



MAMMOTH TRUMPET

Volume 32, Number 1 ■ January, 2017

Center for the Study of the First Americans
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College Station, TX 77843-4352
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Scouting caribou drive lanes under Lake Huron

When glacial meltwater was creating the Great Lakes 9,000 years ago, this floor of present-day Lake Huron was a causeway that caribou transited in their annual migrations. Opportunistic hunters then created rock-lined lanes to channel their prey into kill zones. Investigating these features in icy waters 35 m below the surface would be a grueling task for underwater archaeologists without the help of Jake, the remote-operated vehicle piloted by Ashley Lemke and John O'Shea in their research vessel. For the story on how they explore this exotic paleoenvironment, see [page 16](#).

Photo by Tane Casserley, NOAA

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Department of Anthropology
ISSN 8755-6898

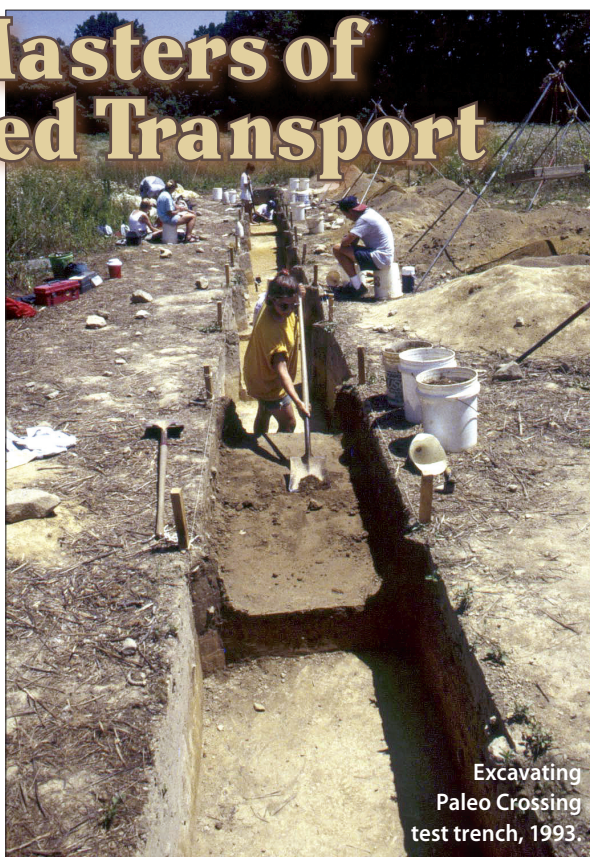
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Clovis, Masters of Organized Transport

ONE OF THE OLDEST and most significant Clovis-age campsites in the Northeast has yielded tantalizing new evidence for extreme long-distance travel by New World colonizers. Geochemical evidence extracted by Neutron Activation Analysis (NAA) from museum-curated stone-tool debitage associated with the 12,900-year-old Paleo Crossing site in northeast Ohio confirms that hunter-gatherers carried Wyandotte chert more than 500 km—possibly as much as 1,000 km—from Harrison County in Indiana to make artifacts. The site was last excavated in 1993.

The new findings substantiate a “long-held, but poorly corroborated assumption that Clovis foragers regularly depended on ‘exotic’ stone for tool production,” researchers write in a landmark paper published last year in the *Journal of Archaeological Science*. Matthew Boulanger, Briggs Buchanan, Michael J. O’Brien, Brian G. Redmond, Michael D. Glascock, and Metin Eren coauthored the paper that marks the “first reported geochemical analysis of Clovis artifacts from eastern North America.” Their findings

verify earlier research by Canadian anthropologist Christopher C. Ellis of Western Ontario University in 2011, who determined that Clovis people in northeastern North America traveled farther than their post-Clovis counterparts to get toolstone. Moreover, this new study explores a new dimension of the Clovis culture, “a geographically widespread hunter-gatherer social network” that made possible its rapid expansion across the continent.



Excavating
Paleo Crossing
test trench, 1993.

CLEVELAND MUSEUM OF NATURAL HISTORY

INSIDE

6 A perplexing anomaly for genetics to resolve

Siberia, says Eske Willerslev's team, is the homeland of all Native American ancestors, who first stopped over in Beringia. But Australo-Melanesian DNA found in Amazonians by David Reich's team suggests another entry.

9 The Smithsonian is his home base, the world is his workshop

Dennis Stanford's illustrious career, which spans more than four decades, is fueled by generous measures of erudition and common sense.

16 Investigating the handiwork of caribou hunters with the help of scuba gear and Jake ROV

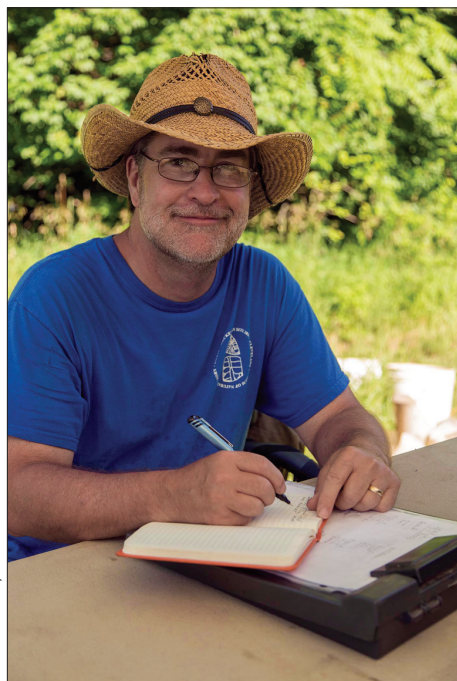
"It's easier to train an archaeologist to dive than to teach a diver to be an archaeologist," says John O'Shea, who is studying rock-lined caribou drive lanes 35 m under the surface of Lake Huron with the help of archaeologists-turned-divers and his famous submersible robot, Jake.

An impressive exercise in logistics

Wyandotte chert toolstone found in great quantities at Paleo Crossing implies the existence of a broad social network that had to be mobilized to move hundreds of pounds of stone in one operation from the Indiana quarry

to the northeastern Ohio camp—the most parsimonious explanation for how it got there, according to Metin Eren. Dr. Eren considers it unlikely that such an enormous quantity of homogeneous toolstone could have been obtained piecemeal through trade along the way, or by means of repeated trips to the Indiana quarry while ignoring lithic material from sources closer to the Paleo Crossing site. A remarkable level of social cohesion would be required of a group to execute the all-at-one-time stone-moving feat. Nevertheless, Eren believes they succeeded. Exactly how they did it remains a matter of conjecture.

Eren suggests two ways the group



Redmond in the field.

may have accomplished the task of appropriating a new far-off source of toolstone, either by stealthily infiltrating an unexplored area, or by advancing boldly en masse after first reconnoitering to assess the risk. He believes these Clovis people, with their highly organized social framework, proceeded boldly but not blindly into new territory, where they would systematically locate and catalog new resources. Choice toolstone was then collected and transported to their permanent camp hundreds of kilometers distant. “When you see this amount of rock traveling such distances,” Eren

emphasizes, “it is a clear indication there were no boundaries, no walls, separating people on the landscape.” Essential to accomplishing the formidable feat was a strong social network designed to organize and set in motion tasks allocated among many individuals.

Eliminating the guess factor in sourcing toolstone

The suggestion that Clovis peoples trav-

eled great distances while colonizing North America has been explored by many researchers over the years. Lithics analysts have routinely relied on visual, “qualitative descriptions” of the toolstone of lithic artifacts found at archaeological sites to match the material to distant “exotic” stone outcrops; long-distance transport of toolstone was then inferred between the two places. (A notable exception to this practice

MAMMOTH TRUMPET



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

POSTMASTER: Send address changes to:

Mammoth Trumpet

Department of Anthropology, Texas A&M University
4352 TAMU
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Newman Printing Co., Inc. Printing and mailing
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—Michael R. Waters, Director

of visually comparing toolstone samples in western North America is the insightful analysis of lithic artifacts at the Eckles Clovis site in Kansas by archaeologist Steve Holen of the Center for American Paleolithic Research.) The source of the toolstone identified in nearly all curated Clovis assemblages therefore depends on someone's subjective assessment of the raw material.

