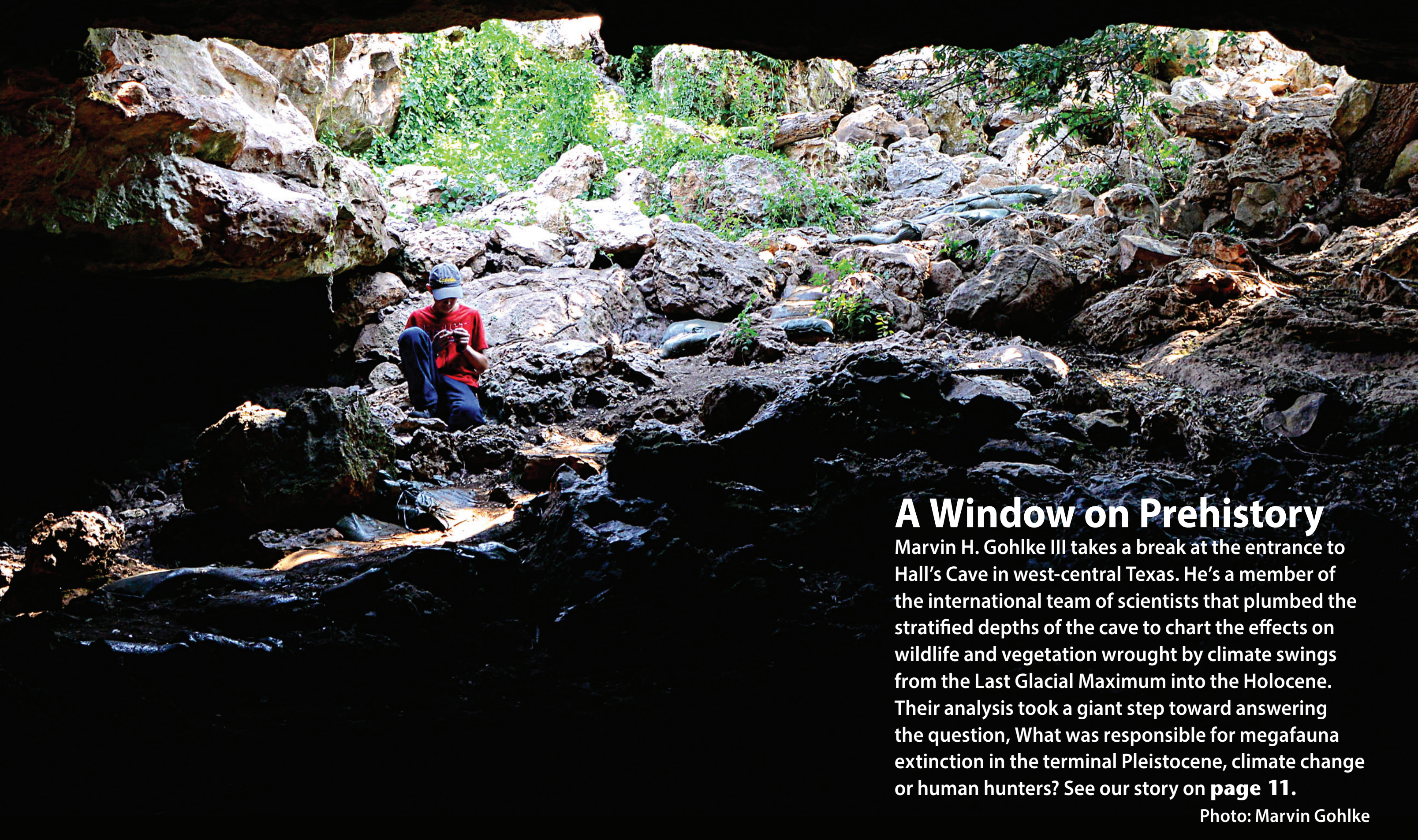

A Window on Prehistory

Marvin H. Gohlke III takes a break at the entrance to Hall's Cave in west-central Texas. He's a member of the international team of scientists that plumbed the stratified depths of the cave to chart the effects on wildlife and vegetation wrought by climate swings from the Last Glacial Maximum into the Holocene. Their analysis took a giant step toward answering the question, What was responsible for megafauna extinction in the terminal Pleistocene, climate change or human hunters? See our story on **page 11.**

Photo: Marvin Gohlke

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PERISHABLE TECHNOLOGIES

A Window into Understanding Paleoindian Material Culture

This Yungas artisan living on the coast of Peru near the Huaca Prieta site makes reed mats of the same shape and twine pattern as those made in pre-Ceramic times.

TOM DILLEHAY, 2008

HUMAN REMAINS can reveal a wealth of information about Paleoindian people—when they existed, their health, ancestry, diet, even the kinds of labor they habitually practiced. But ancient human remains are woefully scarce. In their absence, perishable artifacts, being handmade objects, serve a useful proxy role by offering a glimpse into the personal level of material culture—a role not fulfilled by durable artifacts like stone tools.

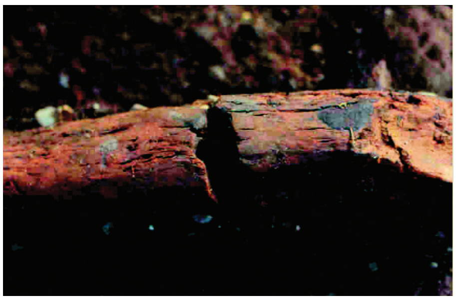
"Soft technology," a term coined by Robert L. Bettinger, Professor Emeritus at University of California–Davis, is a valuable resource. Nevertheless it isn't being put to work by archaeologists, certainly not with the intensity that would satisfy Tom Dillehay. Dillehay, the discoverer of a culture at Monte Verde in Chile that sounded the death knell for the Clovis-First model, laments fellow archaeologists who prize lithic artifacts associated with hunting while overlooking perishable technologies. "What has lagged in our discipline," he tells us, "is a rigorous search to discover perishables in both dry and wet environments." He cites as an example early rock art, like that recently reported in Brazil, which likely dates to the early Holocene, that often shows perishables in the form of clothing, wooden implements, feathers, headdresses, and baskets. "But again," he concludes, "this aspect is rarely examined."

INSIDE

Europeans lead in studying perishable artifacts

Ethnographic evidence shows us that, for many millennia, perishable technologies have formed the bulk of hunter-gatherer material culture even in arctic and subarctic environments and therefore play a pivotal role for our understanding of Paleoindian adaptations, behavior, and social organization.

European scholars were quick to recognize that late-Pleistocene populations in Moravia and elsewhere manufactured and used perishable artifacts Why, then, has it taken North and South American archaeologists a long time to appreciate the diversity of perishable technologies extant in the Upper Paleolithic? Jim Adovasio, formally the Director of Archaeology at Harbor Branch Oceanographic Institute, Florida Atlantic University, and presently Director of Archaeology at the Senator John Heinz History Center, Pittsburgh, who achieved fame with his discovery of the pre-Clovis Meadowcroft Rockshelter in Pennsylvania, notes that European recognition "occurred at a time when most Canadian and American prehistorians believed that such plant-fiber-derived artifacts weren't made or used until the Early Holocene at the very earliest by various so-called Archaic groups." Adovasio suggests that another reason scientists in the Americas have been tardy in appreciating the value of perishable artifacts is the "scarcity of perishable fiber objects in the archaeological record and, conversely, the abundance and near ubiquity of stone tools." It appears that Adovasio is a shrewd judge of human nature.



TOM DILLEHAY, 2008.

Wooden pole (ca. 14,500 yr B.P.) recovered at Monte Verde II, showing piece of twisted twine passing through fragment of animal skin believed to be remains of tent side wall.

Perishable technology continues to be underappreciated and underexamined, Adovasio observes, because "although the subfield of specialists in perishable archaeology has grown, very few scholars choose this area of research, and so it has been professionally ignored."

The emphasis on stone tools and hunting can be traced back to the Old World, where interpretations of Upper Paleolithic lifeways focused on stone tools, big game, and manly hunters, to the exclusion of non-durable technology. Modern archaeology is paying the penalty today. "The obsession with stone tools and occasionally bone implements has limited our insight into the technological and social past of early peoples," says Dillehay. "You frequently find Pleistocene perishables recovered from dry cave contexts, but the wider socio-cultural meaning of these materials has received little attention."

MAMMOTH TRUMPET

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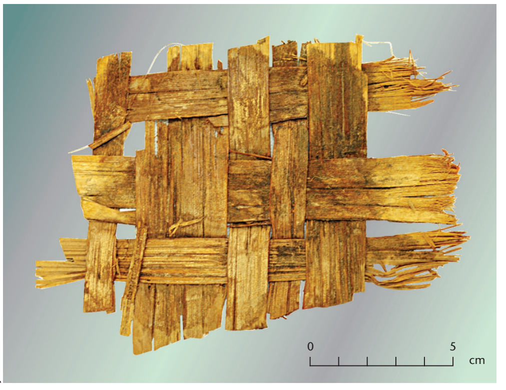
–Michael R. Waters, Director

Dillehay finds that only infrequently does anyone in the Americas pay much attention to wood, hide, cordage, and other artifacts from the Monte Verde II site (**MT 35-3,** "40 years excavating the Monte Verde Complex"). Instead, "The emphasis on the site is always on C-14 dates and the projectile points." It's worth noting that several European scholars have approached him with interest in perishables from Monte Verde II.



J. M. ADOVASIO

Fragment of simple plaited mat from Huaca Prieta dated to terminal pleistocene.

Perishables beg to be found

The relative abundance of recovered lithic artifacts compared with perishables doesn't mean they were more important to an ancient culture. Research into a dry cave in central Coahuila, Mexico, with nearly perfect preservation reversed the idea that stone tools were more widely used than perishable artifacts. Researchers found the average ratio of stone to wood to plant-fiber artifacts was 1:6:26. In other words, perishables outnumbered artifacts made of wood by a factor of 4, and were 20 times more common than stone tools.

J. M. ADOVASIO

▲Fragment of open simple twining, Z-twist (paired) wefts dated to the late Pleistocene, probably a segment of a conical fish trap.

◀Close-up view.

Adovasio finds this ratio repeated in hundreds of dry caves, rockshelters, and other contexts where preservation conditions ensure accurate representation of the relative proportions of artifacts of all classes and compositional media. Moreover, this phenomenon applies to all time periods in all environmental situations, including the ethnographic present. He speaks from experience: "I have been involved in this line of research since the inception of my 50-plus-year career." Adovasio pioneered modern perishables research and stresses over and over again the critical roles that non-durable technologies played in the lives and adaptive strategies of late-Pleistocene and Holocene populations around the world.

J. M. ADOVASIO

Basket fragment, which dates to the middle Holocene, of close simple twining, S-twist (paired) wefts with auxiliary simple plaiting. Note blue-colored elements.

Studying perishable artifacts has always been a parallel and uncontroversial venue for Adovasio's scholarly activities. He remembers that "Tom Dillehay and I began collaborating on perishable technology during the analysis and publication of the Monte Verde II materials, at which time the roles of perishable technology in South America were barely understood." Besides collaborating on the Monte Verde materials, the pair are also collaborators in analyzing and publishing basketry and cordage from Huaca Prieta in Peru (**MT 34-2, -3,** "Huaca Prieta: An ancient maritime economy").

Perishables in the Old World

Once defined as features of the Mesolithic or Neolithic in the Old World (known as Archaic and Formative in the New World), the manufacture of perishables like cordage, baskets, textiles, and sandals is now recognized as a Paleolithic innovation. Collaborative research with Czech scholars on Gravettian inventories from Dolní Věstonice I and II and Pavlov I in Moravia has documented diverse and sophisticated plant-fiber-based technologies that produced cordage, nets, basketry, and textiles. Fragments of fired and unfired clay bear 36 negative impressions of cordage, single and multiple ply, compound and braided; knotted netting; plaited wicker-style basketry; and various textiles woven on a non-heddle loom (a crude frame hung from a tree branch or laid on the ground to secure weaving elements, with no heddle—device to separate warp threads and guide a shuttle).

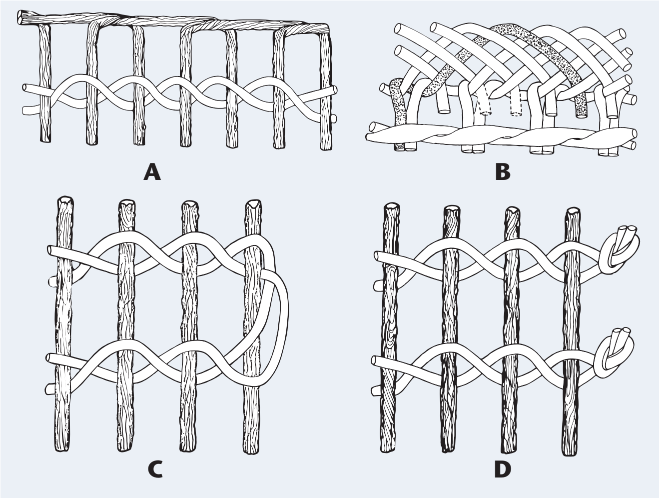
Adovasio suspects that the plaited basketry impressions represent containers or mats. The wide range of textile weaves and element gauges suggests a variety of uses like wall hangings, blankets, and flexible bags, as well as apparel—shawls, shirts, skirts, or sashes. Seams formed by whipping stitches hint that this ancient culture knew how to sew fabric and produce complex products like clothing and bags. Sequentially spaced knots on some of the impressions suggests a netting industry for producing sacks and snares for hunting or fishing.

The impressive inventory of Moravian materials dating to 29,000–24,000 yr B.P.. as well as similar materials from other European and Asiatic sites, is convincing evidence that humans who crossed Beringia more than 20,000 years ago likely possessed perishable-fiber technology in their repertoire of survival strategies.

Perishables in the New World

According to Adovasio, the earliest "perishables in both North and South America, at least in the case of basketry, are twined or plaited." This conclusion is supported both by the earliest Moravian materials which also include twined and plaited specimens as well as early materials from the Great Basin and eastern North America. Coiling is a later development in virtually all areas where it occurs."

The oldest basketry fragment (and perishable fiber artifact) of any type from North America comes from the Meadowcroft Rockshelter in southwestern Pennsylvania. Adovasio investigated the site for years and recognized it as evidence for pre-Clovis human presence in North America. Recovered from the lowest levels of the site was a piece of bark that appears to have been cut. Its morphology is similar to strips used in all later Meadowcroft plaiting and may be the oldest basket fragment found in North or South America. It was radiocarbon dated at 19,600 ± 2400 RCYBP, which Adovasio regards as tentative. Until its age is confirmed, the honor of the oldest known fiber artifacts in the Americas is held by specimens from the Monte Verde II site in Chile. Says Dillehay, "One of the earliest techniques used to manipulate reeds (*Juncus* sp.) for techno-economic purposes was the single- and double-S slipped knot technology identified by Jim Adovasio, which we recovered at Monte Verde II. There were multiple examples of this technology used to tie stakes to foundation timbers of the long tent-like structure at the site."



Selvages from Huaca Prieta, Peru: A, late-Pleistocene end selvage; B, middle-Holocene end selvage; C–D, late-Pleistocene and Holocene side selvages.

Another important South American site, the Huaca Prieta site in Peru, yields more examples of early perishables. Adovasio and Dillehay found cordage and basketry made of reeds. "In the basketry category," Adovasio says, "there are twined and plaited mats. Twined mats are still made today, albeit some with modern materials." Dillehay and Adovasio believe that plant-fiber objects were critical for Huaca Prieta and other maritime societies around the world for fashioning nets and cordage for fishing as well as twined mats for constructing stationary fish traps.

Basket fragment from Huaca Prieta dated to ca. 6000 yr B.P.

Also found at Huaca Prieta were early cotton fibers, textiles, and nets that date later, to 6500–6000 yr B.P. Recovered from late-Pleistocene levels at Huaca Prieta (before the mound was constructed) were several hard sticks made of wood of the algarrobo tree (*Prosopis* sp.) that showed use wear and may have been used to pry open shellfish or dig tubers in wetlands.

Quebrada Jaguay, located in south coastal Peru, also yields evidence for a maritime-based economy, including fragments of nets, whose function may be explained by recovered small bones of fish and maritime birds, and anchovy bones from nearby Quebrada Tacuay.

The role of gender

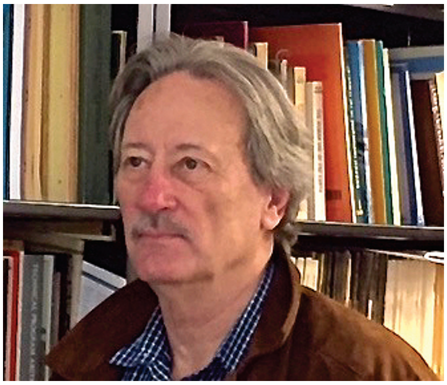
Adovasio allows that "both ethnographically and archaeologically, the manufacture of plant-fiber-based technology is normally the province of females. Hence, the recovery of perishables illuminates another role of females in antiquity, as well as the importance of the technology itself." He doesn't deny that men sometimes made plant-fiber objects; he merely asserts that "in pre-industrial societies, the production of plant fiber derived products is usually the work of women."

Cross-cultural research shows that the production and use of textiles, basketry, and cordage are associated with both sexes. In pre-market societies, however, these technologies—especially basketry and weaving—are usually the province of women. Perishable fiber artifacts recovered from Paleoindian sites attest to the presence of both men and women and thereby reveal the virtually ignored contribution of women. Dillehay believes that women bore the lion's share of labor and certainly equal with men in their material contributions.

Dillehay notes that female burials at Huaca Prieta were often accompanied with reed mats and sometimes also with a few fragmented textiles, which suggests a degree of gender bias toward these materials. Even today, elderly women along the coast in the site area still manufacture mats using techniques similar to examples observed in the archaeological record.

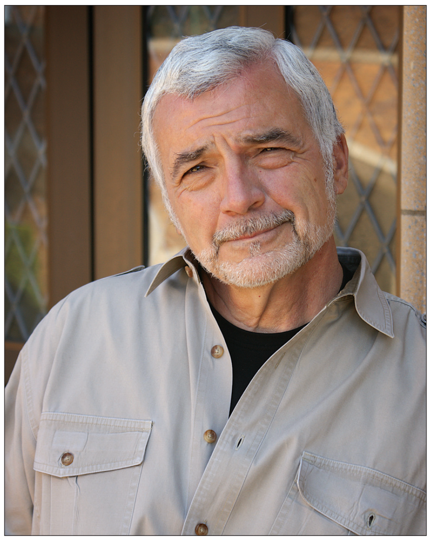
Dillehay and Adovasio believe that successful colonizing of most parts of the world probably owed more to a broader economy than to a specialized one. Adovasio asserts that "while male scholars, in particular, seem to be, and indeed have been, obsessed with specialized big-game hunting for nearly 200 years, we doubt that this specialization is an accurate rendering of the past." The culprit responsible for this misconception, he insists, is the tyranny of preservation and the inescapable fact that archaeological visibility is shaped by that tyranny.

If stone tools are more often recovered in Paleolithic sites simply because they resist decay, they, and their presumed male makers, inevitably assume greater importance than perishable objects, which are less frequently seen in the archaeological record and are often produced by females.


Dillehay.

Dillehay believes that this bias is largely the result of projectile points and megafauna bones, the objects most frequently recovered at sites. Consequently the archaeological record has become dominated by male big-game hunters. Nevertheless he emphasizes that when practicing ethnoarchaeology among indigenous groups in South America (for example, Mapuche, Huilliche, Quechua), he observes that women expend a remarkable amount of labor producing perishable goods of fibers and wood. The experience has instilled in him a deep appreciation for the energy women devote to the material culture of the society.

Sheet bends or weaver's knots, identified in the Gravettian impressions from Moravia and in early nets recovered from the Americas, attest that net hunting was practiced in the late Pleistocene and early Holocene. Subsistence strategies needed for successful net hunting or fishing mandated specialized behavior and social organization. It bespeaks a highly organized communal effort, quite different from that of a culture that subsisted by hunting animals using spears and darts.


Adovasio.

The future of perishables research

Adovasio's top priority in future research "is to examine and describe the majority of the earliest perishable technology from Huaca Prieta."

His second goal, more elusive in nature, hinges on the fact that prehistoric occupants of Huaca Prieta began to decorate their non-durable items at the same time that society was increasing in complexity. Elaborate perishable technology, witness dyed specimens at Huaca Prieta, signifies one's standing on a social scale. "This is certainly true in the ancient Near East," says Adovasio, "and may well be true in this hemisphere also." Dillehay identifies the dyes used as mainly indigo and red and yellow ocher. "Individuals possessing or buried with baskets or textiles with dyed designs were likely socially differentiated," he proposes, "probably not so much in terms of social prestige and status as perhaps occupation, gender, and residential proximity to the sacred mound at Huaca Prieta."

Curiously, little evidence has been found that perishables of any kind were produced on-site at Huaca Prieta. In fact, researchers have concluded that perishable artifacts were made elsewhere and brought to Huaca Prieta via a complex social network. Dillehay has found more than 40 middle-Holocene domestic mound sites within 20 km north of Huaca Prieta that were apparently linked to Huaca Prieta. "We have partially excavated seven of these," he says, "revealing textiles and other artifacts similar to those recovered at Huaca Prieta." He believes they are residential sites of people who worshipped at the mound and deposited sacred offerings there. Many of the sacred items fabricated in these outlying domestic communities are baskets and textiles decorated with color and design schemes that probably signify community affiliation and social identity.

Many late-Pleistocene populations exploited plant fibers for diverse purposes, and technological advances in these industries contributed significantly to their successful adaptation to the New World. The pattern at Monte Verde and Huaca Prieta convinces Tom Dillehay and Jim Adovasio that the successful colonizing of South America owed far more to a broad spectrum of hunting, fishing, and collecting by all members of a group, furnished with articles created by perishable technologies, than to big-game hunting by adult males.

–Katy Dycus

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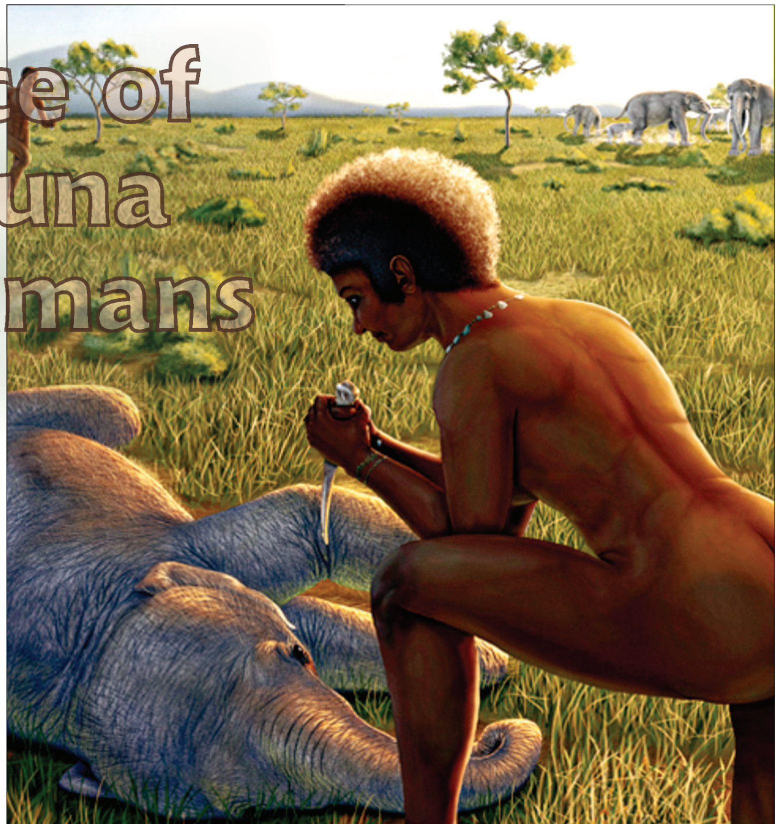
Suggested Readings

Adovasio, J. M. 2010 *Basketry Technology A Guide to Identification and Analysis.* Walnut Creek, CA: Left Coast Press.