Enter "hard science," which introduces objective certainty into the task of identifying the source. With absolute confidence Eren can say of the toolstone found at Paleo Crossing "there is no question it had to be carried from Indiana." Why? Because there are no other sources of Wyandotte chert with the same chemical signature.

How NAA works

To detect the composite elements in a sample by NAA, the material is first irradiated with neutrons to make the sample radioactive. Gamma rays are then emitted from the radioactive sample in a spectrum characteristic of the types and amounts of different elements present in the sample. The chemical signature thus uniquely identifies the precise mix of trace elements present. Matching the sample with candidates is then a straightforward exercise, as free of doubt as fingerprinting or analyzing the DNA of living matter.

NAA isn't the only method successfully used today to objectify toolstone sourcing. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is another technology that matches toolstone with quarry material bearing the same chemical signature (MT 30-2, "Sourcing Clovis toolstone"). NAA can detect the concentration of an element with an accuracy of about 5% and precision as fine as 0.1%, with a sensitivity of less than 1 ppm. Although the procedure is nondestructive, the irradiated sample remains radioactive and therefore requires special handling and disposing.

For many years NAA was used in soil science, geology, forensics, and the computer industry. In 1954 archaeologists first used it to source



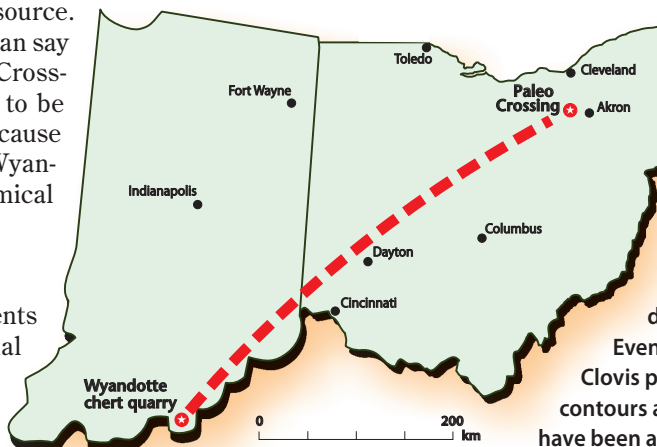
ADAM DURANT

archaeological ceramics, which remains its primary application in archaeology today. Its usefulness in archaeological investigations is hobbled by the current shortage of research reactors; fewer than 10 reactors that analyze archaeological material now exist in the U.S., according to Matthew Bou-

langer of the archaeometry laboratory at the University of Missouri Research Reactor in Columbia, where the Paleo Crossing samples were tested. Despite this dearth of testing facilities, however, archaeologists are making more use of those available. Dr. Boulanger has seen a marked increase in the use of NAA over the last few decades. Beginning in 2005, the Missouri lab analyzed between 3,000 and 4,000 samples a year; that number reached 8,000 samples in 2015. "We are

pleased with the results we are getting from these studies," he reports, "and we would like to see more people trying it out and working with our lab."

Eren enthusiastically en-



The Wyandotte chert quarry in Indiana lies 510 km from the Paleo Crossing site in Ohio, an impressive distance to transport raw toolstone.

Even more impressive is the actual distance Clovis people traveled, allowing for terrain contours and intervening waterways, which may have been as much as 1,000 km.

dorses NAA, which "provided hard, scientific, non-subjective evidence" for long-distance acquisition of stone for toolmakers at Paleo Crossing.

Clovis people were hikers

The straight-line distance from Harrison County in Indiana to the Paleo Crossing site in Ohio is 510 km. Impressive as this figure appears, it falls short of the actual distance these Clovis foragers must have traveled. Cross-country travelers seldom walk in a straight line. Instead, their route is determined by the terrain. If these Clovis people took the easiest overland route possible, Eren calculates they could have traveled 825 km, and that distance jumps to 1,000 km if they followed river systems.

"We have long thought Clovis peoples traveled long distances," Eren says. "And I think it was cool we were able to confirm that."

Imagine, as Eren does, a group of colonizers arriving at the Indiana toolstone quarry not knowing when they will next find an outcrop of quality material. As a hedge against the uncertain future, the band prudently collects hundreds of pounds of stone and distributes it among the party's

Eren directing his field project on the Middle Stone Age at Olduvai Gorge, Tanzania.

strongest hikers in bundles of perhaps 20 pounds, along with all the other equipment necessary for their survival. Led by scouts who seek campsites and conduct business with other groups they meet along the way—trading survival tips on the location of water holes, abundance of game, barriers they may face—the

band proceeds northeast, possibly tracking herds of caribou that skirt the edge of receding glaciers, until they reach their destination at Paleo Crossing.

A site that continues to pay dividends

Paleo Crossing remained hidden until in 1990 avocational archaeologist Jim Remington discovered it and quickly alerted archaeologists at the Cleveland Museum of Natural History (MT 7-4, "Investigations at Ohio site push back dates for Clovis"). Surveys and excavations, led by the museum and then curator David Brose until 1993, painted a remarkably detailed picture of Paleoamerican habitation. Pit features and postmolds were found that may have been part of a Clovis-era house. Investigators discovered more than 10,000 artifacts including Clovis fluted projectile points, endscrapers, prismatic blades, and unifacially worked flake tools. Radiocarbon dates suggested the site may have been occupied as early as 13,000 years ago, when it was established on a south-facing terrace below the crest of a glacial kame, with a series of kettle bogs, or depressions, to the east.

Brose and other researchers identified three fourths of the artifacts—subjectively—as Wyandotte chert, also known as Indiana hornstone. The source lay at an eyebrow-raising distance of more

Lidar image and topo overlay showing site area (the site is just south of the large glacial kame feature).

than 500 km. That revelation, added to a growing database of exotic toolstone sources from other sites across the continent, helped fix an indelible image of Clovis peoples as long-distance travelers. Early researchers at Paleo Crossing envisioned these people pursuing herds of caribou across arboreal spruce parkland and open post-glacial tundra supplied with plenty of water—

prime game habitat and an ideal campsite. That first image of Paleoindian lifeways is broadening and subtly shifting as researchers keep digging.

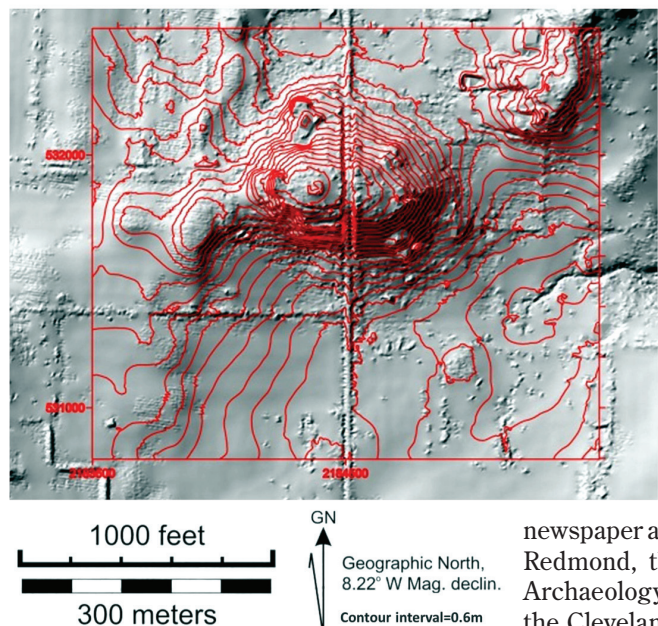
Although no major excavation has been done at Paleo Crossing since 1993, the museum collection is constantly studied by scientists armed with fresh ideas and new tools. Logan Miller, for example, a graduate student in anthropology at Ohio State University, concluded from microwear studies of fluted points in the collection that the stereotypical image of Clovis people as strictly big-game hunters requires a shift in our mind set. Game may have been a staple in their diet, but these foragers also liked a salad with their meat: Miller found that many of the tools were used to cut and scrape plants as well as meat (MT 29-3, "Clovis spear points were used to process plants"). Other researchers have reached a similar conclusion elsewhere (MT 28-1, "The big game hunting conundrum" and MT 22-2, "The Shawnee Minisink site").