Adovasio, J. M., and T. D. Dillehay 2019 Perishable technology and the successful peopling of South America. *PaleoAmerica* 6:3.

First Evidence of S.A. Megafauna Killed by Humans

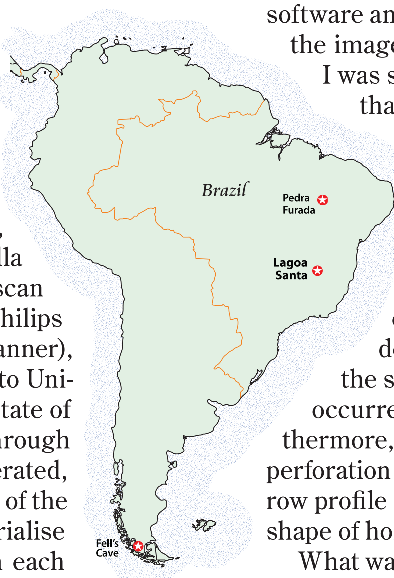


Killing the *Notiomastodon* calf: Paleoartist Vitor Silva gives a credible rendering of the event.

WHEN DIMILA MOTHÉ, a paleozoologist at Laboratório de Mastozoologia of Universidade Federal do Estado do Rio de Janeiro (LAMAS/UNIRIO) in Brazil, created a CT scan of the skull of a baby mastodon, she couldn't predict what she would find. Her initial project sought to understand the formation of the late-Pleistocene mammal's teeth. Instead, Mothé discovered the first direct evidence for megafauna killed by humans in South America.

A surprise find

In 2013 Mothé was a doctoral candidate at the Museu Nacional of the Universidade Federal do Rio de Janeiro. Her goal was to understand mastodon dentition by exploring structures inside the bones of the head and nasal cavity of the fossil of a one-year-old mastodon calf in the collection of the National History Museum and Botanical Garden of the Federal University of Minas Gerais. She explains that proboscideans don't experience the same dental eruption we do. "They have only 6 teeth, a long life, and at each side of the mouth they use one tooth at a time. While they are using one tooth, the other teeth are growing inside the mandible, the maxillary bone, until the last adult molar." Mastodons have 3 baby teeth; then 3 molars form long after the individual is born. Her specimen, a one-year-old baby mastodon, had only 2 teeth in use, she tells us, "one from when it was born, and the other in formation behind it."



To accomplish a noninvasive analysis, Mothé and her supervisor, Leonardo Avilla from LAMAS/UNIRIO, obtained a CT scan (X-ray Computer Tomography using the Philips Diamond Select Brilliance CT 64-slice scanner), which was performed at the Pedro Ernesto University Hospital of the University of the State of Rio de Janeiro. The scan created a view through the fossil. Around 400 slices were generated, and 3-D models of the internal structures of the calf's skull were produced using Materialise Mimics software; then the structures in each slice were artificially color-coded.

The CT scan revealed anatomical structures including the nasal cavity, unerupted deciduous teeth, and part of the brain cavity. What caught Mothé's attention was a perforation that traversed the nasal cavity and, within it, an object about 13 cm long and tapering from 1.2 cm to 2.4 cm in diameter. She remembers that "we were the technicians that worked with the software and 3-D modeling, coloring the layers. I was building the image in my head, but once I completed the 3-D model I was speechless for about 3 hours, until I told the others that it looked like nothing I had in mind."

Faced with this unexpected anomaly, Mothé set about considering possible agents responsible for the perforation, then played devil's advocate to eliminate them one by one.

Was the wound the result of disease or an abscess? No, she found no sign of bone remodeling or healing. Did the perforation occur after death, the work of burrowing beetles or termites on the skull? No, clean-cut borders confirm that the action occurred on fresh bone and before fossil diagenesis. Furthermore, the CT scan confirmed that the object within the perforation was organic in density and not stone. The long, narrow profile of the perforation, however, was unlike the natural shape of horn, antler, or tooth.

What was revealed in the CT scan, Mothé decided, was the wound caused by a spike, unmistakably of human creation, that had been thrust into the skull of a juvenile mastodon.

She remembers exclaiming, "It can't be! I don't believe this! What will I do now, change my thesis?" Her quandary

DIMILA MOTHÉ

Right lateral view (*left*) and top view of the skull of the *Notiomastodon* calf.

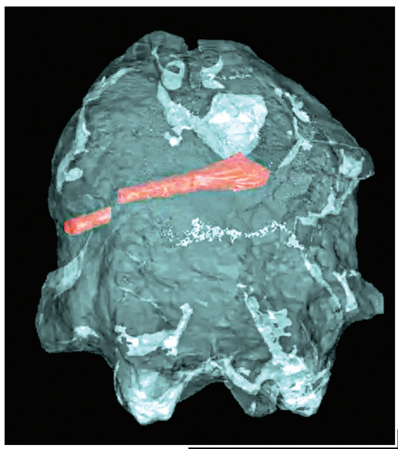
is understandable. Dimila Mothé had set out to enlarge our understanding of the dental processes in mastodons. What she discovered was a first in South American archaeology: incontrovertible direct evidence of megafauna killed by a human hunter.

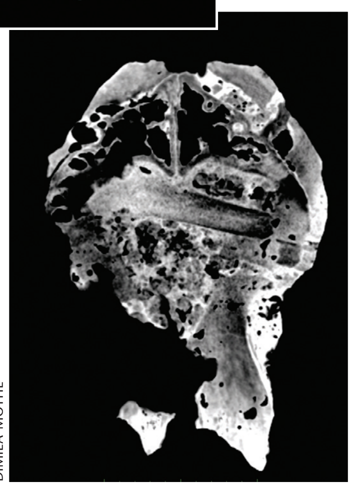
Searching for precedents

Mothé's next step was to investigate the origin of the specimen. The mastodon calf skull was recovered in 1958 by Paula-Couto in Lapa do Caetano cave in Lagoa Santa Karst, southeastern Brazil. Excavations in a Pleistocene layer at the cave early in the 20th century recovered at least nine human individuals, as well as wall paintings and megafaunal remains. Unfortunately, none of this information was published except in National Museum internal reports.

When Mothé learned about the human skeletal remains, she researched recorded interactions between humans and proboscideans. Although upwards of 25 South American sites document human-proboscidean association, most instances merely record human remains and tools in proximity with megafauna. Some records cite megafauna remains that bear evidence for human modification like cutmarks and burnt bone.

The perforation in the calf skull Mothé analyzed matched the morphology of a perforator tool recovered in the Lapa do Caetano cave. This specimen was found in the '60s, at a time when paleontologists collected everything they found within a cave, but frequently failed to record precise information on the spatial relationship among individual objects. Consequently, says Mothé, "We have this record, but don't know how to connect everything."




DIMILA MOTHÉ

◀ A 3-D frontal view of the calf skull and the perforator in red.

▼ A slice of the CT scan, which clearly shows the perforation channel traversing the skull.

Killing with an eye to butchering

The mastodon calf was lying on the ground on its right side when the perforator was driven into its skull. The wound was certainly fatal, but didn't damage the brain. Human butchers in this case were careful to leave the brain undamaged. "Some sites in Russia and Europe have records of younger rather than older proboscideans," says Mothé, "but they are butcher sites." There, processed bones don't include the head. Mothé acknowledges that "we still need to complete this puzzle to understand human strategy toward processing proboscideans here in Brazil."

She hypothesizes that in the case of the Lapa do Caetano mastodon calf, butchers were careful to leave the brain intact because it was a source of calorie-rich fatty tissue for human consumption. Very little of a prey animal was wasted. Flesh was eaten; hide was used to make clothing, shelter covering, and sacks for collecting objects; bones were made into tools.

A close parallel to the killing and butchering event in South America is a pattern revealed in European sites, where humans carried mammoth skulls to caves, where they would break open the skull to extract the brain. Proboscidean brain, it seems, ranked high on the list of favorite entrées on the menu of Late Pleistocene hunters.

Human hunters and proboscidean predation

Mothé surveyed the record of known archaeological sites dating to the Late Pleistocene and Early Holocene in south Brazil. She is careful to differentiate between three kinds of sites:

- **Type 1** Evidence suggests mere contemporaneity or sympatry between humans and proboscideans, although time-averaging cannot be ruled out; no evidence is present of direct ecological interactions. In at least 54.2% of all sites, humans and *Notiomastodon platensis* may have merely coexisted.
- **Type 2** Proboscidean remains are present with evidence for human modification (e.g., cutmarks or burnt bone), suggesting the animal was processed and consumed by humans; no evidence is present, however, that humans hunted and killed the animal. At least 37.5% of all sites are of this type.
- **Type 3** Proboscidean remains are present with embedded artifacts (hunting artifacts like projectile points, not butchering tools). Mothé cites only one site of this type, a kill site investigated by Paula-Couto in 1958.

Mothé cautions that in the literature, evidence recovered from a site that warrants only classification as a type 1 or type 2 site is commonly interpreted as type 3. Thus a probable scavenging site may be recognized as a kill site, which skews the statistical balance and hampers our search for human-proboscidean interaction. Even in North America, Mothé points out, the evidence for proboscidean killing sites (mammoths and mastodons) is remarkably limited: only 15 localities among 77 Clovis sites in United States rank as kill sites, despite the heralded reputation of Clovis as big-game hunters with a specialized lithic industry.

Concerning the interaction of proboscideans and hunter-gathers in Late Pleistocene and Early Holocene Brazil, Mothé says scholars are divided into two camps. One contends that proboscideans and other megamammals were prey animals for human hunters. Those in the other camp, especially archaeologists working on South American sites, argue that humans coexisted with megafauna, but interacted very little with them.

Mothé is an outspoken voice for the first camp. She believes that human hunters preyed on megafauna, but only when employing a specialized strategy. And she has evidence to prove it.

"Most records of humans in South America aren't that old," Mothé explains. "They start in the Late Pleistocene. But now we're starting to find older records for humans in South America." The Monte Verde site in Chile holds the record at 18,000 yr B.P., which Mothé uses as the oldest secure age for humans and proboscideans together in South America. She also uses the youngest published age of mastodon in South Americas at

Fossilized Proboscidean Oral Bacteria

HAVING DEVOTED her professional life to studying mastodon dentition, paleozoologist Dimila Mothé recently expanded our knowledge manyfold by studying the dental calculus of fossilized specimens. Her study, a collaboration between the Mammalogy Lab of Federal University of the State of Rio de Janeiro and other Brazilian and international institutions, appeared in the *International Journal of Paleopathology*. It explores the chemical composition and surface characteristics of fossilized dental calculus from the South American Quaternary proboscidean *Notiomastadon platensis*. Most noteworthy, it's the first record of fossilized oral bacteria from extinct megafauna.

What exactly is dental calculus?

The natural accumulation of dental plaque is a precursor of dental calculus. Mothé explains that oral bacteria growing on the surface of teeth produce a biofilm. Calcium-phosphate minerals from saliva preserve the bacterial biofilm, which in turn traps oral bacteria as well as fungal pathogens, viral particles, and food remains. Plaque accumulates, then calcifies on supra- and sub-gingival surfaces, thus creating dental calculus. Dental calculus collects over the lifetime of the host organism and preserves its original oral microbiome. It can also shield biomolecules (like DNA and proteins) from external damage.

Occlusal view of third molar of *Notiomastodon platensis* with dental calculus (yellowish accumulations).

ALL PHOTOS: DIMILA MOTHÉ

Analyzing samples—"like crashing a party of microbes"

Mothé collected samples of dental calculus from the third molar of five specimens of *Notiomastodon platensis* collected from Brazil, Argentina, and Ecuador. She then analyzed the samples by SEM (scanning electron microscopy) and SEM-EDS (energy-dispersive X-ray spectroscopy) methods, following a rigid protocol to avoid bacterial contamination.

SEM technology scans the surface of the sample with a specialized microscope. Enormous magnification (800–5000x) renders visible tiny structures and details that would otherwise go undocumented. "Basically, this shows you the image," Mothé explains, "and you can perform analysis of the composition of that specific portion of the sample." What these images reveal is a glowing bacterial landscape on the dental calculus. For viewer Mothé, "It's as if we're seeing a huge party! Many bacteria are trapped on the 3-D surface of the matrix. Not only on the dental calculus, but also within it." She was careful to analyze only interior portions of the dental calculus to rule out the possibility of bacteria from outside the calculus contaminating the analysis.

Bacterial communities persist in the dental calculus of fossilized mastodon teeth

One sample revealed a remarkably well preserved biofilm, Mothé recalls, with spherical and elongated structures, the remnants of mineralized remains of the original oral bacteria (coccoid and filamentous). Then unexpectedly a huge concentration of tiny objects appeared. She recalls that "we were staring at the computer, asking, 'What's this?' We were sure it was bacteria, exactly like the bacteria (in size and shape) found in elephants and other large mammals today. What's amazing is that the bacteria have survived over millennia, but not the megafauna."

Mothé was able to scan the sample to determine which chemical elements were present and their concentration. Calcium, oxygen, phosphorus, and silicon were the dominant chemical elements occupying the homogeneous and porous calculus matrix. She sampled several regions on the dental calculus and found that sulfur was especially pronounced where bacteria were most concentrated. Oral bacteria naturally produce sulfur from the decomposition of amino acids and proteins (think bad breath). Traces of this activity remained trapped within the matrix, a chemical signature that was preserved when the whole thing fossilized.

Mothé's accomplishment is the first record of fossilized oral bacterial communities associated with extinct proboscideans. It confirms the parasitic relationship between oral bacteria and

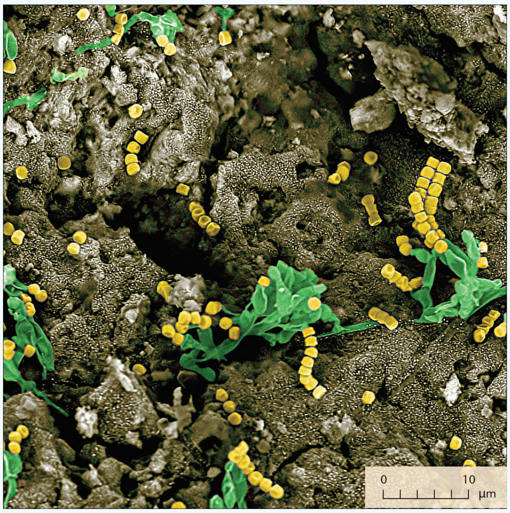
8000 yr B.P. Based on these limits, she estimates that humans could have interacted with proboscideans on the continent for at least 12,000 years. She assumes that humans and proboscideans shared the same environment, resources, water, everything.

Mothé notes records of extinctions before this time range, which encompasses the Late Pleistocene and early Holocene, and she is aware of "several other regions in South America with older records of mastodon, like southern Brazil." But she considers it possible that some mastodon populations were still extant in the Late Pleistocene and early Holocene, and that humans may have exploited them. She allows that "it was perhaps a difficult time for these proboscideans to keep going, so they became extinct." But she doesn't believe that humans alone drove them to extinction.

For how long were humans interacting with proboscideans in this part of South America? Mothé explains that "it depends on the region, but at least for this location in Brazil, the oldest human records are around 14,000 yr B.P. So if we have proboscideans until 8000 yr B.P., that would be a span of at least 6,000 years of interaction. That's longer than modern human history. They coexisted for a long time." Although the mastodon calf hasn't been absolutely dated, Mothé tells us that dates for megafauna at the Lagoa Santa site start at 15,000 yr B.P.

Mothé invites us to compare worldwide paleoarchaeological sites with the South American record of associated ancient human and proboscidean remains, represented by sites such as Monte Verde in Chile. South American sites typically exhibit proboscidean bones with cutmarks or burn marks. Less com-

the mastodon. Furthermore, her discovery promises to expedite the study of paleogenomic aspects of oral microbiota of proboscideans in the future. It also reveals an unpleasant truth. "This parasitic interaction between oral bacteria and extinct mammals," she explains, "caused harm to the ancient creatures. It led to disease that developed when dental calculus accumulated. There are lots of studies on bone pathology, but the invasive bacteria were never found. My hypothesis is that maybe these bacteria are in the blood, and they can cause infections around the whole body, *including the bones.* Maybe this mineralized dental plaque is the source of bacteria that can cause so many other infections."

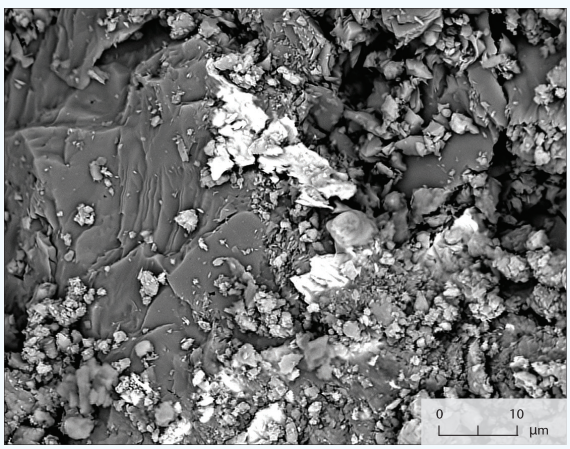


SEM image of dental-calculus surface with small cocci bacteria (yellow), filamentous bacteria (green), and large minerals (white) within the calculus matrix.

Dental calculus is common across the biological spectrum

"Dental calculus is a common pathology for proboscideans," Mothé explains, "especially those animals with this dental morphology." Not all herbivores are equally susceptible to this pathology. Consider, for example, horses. All their teeth erupt at once. Their dentition is relatively free of spaces where bacteria can accumulate, and the grass they crop cleans their teeth. But mastodon teeth had huge cusps for grinding coarse vegetation. This dental morphology promoted the accumulation of food debris and the development of subgingival dental calculus, dental calculus in soft gum tissue at the posterior region of the last molar. Mothé predicts that when the last molar erupted at the back of its mouth, it had already accumulated dental calculus.

Dental plaque is normally present in the mouth of every mammal. The microorganisms present in mammalian dental plaque comprise over 600 different taxa! The formation of plaque is initiated by cocci. *Streptococcus,* for example, is a genus of bacterial coccus notorious for colonizing the mammalian oral cavity. Cocci create filamentous structures, which proliferate as plaque calcifies.



SEM image of dental-calculus surface.

Every one of us has experienced the accumulation of dental plaque on our teeth. The difference between other animals and us is that we go to the dentist at least once a year. We understand that poor dental hygiene can lead to a host of health problems: gingivitis, periodontal disease, arthritis, cardiovascular disease, and even diabetes.

Dimila Mothé finds her study of fozzilized dental calculus a connection with the past: "It's hard to find a lot in common with a giant beast from the Ice Age, but this is a way we can identify with animals from the past. Biological studies seem like things far from us, but they're not. Our dogs have dental plaque, and so do we. Every animal does. So it's close to us. It reminds us that we are animals, a part of this ecosystem, all sharing this earth, sharing biological processes."

–Katy Dycus

Suggested Readings

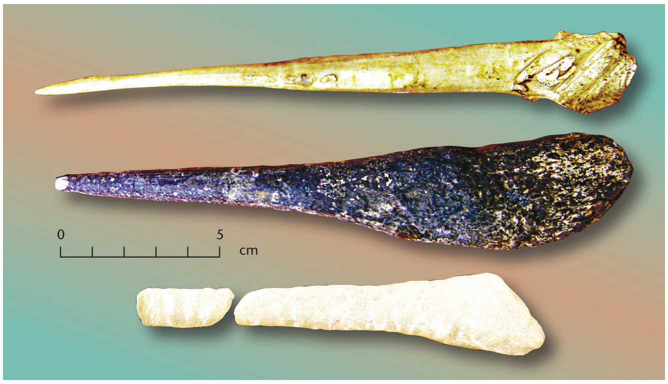
Mothé, D., et al. 2021 The micro from mega: Dental calculus description and the first record of fossilized oral bacteria from an extinct proboscidean. *International Journal of Paleopathology* 33:55-60.

MAMMOTH TRUMPET

Volume 37 ■ Number 1

mon are skeletal remains with tools embedded in, or close to, joints. Seldom are lithic artifacts associated with other body parts such as ribs, vertebrae, or the head.

Mothé offers her mastodon calf as prima facie evidence for a tool firmly lodged within the head of a proboscidean in South America. It clearly refutes the claim that humans in Late Pleistocene South America didn't interact significantly with megafauna, a claim which is defended by South American archaeologists who contend that megafauna were already nearly extinct when humans arrived. Mothé protests: "It seems it wasn't exactly that way." Perhaps, she suggests, Late Pleistocene hunters preyed on megamammals, but with a new strategy.



Two perforator tools (*top*) and 3-D printed model.

LEONARDO DOS SANTOS AVILLA

Targeting juvenile animals as a hunting strategy

"Possibly this strategy of exploiting baby megafauna was practiced in other parts of South America, too," Mothé suggests. "The evidence is there. These proboscideans were everywhere in South America—in Argentina, Colombia, Chile."

It's worth noting that Mothé tried publishing her scientific paper seven times and achieved success on the eighth try. She reports that some reviewers were excited about the topic; others were adamantly opposed.

Mothé cites as evidence that during the Australian Quaternary, exploiting juvenile individuals of large species even at low levels (one or two kills per 10 people per year) would have been sufficient to drive those species to extinction within a few centuries. Similarly, humans were present in the Lagoa Santa region during the Pleistocene-Holocene transition, a period long enough to impact—perhaps permanently—the local mastodon population.

Mothé imagines that humans may have targeted baby proboscideans as a hunting strategy. Certainly hunters would take advantage of a sick or injured calf because it made an easier kill. As for healthy babies, the mastodon herd, like modern proboscideans, doubtless protected them. But a baby that lagged behind the herd or got lost became completely unprotected and vulnerable to hunters. Mothé supposes that "hunters may even have had a strategy to deliberately separate a baby from the herd and then kill it. We don't know this for sure, we're just hypothesizing about it."

Mothé holding a mastodon tooth.

LEONARDO DOS SANTOS AVILLA

The thrust of Mothé's argument is that if the mastodon calf from Lapa do Caetano cave isn't an isolated occurrence, but instead offers compelling evidence that ancient humans, at least in late Pleistocene Brazil, may have routinely exploited baby proboscideans, this practice "would have had a significant impact on the proboscidean population." Proboscideans, like today's elephants, had a long gestation period and probably gave birth to only one calf every 5 to 10 years. Hunting babies would therefore have profoundly impacted the mastodon population and perhaps even contributed to their extinction.

It's unrealistic to imagine that hunters just killed everything in sight, according to Mothé. The kill was strategic, not wasteful; hunters were selective in exploiting prey that would yield adequate energy with minimal effort. With a body mass of 150 kg, which provided about 60 kg of food resource, this baby proboscidean would have netted sufficient meat to feed a small group of Lagoa Santa ancient humans for days. Indeed, it was a high-return prey, a prey that yielded an abundant food supply for a low investment of hunting effort.

A hunting strategy that changed with changing times

Notably absent in most South American sites dating to the Late Pleistocene are tools and weapons designed for hunting big game. "We have sites with specific cultures, as in Venezuela, where spears are found, but in other places like Brazil we don't have tools you'd expect to find with big-game hunting," Mothé says. Lagoa Santa toolmakers made perforators (like the one lodged in the skull of the mastodon calf), spatulas, and fishhooks, usually made of wood, bone, stone, or antler.