A long association of scientist and site

Metin Eren has enjoyed a long and fruitful association with the Paleo Crossing site and its artifacts. His early interest in science and history steered him toward archaeology and away from medicine, a profession that runs deep in his family. "The trouble," he confesses, "is I don't like blood." An article in the *Cleveland Plain-Dealer*

newspaper about a local dig led him to Brian Redmond, the John Otis Hower Chair of Archaeology and curator of archaeology at the Cleveland Museum of Natural History.

The Paleo Crossing collection lies in drawers at the museum, waiting for researchers to tease out more secrets from the site. In 2000 while a junior in high school, Eren joined the summer field program sponsored by the museum to exercise his bud-



Suggested Readings

- Boulanger, M. T., B. Buchanan, M. J. O'Brien, B. G. Redmond, M. D. Glascock, and M. I. Eren 2015 Neutron activation analysis of 12,900-year-old stone artifacts confirms 450–510+ km Clovis toolstone acquisition at Paleo Crossing (33ME274), northeast Ohio, U.S.A. *Journal of Archaeological Science* 53, pp. 550–58.
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- Eren, M. I., B. G. Redmond, G. L. Miller, B. Buchanan, M. T. Boulanger, B. M. Morgan, and M. J. O'Brien in press Paleo Crossing (33ME274): A Clovis site in northeastern Ohio. *In the Eastern Fluted Point Tradition*, vol. 2, edited by Joseph A. M. Gingerich. University of Utah Press.
- Miller, G. L. 2013 Illuminating activities at Paleo Crossing (33ME274) through microwear analysis. *Lithic Technology* 38(2): 97–108.
- 2014 Lithic microwear analysis as a means to infer production of perishable technology: A case from the Great Lakes. *Journal of Archaeological Science* 49:292–301.

ding archaeological interests. With Dr. Redmond as mentor, Eren chose the Paleo Crossing collection as the subject of his undergraduate thesis at Harvard. He later attended Exeter College in England and earned his doctorate in anthropology from Southern Methodist University. Over the years he has collaborated with Redmond on papers that describe various aspects of the Paleo Crossing collection.

Never far beneath Eren's consciousness lurked the original hypothesis that posited a remote source for the chert toolstone. He asked himself, Did people really carry these rocks 500 kilometers? A chance meeting with Boulanger at a Society of American Archaeology meeting led to the decision to subject Paleo Crossing artifacts to NAA analysis.

They chose from the Paleo Crossing collection 88 artifacts, all of them specimens of debitage from stone-tool knapping instead of finished tools, which might suffer damage. All were visually consistent with Wyandotte chert. The results of the NAA tests were startling. Although the bulk of the artifacts tested bore the chemical signature of the Wyandotte chert formation in Harrison County, Indiana, some did not. For Eren, it came as a shock. For lithics analysts, it's a red flag, a warning to beware of look-alike stone whose misidentification based on visual examination can seriously skew research results.

Eren cautions that "just because a rock looks local, it may not be. Some of these samples looked like Wyandotte, but were actually from Flint Ridge," only 150 miles away, much closer to Paleo Crossing. "Here we had a look-alike rock. We thought we were sending samples that were completely of Wyandotte chert, but we were wrong." Eren confesses that it was even possible that *all* the samples could have come from Flint Ridge even though they were identified as Wyandotte from Harrison County, Indiana. "It was impossible to tell," he says, "until we did the analysis."

The authors of the study assure us that the sobering results of the NAA testing don't imply that archaeologists should toss out all older, more subjective, hypotheses. They are confident that "other asserted claims for long-distance Clovis stone acquisition in eastern North America based on macroscopic evaluation of raw material, while not validated, can now at least be considered plausible."

The future for Paleo Crossing and the collection

As for the museum collection of 10,000 artifacts, in a perfect world Eren would like to see the entire assemblage tested to ascertain the source of every piece of toolstone. He readily concedes, however, that this is impossible, owing to fiscal constraints and the need to preserve artifacts so they remain available for nondestructive testing techniques sure to be developed in the future.

For curator Redmond, the NAA testing of artifacts collected from a site dug two decades ago validates the function of his museum. "Keeping everything in one place, artifacts, all the field notes and records, and making everything available for researchers is what museums like ours are set up to do," he says. Without museums, future researchers would be out of luck.


The owners of the land occupied by the Paleo Crossing site continue to preserve the site despite a nearby housing development. For their responsible attitude, the scientific community is grateful.



Eren plans to resume field excavation at the Paleo Crossing site in the hope of finds answers to research questions. "A lot of waste flakes and debitage need to be examined," he says, "so we can better understand what these people were making." Dates need to be refined to determine whether what ex-

Artifacts and debitage from Paleo Crossing, and two (modern) Wyandotte chert samples.

ists is actually a very old Clovis component, older than the 12,000-plus years indicated by early radiocarbon dating. He has, in fact, already submitted a burnt flint sample to the thermoluminescence testing lab at the University of Washington to answer that question. He also hopes to examine features initially identified as postmolds to determine whether there really did exist some sort of structure.

The many years of Eren's association with the Paleo Crossing site have instilled in him enormous respect for its occupants. Well organized, tuned in to their environment, and not shy about stepping into the unknown, "they didn't walk willy-nilly across the landscape and hope they could survive," he tells us. "They planned a route and followed it." In this case, from an outcrop of toolstone hundreds of miles from their Paleo Crossing destination. 

—George Wisner

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WHEN DID HUMANS first enter the Americas? Where did they come from? How many waves of migration were involved? Eske Willerslev, Director of the Centre for GeoGenetics at the Natural History Museum of Denmark, working with a team of 100 other scientists representing 75 institutions from at least 16 countries, has produced a comprehensive genetic picture of the peopling of the Americas that answers these fundamental questions about the First Americans. A separate and more focused study led by David Reich of the Department of Genetics at Harvard Medical School, however, appears to cast doubt on the answer Willerslev's group got for one of these questions. Did one of the teams get it wrong, or is it just a matter of interpretation? Or does it mean that more research is needed to sort out an apparent contradiction?

Answers to the biggest questions about the first Americans can be found in the microscopic alphabet of DNA, but in order to get reasonably definitive answers to questions about the genetic history of a continent you need DNA from a large sample of people both from within that population and from populations thought to be descended from the same group, or groups, that were ancestral to the aboriginal people inhabiting the continent. Willerslev and his team sequenced the complete genomes from 31 living people, including five indigenous North, Central, and South Americans, 12 indigenous Siberians, and 14 people from Oceania, a region that includes Australia and the islands of the south and central Pacific Ocean. In addition, they sequenced portions of the genomes of 23 ancient North and South Americans ranging in age from 200 to 6,000 years ago, including remains from Mexico identified as Paleoamericans based on features of their skulls that appeared distinctly different from the vast majority of modern indigenous Americans (**MT 30-3**, "DNA links Mexican Paleoamerican to Native Americans"). Finally, the team assembled data on single-nucleotide polymorphisms (SNPs) in 79 living people from 28 indigenous populations from across the Americas and Siberia. SNPs are variations at a single site along the DNA molecule. The analysis of hundreds or, even better, thousands of SNPs can reveal patterns characteristic of particular populations. As a result, SNPs are important clues to how populations are related to one another.