Mothé's research begs the question: If humans and megafauna are recorded together in Lagoa Santa, why is evidence for megafaunal hunting and killing so rare? She suggests that megafaunal populations were decreasing, effecting a transition from a wildlife assemblage dominated by larger mammals to one comprising small to medium-sized ones. The transition influenced the hunting strategy of Lagoa Santa humans, who now exploited smaller game more frequently than megafaunal prey. (And perhaps hunters also targeted young proboscideans, whose slaughter didn't require a sophisticated toolkit.)

This change in prey size reflects a notable human characteristic: high adaptive skill, which has enabled humans to become one of the most ecologically and evolutionarily successful species. It was unfortunately also a skill that threatened global biodiversity.

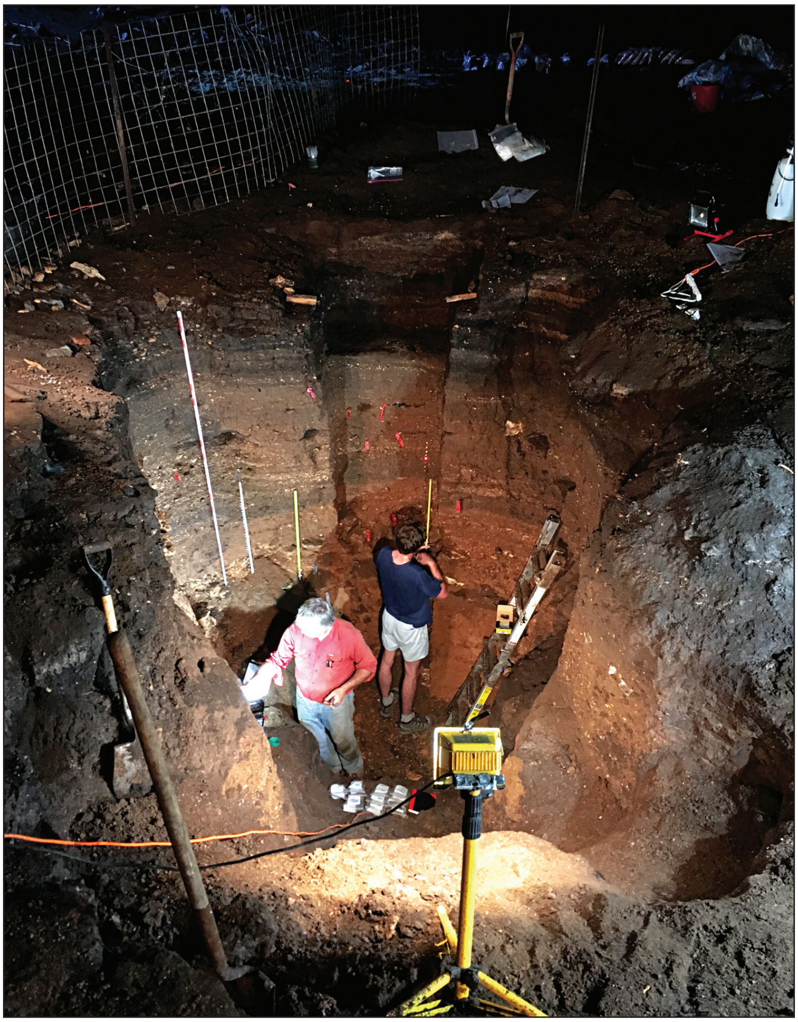
continued on page 20

Hall's Cave

. . . where aDNA reveals the cause of megafauna extinction

ONE OF THE MOST IMPORTANT and contentious questions in American archaeology and paleontology is, What caused the extinction of the Pleistocene megafauna? Often it's reduced to a debate between those who think climate change caused the extinctions versus those who think Paleoindians killed all the giant mammals, but other possible causes have been proposed. Some think a deadly disease may have killed off many species (**MT 18-4,** "Tuberculosis found in mastodon makes the case for hyperdisease in megafauna"), whereas others suggest it was caused by a comet colliding with the Earth (**MT 23-1 ff.,** "The Clovis comet: Evidence for a cosmic collision 12,900 years ago").

Extraordinary new research at a unique site in southern Texas reveals a wealth of data that point to a more nuanced answer to the question. Lead researcher Frederik Seersholm, a Ph.D. candidate from the Curtin University School of Molecular and Life Sciences, along with an international team of 15 other coauthors including Mike Waters, Director of the Center for the Study of the First Americans, presented their results in the June issue of *Nature Communications*.



MICHAEL BUNCE

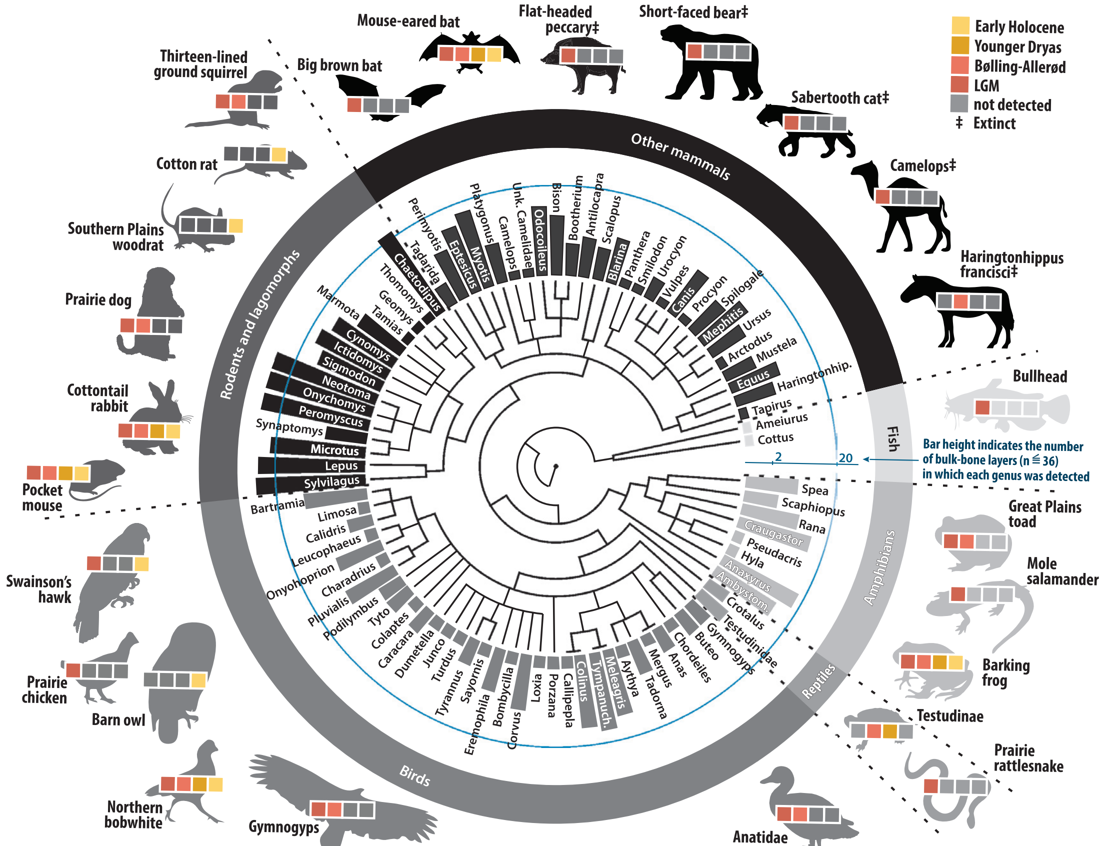
Dan Werndly and Tom Stafford measuring the stratigraphic profile of composite pit 1d/E in Hall's Cave.

The "one-two punch" hypothesis

At the end of the Pleistocene Epoch two things happened that transformed the face of North America. First, beginning around 14,700 yr B.P. the climate warmed significantly, which resulted in the melting of the glaciers that had once covered northern North America. And second, humans worked their way from Siberia across or along the southern margin of Beringia into this new world. Shortly thereafter, 36 genera of megamammals, including mammoths, mastodons, and giant ground sloths, ceased to exist in North America. Seersholm and his coauthors note that because the change in climate and the arrival of the first Americans occurred "nearly simultaneously," it's been difficult to disentangle the contributions of each to the extinction event.

Abundant evidence confirms that Paleoindians hunted at least 6 of the 36 genera, but 13,000 years ago there weren't that many people around and they tended to live in small groups, so could they really have had such a devastating impact on North America biodiversity in such a short period of time? On the other hand, megafauna had survived episodes of climate change before during previous interglacial periods. What was so different about the last one that caused so many species to vanish?

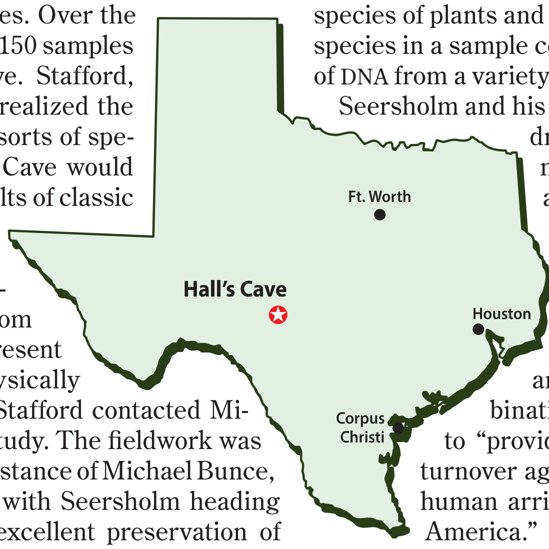
One answer to this question is that it was the combined effects of climate change and human hunting that led to this cascade of extinctions. This is the "one-two punch" hypothesis, which could finally explain the abrupt disappearance of the Pleistocene megafauna. Until now, that hypothesis has had little in the way of evidence to support it. New discoveries at Hall's Cave, however, have changed all that.



This dendrogram compiled of results of bulk-bone metabarcoding (BBM) speaks volumes about animal genera and species present—and absent—in the vicinity of Hall's Cave from the Last Glacial Maximum until the early Holocene.

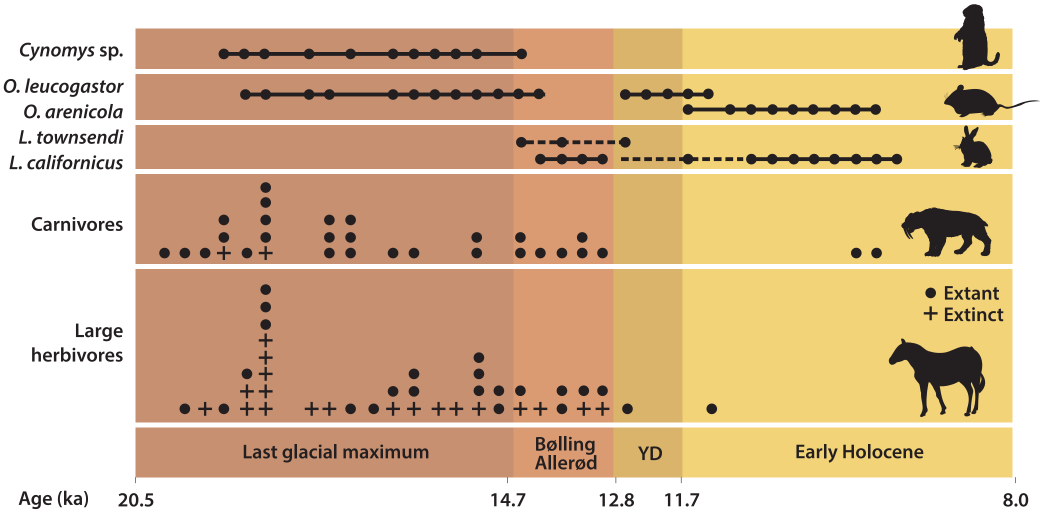
Hall's Cave, a treasure trove of ancient DNA

Hall's Cave is a limestone cavern on the Edwards Plateau in south-central Texas. The stratigraphy and faunal remains dating to the late Pleistocene and Holocene were first studied by paleontologist Rickard Toomey in the early 1990s along with paleontologist Ernest Lundelius of the University of Texas. Tom Stafford of Stafford Research Laboratories continued to study the geological deposits in the cave with a special emphasis on dating the late-Pleistocene vertebrates. Over the years he has radiocarbon-dated over 150 samples of bone and charcoal from the cave. Stafford, being an interdisciplinary scientist, realized the potential of the cave deposits for all sorts of special studies. He thought that Hall's Cave would be an ideal place to compare the results of classic field paleontology and new ancient-DNA methods for detecting different taxa because the cave had a well-dated sedimentary record dating from the Last Glacial Maximum to the present that contained chemically and physically well-preserved vertebrate remains. Stafford contacted Michael Bunce about conducting this study. The fieldwork was spearheaded by Stafford with the assistance of Michael Bunce, Daniel Weirdly, and others in 2016, with Seersholm heading up the laboratory DNA work. The excellent preservation of bone means that ancient DNA is likewise well preserved, and Seersholm and his team use a combination of two approaches to study ancient DNA: bulk-bone metabarcoding, and sedimentary ancient DNA analysis. Studies of sedimentary ancient DNA have shown that, in the right environment, DNA shed from plants and animals can be recovered from sediment and identified even after being buried for thousands of years (**MT 33-4,** "Technological Revolution: Ancient human DNA recovered from Pleistocene cave sediments"). Metabardcoding keys on short segments of genetic code that characterize particular species of plants and animals to identify the presence of those species in a sample containing broken and jumbled fragments of DNA from a variety of species.