These data, combined with previously published genomes, including those obtained on ancient human remains such as the 24,000-year-old Mal'ta child from Siberia (**MT 29-2**, "Ancient Siberian boy reveals complex origins of First Americans") and the 12,600-year-old Anzick child (**MT 29-2**, "Clovis child answers fundamental questions about the First Americans"), provide an unprecedented clear window into American population history. Their results were published in the August 21 issue of the journal *Science*.

The First Americans came from Asia—not Europe

Willerslev and his team first "explored the genetic structure of Native American populations in the context of worldwide populations." They found as expected that all Native Americans are more closely related to each other than to any other world population. Yet Willerslev's group also confirmed some genetic differences between the native peoples of northern North

Genetic Clues Answer Fundamental Questions about the Peopling of the Americas

America, including the Paleo-Eskimo, Inuit, and Athabascans, and the rest of the hemisphere.

The most closely related non-American populations are the Siberian Yupik and Koryak, but their close relationships have somewhat different histories. The Koryak represent descendants of the population from which the First Americans emerged, whereas Willerslev and his team judge the Yupik to represent a "back-migration of the Inuit into Siberia." Willerslev's group therefore concludes that their "results support a common Siberian origin for all Native Americans, contradicting claims for an early migration to the Americas from Europe (**MT 28-2**, "Do Clovis origins lie in Paleolithic Spain? Part 1").

When did Paleoasians become the First Americans?

The most fundamental question in American prehistory is, of course, When did people first set foot in the Americas? Genetics may not be able to provide a definitive answer to this question, but it can shed light on when the precursors of the First Americans became genetically isolated from their Asian forebears and on when American populations began to diverge from one another, which may correspond to the time when they began to disperse throughout the Americas. This genetic isolation may have happened at the same time people crossed over into America, or it may have happened when the ancestors of the First Americans became isolated in some region of northeastern Asia perhaps centuries before their descendants found their way into the New World.

Genetic data can be used as a kind of calendar because mutations tend to occur at a more or less constant rate in a population. Therefore, when two populations move away from each other, they each begin to accumulate different mutations that will make the groups more and more different over time—assuming they continue to remain geographically isolated from each other. Once you know the rate at which mutations occur, you can reliably estimate how long ago two groups separated, based on the number of mutations unique to each group.

Willerslev's team notes that "there is still some debate regarding mutation rates in the human genome," so there is a

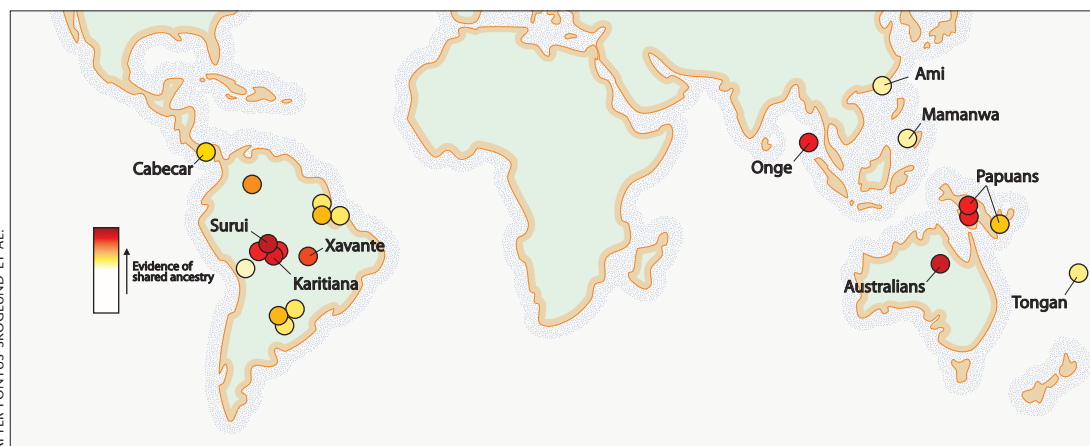
which caused massive melting of the continental ice sheets and a rise in sea level that submerged the Bering Land Bridge.

When did distinctive local populations begin to develop?

If the First Americans arrived as a single population, when did they begin to develop into the regionally distinctive northern and southern subgroups?

Willerslev and his team calculate that the modern Athabascans and the Karitiana of the Amazon diverged around 13,000 years ago. Although it isn't known where this divergence

occurred, Willerslev and colleagues suggest, based



Genetic similarities exist between some Australasian groups and some South American groups that aren't found in populations in North and Central America and Europe. Dark red indicates strong evidence of shared ancestry; the lighter the color, the less evidence of shared ancestry.

degree of imprecision in directly inferring time from numbers of mutations. According to their best estimates, the ancestors of contemporary Native Americans separated from the ancestors of the Siberian Koryak around 22,000 years ago. That estimate holds regardless of whether there was a "clean split" between the two groups or whether there continued to be some back-and-forth gene flow between the groups.

Willerslev and his team conclude that both the northern and southern subgroups of Native Americans "are descendants of the same source populations that split off from ancestral East Asians" during the Last Glacial Maximum (LGM), between about 22,000 and 19,000 years ago. Using a variety of additional data relating to paleoclimate, Willerslev's group further determined that the initial migration wave that gave rise to all contemporary Native Americans "likely followed a coastal route."

The LGM was a time of extreme cold temperatures when the glaciers that covered much of northern North America reached their maximum extent. Willerslev and his coauthors propose that the "harsh climate conditions during the LGM may have contributed to the isolation of ancestral Native Americans ultimately leading to their genetic divergence from their East Asian ancestors."

Once the LGM ended, however, gene flow between northeastern Asia and North America, especially northern regions, picked up again for several thousand years. By 12,000 years ago, however, gene flow between Athabascans and Siberians stopped. Willerslev and his coauthors attribute this sudden rupture to the warming at the end of the Pleistocene,

on "several independent lines of evidence," that it's "more likely to have occurred in lower latitude North America" than in the far north.

The Anzick child, at around 12,600 CALYBP, shows genetic connections to the southern branch of the Native American family. In contrast, the genomes of the 8500 CALYBP Kennewick Man (MT 31-2, "Kennewick Man's DNA reveals his ancestry") and several other ancient Americans "are closely related to present-day Native American populations from the same geographical regions." So, by around 9,000 years ago, in at least some parts of the Americas, regionally distinctive populations had developed that are still reflected in the genetic profiles of modern populations.

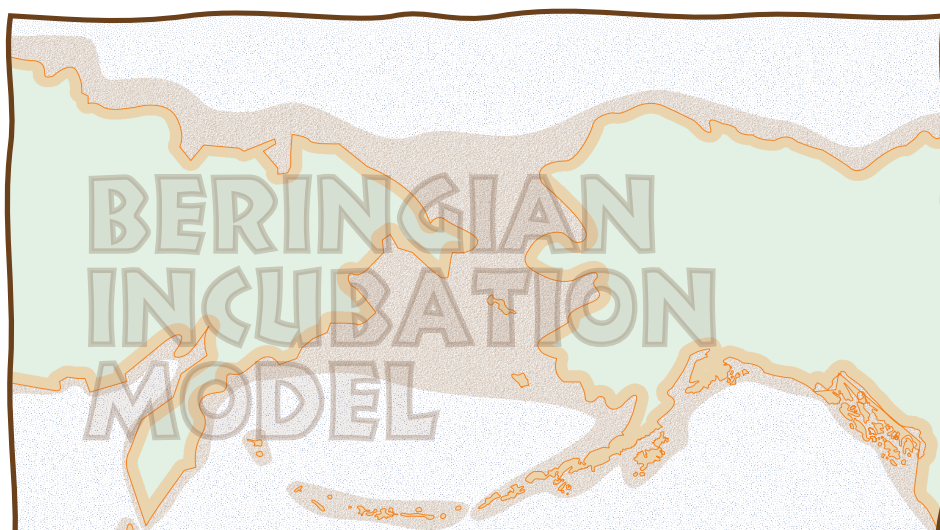
Did some of the First Americans come from Australia or Melanesia?

Willerslev and his team examined their genetic data to see if they could

Skoglund.




identify other episodes of migration or at least contact between Native Americans and other Eurasian populations. They were surprised to find that "some American populations—including the Aleutian Islanders, Surui [a Brazilian tribe], and Athabascans—are closer to Australo-Melanesians as compared with



THE BERINGIAN INCUBATION MODEL, also known as the Beringian Standstill Model, proposes that the ancestors of Native Americans became isolated in Beringia for a period of about 15,000 years during the Last Glacial Maximum. The subsequent period of warming melted the glaciers blocking the way into America, and as the Bering Land Bridge flooded behind them, the now genetically distinct population followed the open coastal route into a New World. The recent discovery of two rare mitochondrial lineages in two infant skeletons at the Upward Sun River site in central Alaska (MT 31-1, “Digging deeper into Upward Sun”) confirms the presence of considerable genetic diversity in the population

that inhabited late-Pleistocene Beringia and strongly supports the general model.

Extensive genetic evidence compiled by Willerslev’s team enabled them to “re-assess the Beringian Incubation Model.” Their findings do not refute the model, but they do force a rethinking of the timing of the period of isolation. They conclude that the period of isolation began no later than 23,000 years ago and likely lasted no longer than 8,000 years. Available data don’t specify, however, where the population was isolated, whether in Siberia or Beringia. Willerslev’s team are confident, however, that “future ancient DNA and archaeological findings” will resolve these questions. 

—Brad Lepper

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D. G. Smith, C. J. Mulligan, C. M. Bravi, O. Rickards, C. Martinez-Labarga, E. K. Khushnutdinova, Sardana A. Fedorova, Maria V. Golubenko, Vadim A. Stepanov, Marina A. Gubina, Sergey I. Zhadanov, L. P. Ossipova, L. Damba, M. I. Voevoda, J. E. Dipierri, R. Villems, and R. S. Malhi 2007 Beringian Standstill and Spread of Native American Founders. *PLoS ONE* 2(9):e829. doi:10.1371/journal.pone.0000829.

other Native Americans, such as North American Ojibwa, Cree, and Algonquin and the South American Purepecha, Arhuaco, and Wayuu.”

The team acknowledges that this observation “is based on the analysis of a small fraction” of the data sets and that “the trends in the data are weak,” but if confirmed, Willerslev and his coauthors argue, “there may be a distant Old World signal related to Australo-Melanesians and East Asians in some Native Amer-

icans.” Figuring out when, how, and where these shared genetic variants came to be a part of the genomes of some Native American groups has important implications for our understanding of the population history of the New World.

Willerslev’s team suggests the contact may have occurred after the initial peopling of the hemisphere by Native American ancestors. Otherwise, the genetic signal would be more widespread in groups throughout the continent. They

further suggest these Australo-Melanesian genes may have come into the Americas through the Aleutian Islanders, “who have a relatively greater affinity to East Asians” and Australo-Melanesians than to Native Americans. This is one possible explanation of the data, but as Willerslev’s team acknowledges, it’s not the only one. Reich argues that the elevated frequencies of these alleles is greater than could occur by chance.

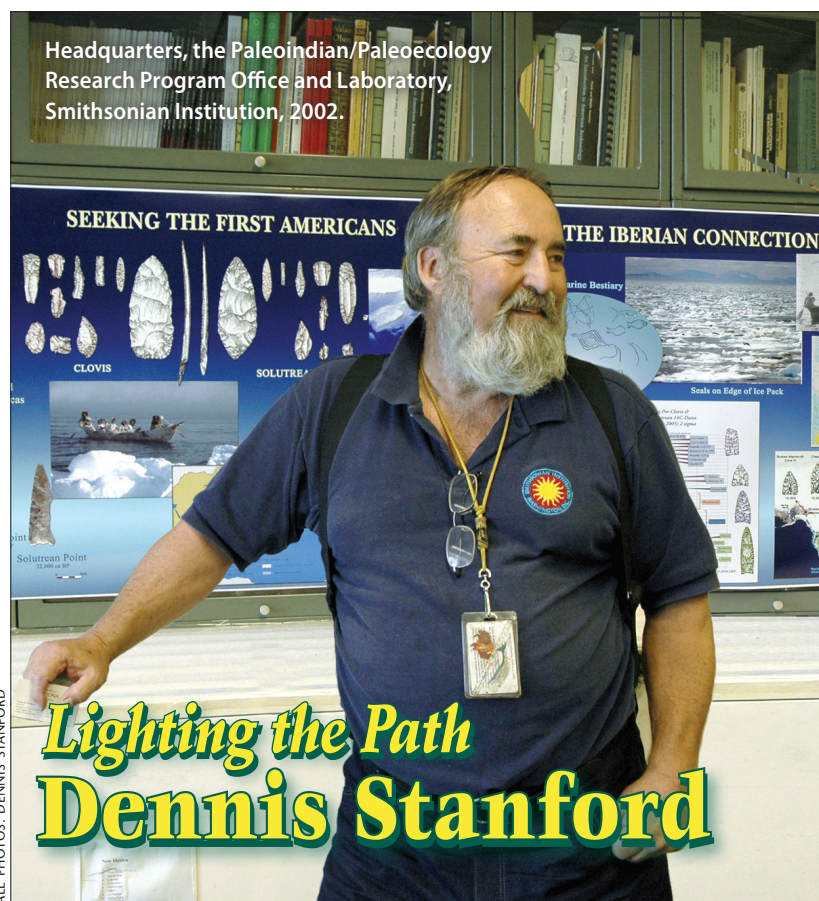
Another alternative explanation is that the Australo-Melanesian genes arrived very early as part of a separate migration of people from Oceania either directly across the Pacific Ocean or along the coast. Willerslev and his coauthors refer to this as the Paleoamerican model, which proposes, based on the occurrence of a distinctive head shape in some early American skeletons, that the First Americans included two distinct waves of migration. The first was a group from an Asian population that was ancestral to both the Paleoamericans and the Australo-Melanesians. According to the Paleoamerican model, these people brought to America the Australo-Melanesian genes along with their distinctive head shape. The second wave was the ancestors of modern Native Americans who eventually replaced the Paleoamericans except for a few relict populations, such as the Patagonians from Tierra del Fuego and the Pericues of the Baja California Peninsula, who survived into the historic era.

To test this model, Willerslev’s team examined the genomes of 17 ancient individuals identified as Paleoamericans from the Pericues and the Fuego-Patagonians. They determined that these so-called Paleoamericans “cluster with other Native American groups and are outside the range of Oceanian genetic variation” (see also **MT 30-3**, “DNA links Mexican Paleoamerican to Native Americans”). Therefore they find “no support for an early migration of populations directly related to Australo-Melanesians into the Americas.”

A history of Native Americans written in DNA

Willerslev and his interdisciplinary team of scientists compared the genomes of

continued on page 14



It was an auspicious beginning for a lad infected with a craving to learn more about archaeology.

"We found Dennis to be very knowledgeable and interested in local archaeology and history," says Haynes, "and we encouraged him to study anthropology at the University of Wyoming." Stanford took their advice and went on to complete his B.A. at the University of Wyoming and his M.A. and Ph.D. at the University of New Mexico in 1972.