Seersholm and his colleagues believe that by analyzing how dramatic changes that occurred in the terminal Pleistocene influenced biodiversity at a local scale, we may gain insight into causes of global mass extinction. In a Curtin University press release, Seersholm stated that those new insights would come from "combining new genetic methods with classic stratigraphy and vertebrate palaeontology." This combination enabled Seersholm and colleagues to "provide a detailed chronology of biodiversity turnover against the backdrop of impacts from both human arrivals and climate shifts in central North America."

The team selected 30 bulk samples of previously excavated non-diagnostic small-animal bones and six additional bulk



Vertebrate diversity through time tracked via bulk-bone metabarcoding (BBM) at Hall's Cave. The lower two panels identify the presence of extinct and extant species of large (>30 kg) carnivores and herbivores in each layer. The upper three panels indicate population replacement of selected indicator species.

samples obtained from larger, fragmentary bones. They divided the samples into "four distinct climate intervals": Last Glacial Maximum (LGM) (20,000–14,700 yr B.P.); Bølling-Allerød interstadial (14,700–12,600 yr B.P.); Younger Dryas (12,600–11,700 yr B.P.); and Early Holocene (11,700–8000 yr B.P.).

For each sample, consisting of 100 bone fragments, they ground samples to powder and extracted genetic material, then looked for those short segments of genetic code that identify the presence of particular species in each layer. Then they did the same genetic analysis for 32 sediments samples in which they identified the plant species present. They made sure DNA preservation didn't differ significantly from one sediment layer to another to ensure that their results accurately reflected the changes in the plant and animal communities over time.

Waters (*left*) and Stafford checking stratigraphy.

What was living in and around Hall's Cave?

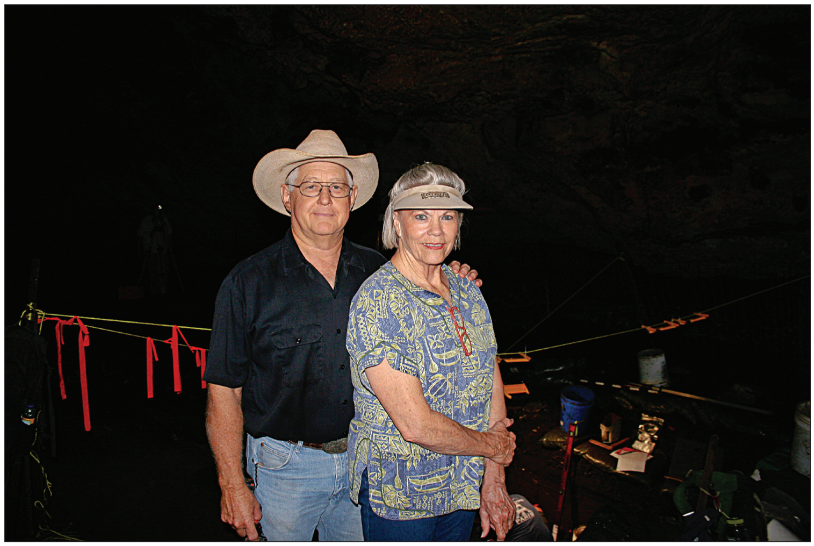
Seersholm and colleagues identified "at least 100 different vertebrate species" in their samples, including 50 mammals, 36 birds, 9 amphibians, 3 reptiles, and 2 fishes. Remarkably, even though the team sampled a total of only 2,957 bone fragments, their results compared favorably with Toomey's original paleontological study of hundreds of thousands of bones that he recovered from Hall's Cave. For example, Seersholm and colleagues identified 36 of the 56 mammal genera previously identified at the site, and also found evidence for 7 genera not detected in the earlier study. These results attest to the overall accuracy and efficiency of the ancient-DNA methods used by Seersholm's team.

They also recovered ancient DNA from a number of different kinds of plants, including especially hackberry and oak trees, which they found through all time periods. They caution, however, that the abundance of hackberry might only reflect the fact that "hackberry trees were growing in the entrance of Hall's Cave as they do today." The team found that oak, mulberry, and currant grew in all time periods in about the same amounts. In contrast, they found juniper, walnut, and ash only in some periods. The record of plants Seersholm and colleagues recovered using ancient DNA generally agreed with the results of previous studies of pollen from the cave. One seemingly surprising exception was the absence of DNA from pine trees when pine was the most abundant type of tree in the pollen record. But pine pollen is spread widely by wind and can be found far from parent trees, whereas ancient DNA only comes from local sources. Therefore, this apparent discrepancy likely just means that pine was growing in the region, but not in the local area around Hall's Cave. Overall, however, Seersholm and his coauthors conclude that both the ancient DNA and the pollen recovered from the various sedimentary layers reflect similar patterns of change in vegetation from the Pleistocene to the Holocene. This is important because it means that the well-established method of using pollen to reconstruct past environments confirms the results of the sedimentary DNA approach.

Shifting plant and animal communities

During the LGM (20,000–14,700 yr B.P.) the vegetation in the vicinity of Hall's Cave was predominantly grasslands with scattered trees. Small-mammal species living in and around Hall's

Cave included bog lemming, northern grasshopper mouse, white-tailed jackrabbit, big brown bat, and prairie dog. Ducks, swans, and geese were also present. The end of the LGM witnessed the most dramatic period of change in the entire sequence. Overall animal diversity, particularly vertebrates, declined significantly beginning at around 12,600 yr B.P., and the trend continued throughout the sequence up to the Early Holocene.



Lee and Fran Hall and the Hall Family have been the stewards of Hall's Cave. They have protected the site, and allowed and encouraged scientific research of the cave to learn more about this unique site and the environmental and archaeological history of central Texas. This and all other studies in the Cave wouldn't have been possible without their support.

The environment at Hall's Cave during the Bølling-Allerød interstadial (14,700–12,600 yr B.P.) shifted to an open woodland of mostly oak and ash trees with walnut and sumac shrubs. With the loss of grasslands, grazing mammals like horses, camels, and musk oxen disappeared along with the carnivores that preyed on them, notably the saber-toothed cat and the short-faced bear. The change from grassland to woodland is also reflected in the disappearance of the prairie chicken, which Seersholm and his colleagues called one of the "most notable species changes" in the Hall's Cave record.

Dan Werndly and Mike Bunce at the entrance to Hall's Cave.

The Younger Dryas (12,600–11,700 yr B.P.) was marked by a return to a dry, cool climate with a sharp decline in trees. The pollen record shows a corresponding increase in sagebrush, which you might expect, but the DNA record for Hall's Cave shows a complete absence of sagebrush in this period. Large-mammal herbivores and carnivores suffered a significant loss of diversity, but not small mammals. Bog lemming, northern grasshopper mouse, and least weasel were present at this time.

***Bison antiquus* skull in situ.**

The Early Holocene (11,700–8000 yr B.P.) is marked by a rise in temperature and an increase in plant diversity. One reason for this increase is the return of warm-loving species to regions they had previously occupied as the temperature rose; another is the appearance of species new to the region like dayflowers and red bud. The environment in the vicinity of Hall's Cave became an oak-juniper woodland.

Although diversity in plants recovered, diversity in mammals, particularly large mammals, never did. Among small mammals characteristic of the Holocene layers of Hall's Cave are the raccoon, Mearn's grasshopper mouse, and cotton rat.

A pattern evident in ancient DNA recovered from the sediment layers of Hall's Cave is that change in temperature is coincident with many changes of species living in the area. For example, the colder temperature of the LGM detected in the corresponding layers of the cave at Hall's Cave occurs simultaneously with the presence of the big brown bat, which is absent in layers dating to the Bølling-Allerød interstadial because the winters had become too warm for the bats to hibernate. By the beginning of the Holocene, warm-adapted species like the cotton rat appear for the first time. Similar trends are evident in plants. Plants like sagebrush, bedstraw, and walnut that require a warm climate disappeared during the Younger Dryas, but thrived again during the Early Holocene.

Changes in rainfall likewise significantly influenced the changing mix of plant and animal species. Increasingly dry climate from the end of the LGM to the Early Holocene resulted in the gradual disappearance of wetland species and burrowing animals. Indeed, Seersholm and colleagues note that one of the most striking characteristics of the LGM and Bølling-Allerød layers compared with the Younger Dryas and Early Holocene layers was the abundance of burrowing mammals in the earliest periods because wetter soil was easier for the animals to dig through. Prairie dogs disappeared by the beginning of the Bølling-Allerød, the thirteen-lined ground squirrel shortly thereafter. The consequences of increasing dryness are also revealed in the ancient DNA record, which shows that such wetland-adapted species as ducks, geese, and the mole salamander disappeared from the ancient DNA record at Hall's Cave at the end of the LGM.

MICHAEL BUNCE

Dan Werndly sampling for plant ancient DNA. Gloves and full body suit avoid contaminating with modern DNA.

Ecosystem collapse at the end of the Pleistocene

Ancient DNA recovered from the layers of Hall's Cave reveals that central Texas experienced an environmental collapse at the end of the Pleistocene "that altered the entire ecosystem." During the LGM, rich grasslands sustained and were maintained by large grazing mammals including bison, musk oxen, horses, and camels. By the end of the Younger Dryas these and other large mammals had disappeared. The formerly "rich species diversity of mammals was lost."

Stafford. Behind him are the stratified sediments of Hall's Cave.

Seersholm and his coauthors argue that changing environmental conditions of the Younger Dryas had a profoundly different impact on plants in the vicinity of Hall's Cave than on mammals. This difference has important implications for the extinction of Pleistocene megafauna in North America. The fact that plant diversity fully recovered during the Holocene but not that of large mammals signifies to Seersholm and his coauthors that the appearance of human hunters on the landscape was the second of the "one-two" punches responsible for the local extirpation of large mammals and the extinction of many megafauna. This explanation is supported by the fact that small mammals like rodents, which weren't hunted by humans, responded rapidly and successfully to the changing climate. Seersholm and colleagues point as an example to the northern grasshopper mouse, which disappeared, reappeared, and disappeared again in response to shifts in climate.