Pondering Clovis-First

When Stanford completed his Ph.D., the Smithsonian Institution, which had just initiated a program in Paleoindian Studies, hired him as Associate Curator of Archaeology in the Department of Anthropology. His early fascination with American prehistory would guide his career and research for the next 30 years.

Clovis-First dominated as the model in the 1970s for the peopling of the New World. Stanford's ideas evolved over the next three decades. It seemed reasonable to him that investigating the arrival of early people by way of the Bering Land Bridge should lead to evidence of pre-Clovis cultures in the Arctic. Although earlier-than-Clovis cultures occupied the arctic, no evidence of an early Clovis lithic technology has ever materialized. "Over the past fifty years," Stanford states in an article published with Bruce Bradley in *World Archaeology* in 2004, "archaeologists have expended a great deal of effort and resources trying to find evidence of Clovis ancestors in Alaska and north-eastern Siberia, but there is a lack of data supporting an Asian connection and the origin of the Clovis culture and technology still remains a mystery." Many archaeologists pricked up their ears when they realized Stanford's ideas cast a shadow over Clovis-First, a theory Stanford believes was based on informed speculation and not supported by archaeological evidence.

Stanford found surprisingly uniform

A TRAILBLAZER IN HIS FIELD, Dennis J. Stanford, Curator of Archaeology at the Smithsonian Institution, seeks to understand America's first inhabitants in relation to changing climate and ecosystems during the terminal Pleistocene. His search for information about ancient Americans began early. Raised in the Rocky Mountain states of Wyoming, Colorado, and New Mexico, Stanford prowled the countryside as a youngster and, like many another career archaeologist, caught artifact fever when he discovered stone tools, tokens of the rich prehistory of the plains. These discoveries fueled a desire to know more about ancient cultures that made the tools and where these early Americans came from.

Teenager Stanford appeared at the Union Pacific Mammoth site about 30 miles from Rawlins, Wyoming, and volunteered to help on-site archaeologists George Agogino, Henry and Cynthia Irwin, and C. Vance Haynes, Jr. Stanford stayed overnight several days to guard the site and keep the water pump running.



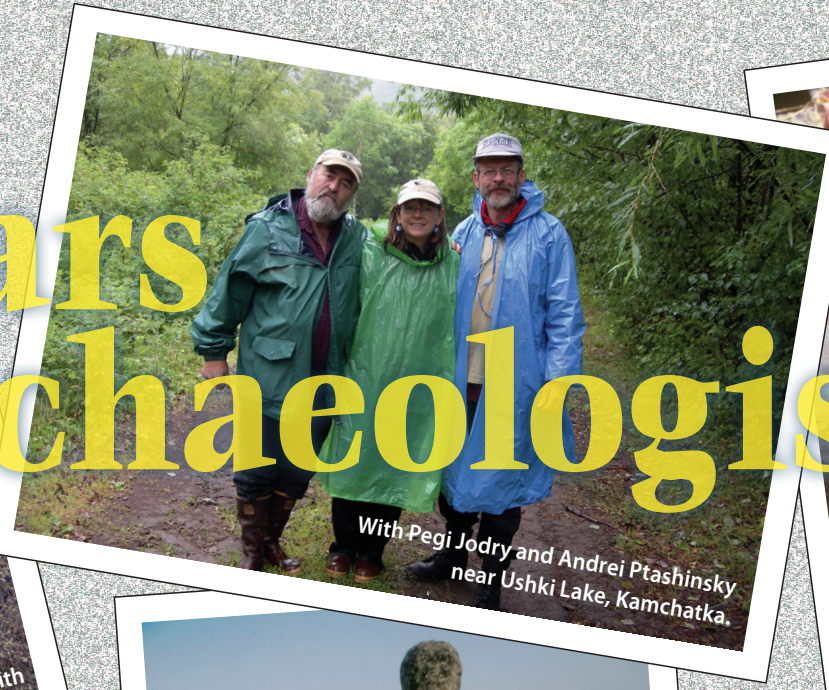
On location at the Garden of the Gods in Colorado for the film "Infinite Voyage," 1988. Tests set up by physics students at Colorado College in Colorado Springs compared the velocity of a dart thrust by an atlatl with that of a hand-thrown javelin. Says Stanford, "Not only did the atlatl dart win hands-down, the dart went through the target and ¼-inch plywood backing and penetrated the sensing device. Filming had to stop while students went back to the University to repair their device."

technology expressed in the Clovis toolkit across environments from the sub-tropics to the sub-Arctic. Bifacial thinning, large-blade production, and specific sequences of flake and blade removal are complex production strategies that identify

45 Years an Archaeologist



A successful seal hunt with
Silas Negovanna on the Arctic Ocean
at Walakpa Bay, Alaska, 1968.



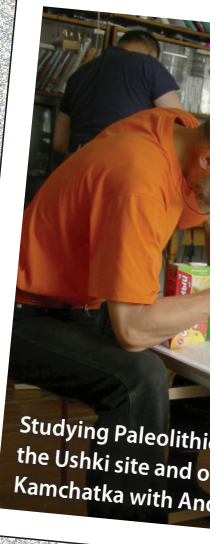
With Pegi Jodry and Andrei Ptashinsky
near Ushki Lake, Kamchatka.



Studying Solutrean artifacts with
Bruce Bradley at Les Eyzies, France, 2001.



Stanford with Jane and Bob Jones at
the Jones-Miller Hell Gap bison kill site
near Wray, Colorado, 1974.



Studying Paleolithic
the Ushki site and o
Kamchatka with And



At Pueblo Bonito in Chaco Canyon,
New Mexico, 1984. (Stanford
re-surveyed Chaco Canyon in 1971
for the NPS reorganization project.)

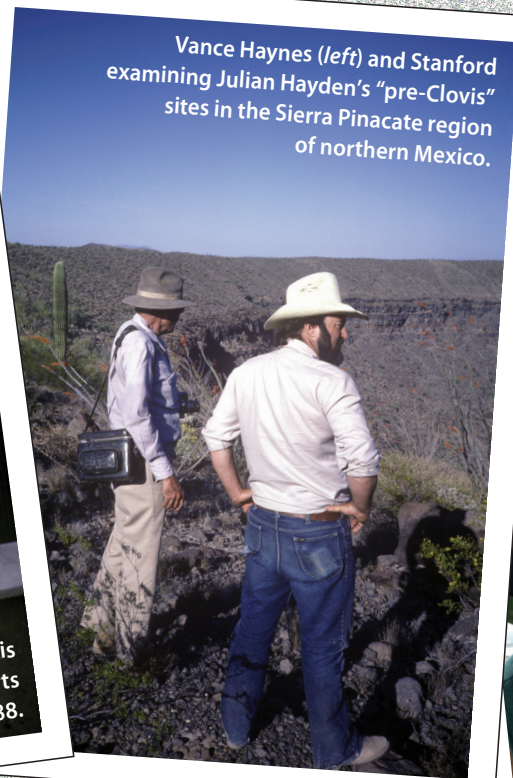


Dick Jordan (left) and Jim Dixon
(right) flank Stanford on the
Coleen River in Alaska, 1989.

ist



Excavating a large Clovis point at the Ritchie-Roberts site in Washington, 1988.