Seersholm summarizes the study's main conclusion in a press release issued by Curtin University: "We found that while small mammals and plants in the region seemed to be able to cope fine with the changing climate, the megafauna did not. Because humans are the only other major factor, we hypothesize that human hunting of megafauna was the driving force of the animals' decline." The rich DNA record of Hall's Cave, supplemented by the pollen and animal bone records, enabled Seersholm and his colleagues to write a detailed environmental history for Hall's Cave, which provides strong support for this hypothesis. MT

–Brad Lepper

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Suggested Readings

Kleer, A. 2020 On the hunt for megafauna in North America. Curtin University press release: **https://research.curtin.edu.au/story/on-the-hunt-for-megafauna-in-north-america/**

Seersholm, F. V., D. J. Werndly, A. Grealy, T. Johnson, E. M. K. Early, E. L. Lundelius Jr., B. Winsborough, G. E. Farr, R. Toomey, A. J. Hansen, B. Shapiro, M. R. Waters, G. McDonald, A. Linderholm, T. W. Stafford Jr., and M. Bunce 2020 Rapid range shifts and megafaunal extinctions associated with late Pleistocene climate change. *Nature Communications* 11; **https://doi.org/10.1038/s41467-020-16502-3.**

ARCTIC RESEARCHER Vladimir Pitulko of the Institute for the History of Material Culture, Russian Academy of Sciences in St. Petersburg, has spent a good deal of his life searching for information about Paleosiberians, early peoples who occupied far northeastern Siberia for more than 40,000 years. He supplies much-needed scholarship because a dearth of early archaeological sites and human remains accounts for a poor understanding of the population history of these ancient humans and their relationship to ancient and modern populations across Eurasia.

The search for Paleosiberians

Vladimir Pitulko

Pitulko using wind and sun to dry mammoth tbones from the Yana mass accumulation, August 2021.

Born in 1960, Pitulko enrolled at Magadan State Teacher Training Institute and moved on to Leningrad State University, where he majored in archaeology, joined field research teams, and in 1995 earned a Ph.D. He's attuned to American ways and customs, having later received advanced training under a Fulbright Program grant at the Smithsonian Arctic Studies Center in Washington, D.C., and continued to work with their collections under a Smithsonian grant. He describes himself as a "northern man" who thrives in cold weather. That's decidedly a benefit, perhaps a necessity, for someone immersed in Siberian prehistory.

Land for colonizers . . . but only the hardy need apply

Northeastern Siberia is one of the most remote and extreme environments colonized by humans, but during the late Pleistocene and Holocene its population history was highly dynamic—witness the dozens of diverse ethnolinguistic groups that now inhabit the region. In a 2019 article in *Nature*, "The Population History of northeastern Siberia since the Pleistocene," Pitulko and colleagues analyze 34 ancient genome sequences, including two from fragmented milk teeth found at the 31,000-year-old Yana RHS site, which yielded the earliest and northernmost Pleistocene human remains ever found. They discovered complex patterns of past population admixtures and replacements throughout northeastern Siberia, including evidence of at least three large-scale human migrations into the region. Judging by the enormous influx of newcomers, this unforgiving territory might be mistaken for some of the choicest real estate in a broker's catalog.

Yana RHS, the northernmost site in the world occupied in the Pleistocene, was settled by a previously unknown group of ancient North Siberians who diverged about 38,000 years ago from West Eurasian hunter-gatherers. The Yana RHS population practiced a flake-based stone-tool industry and also produced highly developed bone and ivory artifacts. The Yana RHS people dispersed at the onset of the Last Glacial Maximum (LGM), about 29,000 yr B.P. The site then remains cloaked in mystery until about 20,000 yr B.P., when it was re-occupied by the first identifiable ancestors of Native Americans . . . whose origin is unknown. Later assemblages from Yana RHS are dominated by a distinctive microblade stone-tool technology, which spread north and east out of the Amur region but didn't cross the Bering Land Bridge until well after the peopling of the Americas.

A descendant of the new inhabitants of Yana RHS, represented by the 9800-year-old skeleton from Kolyma River, is closely related to the Siberian ancestors of Native Americans and ancestral to present-day inhabitants of the region. Gene-flow events in both directions were occurring across the Bering Strait at this time.

"When did First Americans arrive in the New World?" begs multiple answers

"One of the most intriguing questions in prehistory is when the First Americans arrived in the New World," Pitulko acknowledges, "but the answer should be split in two. Northwestern North America is part of the New World, but in the late Pleistocene it was a part of the Bering landmass. In Western Beringia (now arctic East Siberia) we find firm evidence for human occupation beginning at least 40,000 years ago. Although these people didn't cross to America, they made a genetic contribution to the populations formed by multiple migrations to the Americas. Now disappeared, Central Beringia is thought to be the area where the American pioneer population formed."

ELENA PAVLOVA

First discovery of in situ cultural material at the Yana site. The investigator is pointing the scale bar to the location of a horse mandible, found in association with lithic flakes and bone fragments, that produced the first radiocarbon date, September 2002.

The biggest question remaining, Pitulko feels, is when these people found their way to areas south of the Laurentide glacier. Since there is no well-recognized archaeological evidence for that, the record for most of the American continent starts about 15,000 years ago, although new information turns up almost every day. Until new evidence presents itself, Pitulko stands by the theory that First Americans arrived from Siberia on foot.

ANDREI SHUBENKIN

Type 1 bead (simple rounded mammoth ivory bead painted with red ocher) from the westernmost limit of the Northern Point area, found by water screening through 2-mm mesh, July 2016.

He confesses interest in other hypotheses in archaeological literature—for example, the strong similarities between American stemmed points and those made in the "incipient Jōmon" period in northern Japan (**MT 36-2,** "Loren Davis: Validating a Pacific Coast entry route"). He was also impressed by Dennis Stanford and Bruce Bradley's Solutrean Migration theory, which found similarities in knapping between Solutrean and Clovis lithic technologies (**MT 17-1,** "Immigrants from the *other* side?"), but Pitulko remains skeptical about the watercraft technology and arctic-survival technology Solutreans would have needed to cross the North Atlantic along the pack-ice limit.

ELENA PAVLOVA

Aerial view from the west of the Yana site area. Cultural remains have been found along the left bank, which has been heavily eroded by the river.

"The land bridge was there, giving ancient Siberians the option to cross to the New World," Pitulko explains, "as the opportunity to explore and occupy new space became necessary. The ancient Siberians were also the closest source population and had a much better starting point to reach the New World."

The role of mammoths in the Paleolithic

Rising temperatures and consequent rising sea level at the end of the last Ice Age enormously altered the mammoth steppe of Russia, shrinking and drowning former mammoth grasslands and leaving herds stranded on isolated islands. The tusks of these long-dead mammoths, encased in ice for millennia, now lure "mammoth pirates" into the Russian wilderness, where they make fortunes from trade in mammoth tusks. The tusks contain valuable information about climate, diet and the environment, which is lost to science by the illegal trade in mammoth ivory (**MT 33-4,** "Of mammoths and men").

Pitulko explains that the principal reason early hunters targeted mammoths was to obtain tusks and bones for tools, and likely also fat for fuel. When shattering the bones for toolstock, these early hunter-gatherers discovered the immense nutritional value of the marrow inside. Little of the difficult-to-kill creature went to waste. The Yana RHS site in Arctic Siberia yielded mammoth tongue bones, indicating that mammoth meat was eaten in spite of its poor quality compared with meat of game animals found at the Yana site—horse, bison, and reindeer. Hunting mammoth as a source of meat would have ranked low as a reason compared with the need for tusks, bones, and fat.

Although it's difficult to gauge the length of time required for bones to accumulate at a site, Pitulko believes that the occupants of Yana RHS hunted mammoths infrequently. Although the Yana site yielded the remains of 200–300 mammoths, radiocarbon dating verifies that these accumulated over a period of several hundred years.

If Paleosiberian mammoth hunters can be found at fault, it was for their practice of targeting members of a herd whose existence was essential for the future of the mammoth population. The open landscapes of northern Eurasia, where wood was scarce, likely forced the Yana people to target mammoths for ivory, which they used to make ivory hunting tools such as full-sized thrusting spears and composite tools, just as Greenland Eskimos used narwhal tusks to make spears or spear shafts in the absence of wood. Yana hunters preferred specific mammoths as a source of toolstock for making spears; the most desirable were adolescent and young adult female mammoths bearing slightly curved tusks 120–180 cm long. This selective hunting, which targeted the subset of specimens that would have produced offspring and thereby contributed to population stability, coupled with environmental changes of the LGM, may have nudged mammoth populations closer to extinction.


ELENA PAVLOVA

Pitulko cleaning the northern wall of the excavation area at the Zhokhov site, June 2005.

Pitulko's research into human culpability as a major factor in mammoth deaths hasn't gone unnoticed. "Vladimir has been central in introducing humans as an important factor in generating the large accumulations of mammoth/elephant bones in Russia/Siberia," says his long-time friend archaeologist Ole Gron of University of Copenhagen. "A focus on registering lithic artifacts as well as projectile impacts has been important in puncturing the somewhat complex constructed natural-disaster scenarios that earlier were used to explain these accumulations."

Pitulko in the early '90s at the storage area in the Institute for the History of Material Culture, St. Petersburg, unpacking wooden artifacts from the Zhokhov site. He's holding a wooden sled runner excavated in 1991.

Pitulko theorizes that both Old and New World hunters frequently attacked the least formidable animals, especially if they had relatively straight tusks. Narrow ravines or passes were preferred for the kill site, and mass killings or pitfalls weren't hunting strategies (**MT 36-1,** "Beyond survival: Hunting mammoths in the Paleolithic"). The relative ease in killing and butchering younger animals may have led to this preference.

The foreshaft construction of spears found at the Yana site, a technology shared with Clovis toolmakers, made it possible to throw with greater force and from a safe distance. Some ivory points from the Yana site were more than 60 cm long.

The origin of Native Americans remains elusive

The three models for Native American origins currently contending for favor with archaeologists are:

1. SW Europe via the North Atlantic during the LGM (Solutrean Migration hypothesis)
2. NE Asian maritime region via North Pacific coastal rim after the LGM (Coastal Entry route)
3. NE Asian interior via Beringian interior after the LGM (Overland route via the Ice-Free Corridor)

In 2019 Pitulko and colleagues wrote an interdisciplinary critique of these models and found difficulties with each of them, They conclude that a wholly credible model has yet to be formulated and can now be sketched only in general terms.

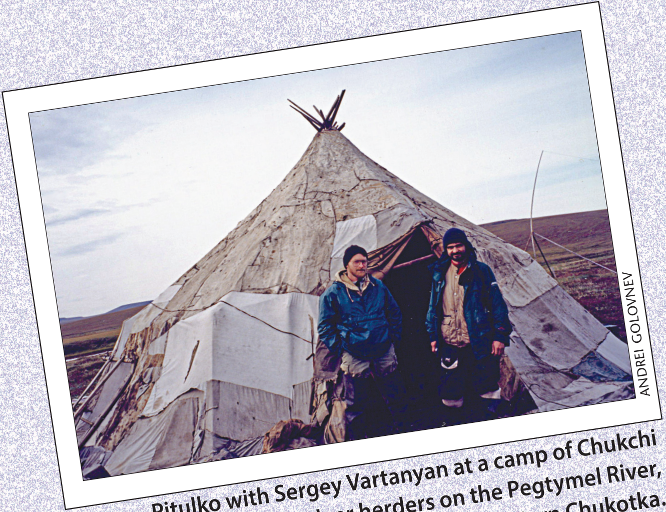
Pitulko observes that many anthropologists who had disputed dates on older sites executed an abrupt about-face with the collapse of the Clovis-First model. For most scientists, however, the change in their favored theory is spatial rather than temporal: They now support the theory that the initial peopling was via a Northwest Pacific route and not an interior Ice-Free Corridor. This view has gained favor with new evidence that an ice-free corridor wasn't available until the beginning of the Younger Dryas.

A synthesis of data and analyses in archaeology, genetics, and quaternary studies has resolved some issues, but has failed to answer to Pitulko's satisfaction the question, Why was the Western Hemisphere settled so late in human prehistory? Pitulko notes that all the models are based on similarities in lithic technology between artifact assemblages in the Americas and those in various parts of northern Eurasia, yet each fails to accommodate environmental variables that either expedited or prevented movements of people to the Western Hemisphere during the past 50,000 years.