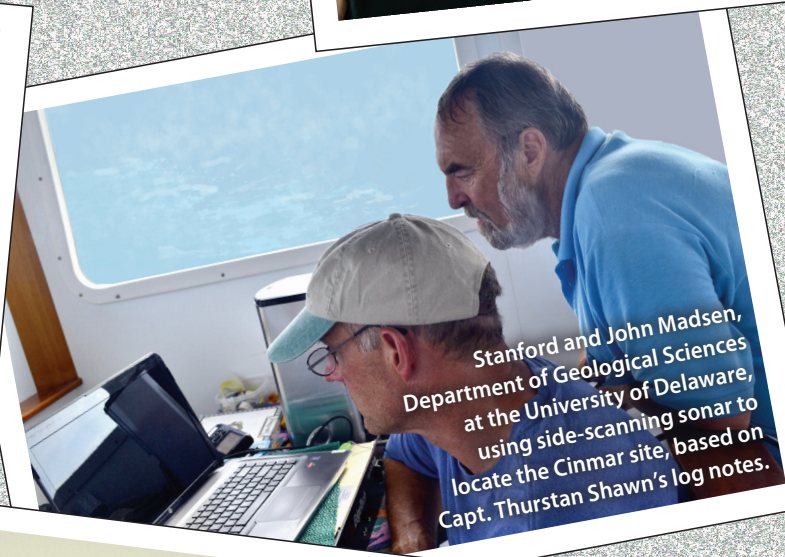
Vance Haynes (left) and Stanford examining Julian Hayden's "pre-Clovis" sites in the Sierra Pinacate region of northern Mexico.



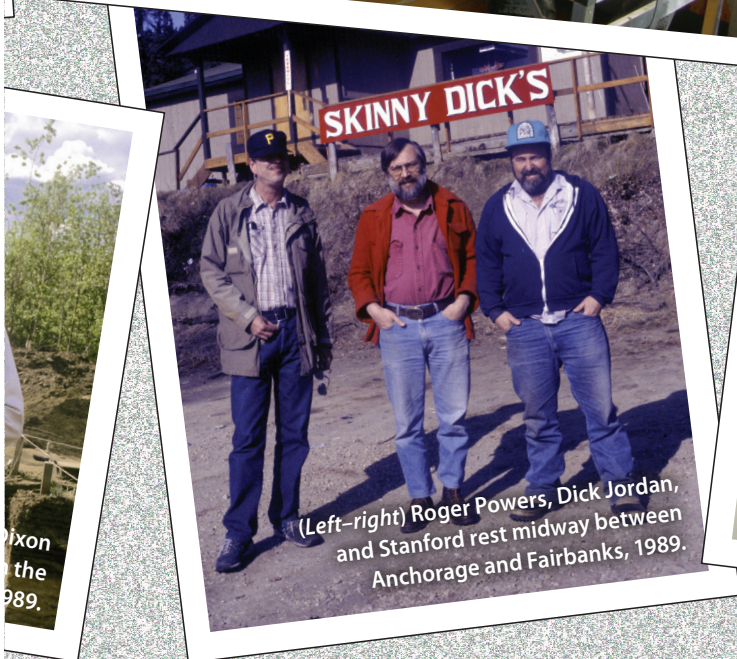
Examining the construction of a seagoing curragh in Ireland.



Studying Paleolithic artifacts from the Ushki site and other locations in Kamchatka with Andrei Ptashinsky, 2009.



Stanford and John Madsen, Department of Geological Sciences at the University of Delaware, using side-scanning sonar to locate the Cinmar site, based on Capt. Thurstan Shawn's log notes.



(Left-right) Roger Powers, Dick Jordan, and Stanford rest midway between Anchorage and Fairbanks, 1989.



Margaret Jodry, Mike Waters, Jason LaBelle, and Stanford, speakers at the Stone Age Fair in Loveland, Colorado, 2009.



Stanford at the Stone Age Fair in Loveland, Colorado, 2009.

tools as Clovis, and its distinctive basal fluting is a rarity in biface production around the world.

Where were the ancestors of Clovis? Such well-developed bone and lithic technologies couldn't have sprung up overnight. Somewhere Stanford hoped to find evidence of a transitional technology.

Asian origins?

American archaeologists, convinced that the Clovis culture originated in northeastern Asia, focused their attention on Alaska, but in the past 70 years no evidence has come to light of an early lithic technology related to Clovis in Alaska or Canada. "There are a few sites west of the Bering Straits that are older than Clovis," Stanford tells us, "but their lithic technologies are not what we would expect as a technology that would be a precursor to Clovis technology." Recent research shows that the ice-free corridor may have been barren of plant and animal life over a long period, making human habitation impossible until about 13,000 years ago. By then, Stanford believes, ancient Americans had already settled south of the ice-free corridor and were poised to move north when the climate allowed.

"One has to look over a thousand kilometers west of the Bering Strait to find technologies older than Clovis," Stanford points out, "or even to find artifacts that are remotely similar. The bottom line is there are no pre-12,000-

Excavating the Jones-Miller Hell Gap bison-kill site near Wray, Colorado, 1974.



year-old sites in Beringia that contain a lithic technology that remotely resembles anything we would be expecting as a precursor to Clovis."

Early immigrants, Stanford reasons, must have used alternative routes to reach the Americas. Discoveries indicate that early Paleolithic people likely developed seagoing watercraft and could thus have entered the Americas by a coastal route. "The myopic landlubber's view," Stanford states, "sees water as an impediment to travel, whereas many technologically simple cultures view water as a highway, and the means of relatively simple travel and transport." Unfortunately, materials used in early boat construction were too perishable to survive for long, and boats abandoned near the water's edge would be lost to decay over the millennia owing to rising sea levels with deglaciation, thus frustrating efforts to find direct evidence.

These ideas have caused Stanford to stick his neck out and suggest an alternative working hypothesis for the origins of Clovis technology. His theory, complex and sophisticated, was a long time in maturing.

The Solutrean model

Significant similarities between Clovis and the older Upper Paleolithic Solutrean technologies of southwestern Europe have

long intrigued him. The Solutrean culture produced bifacially flaked lanceolate projectile points with concave bases and basal edge grinding more than 6,000 years before Clovis. "Solutrean is the only Old World culture that meets our criteria for an ancestral Clovis candidate," Stanford says. Solutrean technology bears a striking similarity to Clovis in both typology and manufacturing techniques. Significantly, both cultures manufactured thin bifaces using overshot flaking.

Most Solutrean sites are found in southwestern France and northern Spain and date between 22,000 and 16,500 CALYBP, a time when continental glaciers covered much of Europe. Solutrean toolmakers favored exotic toolstone and blessed history with caches of beautifully made oversized bifaces.

Crossing the North Atlantic

Arctic ice formed much farther south during the Last Glacial Maximum, covering large portions of the North Atlantic and

connecting Europe and North America with a bridge of ice. Ice-edge animals adapted to intensely productive sub-Arctic waters ensured a dependable food source of migratory sea mammals, birds, and fishes in the Bay of Biscay from early fall to spring. "The question isn't, Did the Solutrean people exploit the marine resources," Stanford says, "but, Why would anyone think they could ignore the rich en-

vironment at their doorstep?"

Stanford suggests that the climate of the LGM may have forced human populations in Europe to locate along rivers and coastlines, where they learned to exploit marine mammals, fish, and seabirds on winter sea ice and ice-edge margins. Migrating seals may have tempted the Solutreans to stray farther from land, over sea ice on foot and over the water in sealskin boats.

Large family hunting groups, Stanford believes, likely traveled the 2,500 km to the western Atlantic seaboard by boat. Although no direct evidence of Solutrean boatmaking has ever been found, ample precedents render it feasible: Ancient peoples made their way to Australia 60,000 years ago, and the Thule Inuit of Alaska traversed great expanses of water to colonize Greenland. Stanford is convinced that Solutreans were entirely capable of mastering the technology for making and piloting seagoing watercraft.

Missing links

Three sites in eastern North America—Meadowcroft Rockshelter in Pennsylvania, Cactus Hill in Virginia, and Page-Ladson in Florida—have yielded pre-Clovis radiocarbon dates associated with artifacts that show technological characteristics of developmental Clovis technology. This suggests to

Stanford that these technologies were transitional between Solutrean and Clovis. Stanford is confident that in time data will support this idea.