Important issues to address now

Pitulko believes more and better archaeological evidence is needed to answer genetic and biological questions about the an-

A Siberian Odyssey


ANDREI GOLOVNEV

Pitulko with Sergey Vartanyan at a camp of Chukchi reindeer herders on the Pegtymel River, western Chukotka.


ELENA PAVLOVA

Mud deters Yana mosquitoes, though it tends to dull the romantic image of archaeology.


ELENA PAVLOVA

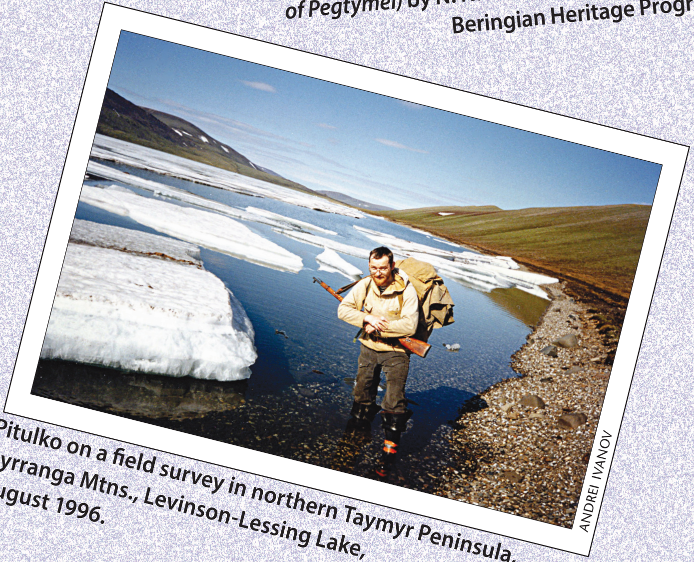
Pitulko piloting an ARGO Response ATV across the Balyktakh River in a field survey on Kotelny Island (New Siberian Islands), August 2003.


VLADIMIR PITULKO

Reindeer depicted at Stone IV of the Pegtymel Rock Carvings, Pegtymel River, Western Chukotka, composition 16, in *Mysteries in the Rocks of Ancient Chukotka (Petroglyphs of Pegtymel)* by N. N. Dikov (1999), Anchorage: Beringian Heritage Program.


ELENA PAVLOVA

Pitulko (*right*) chatting with John Hoffecker at the Beringian Standstill Workshop held at the Institute of Arctic and Alpine Research (INSTAAR), University of Colorado at Boulder, February 2016.


ANDREI IVANOV

Pitulko on a field survey in northern Taymyr Peninsula, Byrranga Mtns., Levinson-Lessing Lake, August 1996.

cestry of First Americans and about their means of entry and the timing of their arrival. Archaeologists in both the U.S. and Russia need to search out human remains as a source of genetic material, although he admits that the chance of recovering this material in non-frozen regions is generally low. He believes that more energy should be devoted to the search for potentially old sites and then dating them, particularly in East Siberia, Western Beringia, and NE Russia, an area that remains almost unexplored even now. "It would be helpful," he tells us, "if we could fill in the gaps in the record first of all, although we are short of the funding and people to do the work of expanding the archaeological record."

His world-acclaimed scholarship, fueled by decades of field work in the harshest environment on this planet, hasn't dulled Vladimir Pitulko's humility. "These important results wouldn't happen," he says, "without the support of my family and friends."

Pitulko's future in First Americans studies

For Pitulko, his work remains for him an intellectual challenge. He gets great pleasure from working in the wilderness and sharing his discoveries with the archaeological community. "For myself," he states candidly, "I'm going to do my work as long as I can, similar to a good sled dog who pulls the sled for as long as he can and dies in the harness." He hopes to continue working at the Yana site and in other North Siberian regions, although the work is difficult and takes lots of time. New information is discovered every year, and haste is important because the high erosion rate on the riverbank makes it important to explore before information is lost. He would also like to concentrate on the large amount of information he has already gathered, studying data, writing, and publishing.

Pitulko has received many awards and has authored, coauthored, or coedited 10 books and has to his credit 8 articles published in *Nature* and *Science,* thus cementing his place in acclaimed contributors to our knowledge of Arctic archaeology.

"Pitul'ko has unlocked the Paleolithic prehistory of the Siberian Arctic leading to the doorstep of the Americas—mammoths, dogs, ivory technology, and much more," says William Fitzhugh, Senior Scientist, Smithsonian Institution Arctic Studies Center and curator of North American archaeology. "His work at Zhokhov and Yana has transformed our view of early humans and how to do archaeology in permafrost regions. He's unlocked the freezer—and kept his hands and feet warm in the process."

–Martha Deeringer

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Suggested Readings

Sikora, M., V. V. Pitulko, et al. 2019 The population history of northeastern Siberia since the Pleistocene. *Nature,* https://doi.org/10.1038/s41586-019-1279-z

Pitulko, V., P. Nikolskiy, A. Basilyan, and E. Pavlova 2013 Human habitation in Arctic Western Berinigia prior to the LGM. *Paleoamerican Odyssey,* ed. K. E. Graf, C. V. Ketron, and M. R. Waters. Center for the Study of the First Americans, Dept. of Anthropology, Texas A&M University, College Station.

First Evidence of S.A. Megafauna Killed

continued from page 10

Humans as another lineage of mammals

Mothé declares that "in the future, my goal is to understand proboscideans within the context of the Ice Age here in South America, compared with other places. I want to follow this research line because there's a lot to discover in relation to humans and megafauna. There are many specimens in collections, so we should review them to search for evidence that could lead to another find. It's important, too, to determine which sites have the potential to reveal their secrets."

Conventional wisdom has dictated that adult mammals were the sole target of human hunters, but Mothé's analysis of the skull of the *Notiomastodon* calf from Lapa do Caetano cave has changed that thinking.

Paleozoologist Mothé's main line of research is the evolution of proboscideans, and she hopes to determine which proboscidean species existed in South America during the Ice Age and Pleistocene. She finds it puzzling that "we didn't have mammoths in South America; we only had these types of mastodons. I wonder why mammoths appear in Central America (they reach as far as Panama) but not in South America."

For Mothé, humans in South America are merely another lineage of mammals that arrived and started to interact with the populations of animals that were already there. "We know there are cultural aspects of ancient humans," she tells us, "but I'm more interested in these biodiversity interactions: how humans competed for resources with the other mammals, how they used the environment, how humans exploited these giant mammals as resources."

–Katy Dycus

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Suggested Readings

Mothé, D., et al. 2020 An artifact embedded in an extinct proboscidean sheds new light on human-megafaunal interactions in the Quaternary of South America. *Quaternary Science Reviews* 229:1–8.

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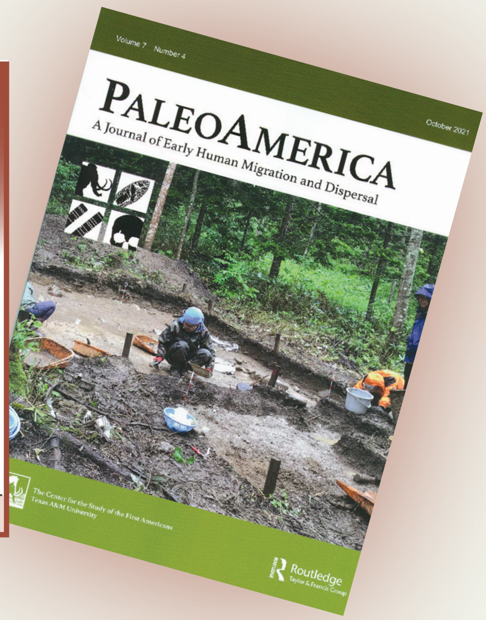

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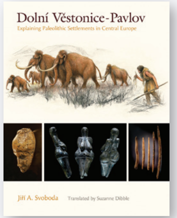

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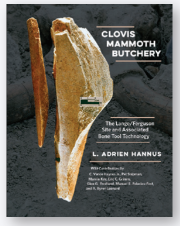

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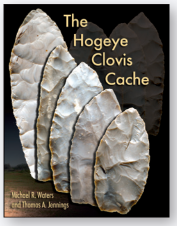

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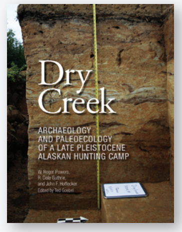

Dry Creek: Archaeology and Paleoecology of a Late Pleistocene Alaskan Hunting Camp, W. Roger Powers, R. Dale Guthrie, and John F. Hoffecker; edited by Ted Goebel. 2017. 344 pages. Hardback (ISBN 978-1-62349-538-1).
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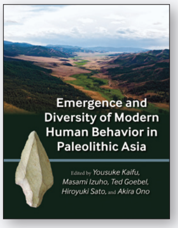

Emergence and Diversity of Modern Human Behavior in Paleolithic Asia, Yousuke Kaifu, Masami Izuho, Ted Goebel, Hiroyuki Sato, and Akira Ono. 2014. 230 pages/ Hardback (ISBN 978-1-62349-276-2).
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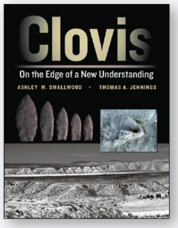

Clovis: On the Edge of a New Understanding, Ashley M. Smallwood and Thomas A. Jennings, editors. 2014. 376 pages. Hardback or e-book (ISBN 978-1-62349-201-4).
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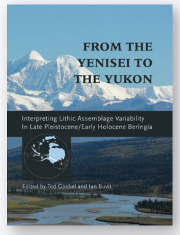

From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/ Early Holocene Beringia, Ted Goebel and Ian Buvit, editors. 2011. 408 pages. Hardback or e-book (ISBN 978-1-60344-321-0). Reg. price $80.00
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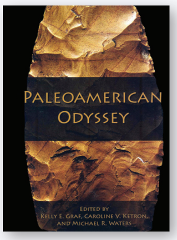

Paleoamerican Odyssey, Kelly E. Graf, Caroline V. Ketron, and Michael R. Waters, editors. 2014. 584 pages. Paperback (ISBN 978-1-62349-192-5)
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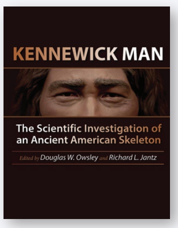

Kennewick Man: The Scientific Investigation of an Ancient American Skeleton, Douglas W. Owsley and Richard L. Jantz, editors. 2014. 600 pages. Hardback (ISBN 978-1-62349-200-7).
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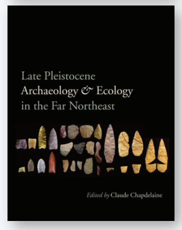

Late Pleistocene Archaeology and Ecology in the Far Northeast, Claude Chapdelaine, editor. 2012. 264 pages. Hardback or e-book (ISBN 978-1-60344-790-4).
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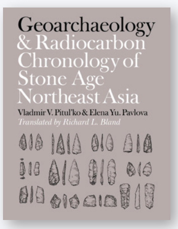

Geoarcheology and Radiocarbon Chronology of Stone Age North East Asia, Vladimir V. Pitul'ko and Elena Yu. Pavlova; Richard L. Bland, trans. 2016. 256 pages. Hardback (ISBN 978-1-62349-330-1).
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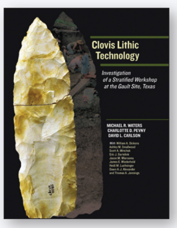

Clovis Lithic Technology: Investigation of a Stratified Workshop at the Gault Site, Texas, Michael R. Waters, Charlotte D. Pevny, and David L. Carlson. 2011. 224 pages. Hardback or e-book (ISBN 978-1-60344-278-7).
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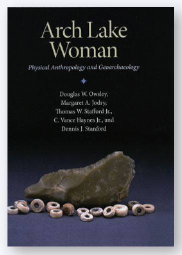

Arch Lake Woman: Physical Anthropology and Geoarchaeology, Douglas W. Owsley, Margaret A. Jodry, Thomas W. Stafford, C. Vance Haynes, and Dennis J. Stanford. 2010. 93 pages. Hardback (ISBN 978-1-60344-208-4).
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