Not everyone has leapt aboard the Solutrean boat, but Stanford is content to let time weigh the merits of his and Bradley's idea. "The hypothesis that a Solutrean Paleolithic maritime tradition ultimately gave rise to pre-Clovis and Clovis technologies in the Americas is supported by abundant archaeological evidence that would be considered conclusive were it not for the intervening ocean," Stanford says.

Supporting evidence

Discoveries in genetics at Emory University and the Universities of Rome and Hamburg indicate that mitochondrial DNA, which is inherited from the mother, normally contains four markers shared by 95% of Native Americans. A recently identified fifth marker, haplogroup X, is present in only about 20,000 Native Americans and some pre-Columbian populations. This fifth marker is also present in European populations but absent from Asians. Genetics research places this marker in the Americas 12,000 to 34,000 years ago. Stanford and his companion theorist, archaeologist Bruce Bradley of the University of Exeter, believe the Solutreans may have introduced this genetic marker to North America.

Field studies

Stanford's office at the Smithsonian is often empty as he conducts fieldwork. He has investigated sites in Siberia, China, Alaska, the Rocky Mountains, the Great Plains, and the southeastern U.S. His diverse interests have also taken him to Central and South America and southwestern Europe. Stanford and Bradley's book *Across Atlantic Ice: The Origin of America's Clovis Culture*, published in 2012, in February 2016 was awarded the Secretary's Research Prize by the Smithsonian Congress of Scholars, which recognizes and promotes excellence in scholarship across the Smithsonian Institution.

Tracks in the field

Dennis Stanford's archeological tracks can be traced across a wide field of interests, which include New World Paleoindian cultures in relation to changing climates and ecosystems during the terminal Pleistocene, interdisciplinary Quaternary studies, stone-tool technology, and experimental and public archaeology. His list of publications stretches across many pages and covers a wide range of scientific journals and Smithsonian


publications along with popular magazines such as *National Geographic* and *Natural History*. He has authored and coauthored 9 monographs, 139 research papers, and 12 television productions. To his already long list of accolades he recently added the Secretary of the Smithsonian Institution's Award for Outstanding Contribution to Science and the Mission of the Smithsonian Institution.

"The Smithsonian Institution made a good decision over four decades ago when it selected Dennis Stanford as director and curator of its Paleoindian collections," says George Frison of the University of Wyoming. "I am unaware of any individual more dedicated to or who has made more positive contributions to this special area of archaeological research. He has helped many aspiring young archaeologists on their professional careers by making the Smithsonian collections, along with his great depth of knowledge, available to them. One of my outstanding achievements was collaborating with Dennis on the analysis and the 1982 publication of the Paleoindian Agate Basin site located in southeast Wyoming."

"I first met Dennis more than 40 years ago when he was a graduate student working on the Walakpa site near Barrow, Alaska," says James Dixon of the University of New Mexico. "By the 1980s it was becoming obvious to many of us that Clovis origins were not in Siberia, and I think his early work near Barrow opened his mind to the possibility of a Solutrean north Atlantic crossing to the Americas. Dennis is a



Richard Morlan (right) and Stanford experiment using a hafted Clovis-style biface to break bone and butcher an elephant. An electronic monitoring system provided printouts of distance traveled by the knife, as well as force applied, elapsed time, and hard contact with bone, 1978.

courageous independent thinker and the most knowledgeable Paleoindian archeologist working in North America today." 

—Martha Deeringer

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Genetic Clues Answer Questions

continued from page 8

ancient people, modern Native Americans, Siberians, and indigenous Australians and Melanesians. That evidence answers many of the most important questions that have perplexed archaeologists for decades.

Based on these data, it now appears that Native Americans and East Asians diverged from one another sometime after 23,000 years ago. That this date corresponds to the Last Glacial Maximum, a period of extreme cold, suggests that this period of climate change was in some way responsible for separating the ancestors of these groups.

Willerslev and his coauthors write that their data do not “support archaeological claims for an initial peopling substantially earlier than the LGM.” Their conclusion, which is consistent with previous studies, does not rule out the possible presence of people in America prior to that date. It just means that if people were here, they didn’t survive to contribute to the gene pool of the people who initiated the ultimately successful colonizing event sometime after 23,000 years ago, or that their contributions were comparatively limited and have not yet been detected by genetic research.

Willerslev’s team also argues that their data are “consistent with a sin-

Nielsen



gle initial migration of all Native Americans and with later gene flow from sources related to East Asians and, more distantly, Australo-Melanesians.” Their data confirm East Asian affinities published by Reich in 2012 and by Verdu et al. in 2014, and a link to Australo-Melanesians published by Skoglund et al. in 2015. They argue further that sometime around 13,000 years ago this single population diverged into northern and southern subgroups, as was earlier published by Reich et al. in 2012 and in the paper on the Clovis genome. It likely isn’t a coincidence that this “diversification event” happened at about the same time that the large continental glaciers receded, opening both “coastal and interior corridors into unglaciated North America.” They sug-

gest that “one or both of these routes” played a role in channeling the movement of peoples across the continent possibly leading to the formation of the two distinctive populations.

What about those Australo-Melanesians?

David Reich of the Department of Genetics at Harvard Medical School and Pontus Skoglund, a postdoctoral fellow in Reich’s lab, along with seven other colleagues from five institutions in the United States and Brazil, published a study in the September 3 issue of the journal *Nature* that focuses on the narrower question of how many founding populations contributed to the peopling of the Americas. Their remarkable conclusion is that “some Amazonian Native Americans descend partly from a Native American founding population that carried ancestry more closely related to indigenous Australians, New Guineans and Andaman Islander than to any present-day Eurasians or Native Americans.”

Reich and his colleagues examined the genetic profiles of a sample of “individuals from Central and South America” that showed the least evidence of recent European or African admixture. They then compared a panel of 7 of the Central and South American groups with genetic profiles of 24 populations—4 from each of 6 worldwide regions.

Reich and his team proposed that if the two Native American populations descended from a single and homogeneous ancestral group, then the genetic differences between the two Native American populations and the several outgroups must then have developed “entirely after their separation from the outgroups.” Therefore both Native American groups should be more or less equally different from the outgroups—assuming, of course, that genetic mutations accumulated at approximately the same rate on each branch.

After analyzing their data, Reich’s team found that this was not the case. Therefore “the analysed Native American populations do not all descend from a homogeneous ancestral population since separation from the outgroups.” Specifically, two Native American groups from the Amazon, the Surui and Karitiana, share significantly more unique genetic variants with Australo-Melanesians, including the “Andamanese Onge, Papuans, New Guineans, indigenous Australians and Mamanwa Negritos from the Philippines,” than do other Native American groups. Further analyses identified another South American group, the Xavante from central Brazil, that also share a com-

paratively close relationship to the Australo-Melanesians. The fraction of Amazonian ancestry in the South American groups was determined to be about 1–2%, but this is still significant.

Reich and his team argue that the “geographic distribution of the shared genetic signal between South Americans and Australasians cannot be explained by post-Columbian African, European or Polynesian gene flow into Native American populations.” Nor do they think their results “imply that an un-mixed population related anciently to Australoasians migrated to the Americas,” although they acknowledge this as a “formal possibility.” Instead, they suggest the ancestral population that brought the Australasian genes to the Amazonian groups “was already mixed with a lineage related to First Americans at the time it reached Amazonia.”

Finally, Reich and his colleagues conclude that “the genetic ancestry of Native Americans from Central and South America cannot be due to a single pulse of migration” from East Asia into the Americas. They propose at least two migration pulses, one of which “had ancestry from a lineage more closely related to present-day Australasians than to present-day East Asians and Siberians.”

In further support of this idea, they note that the “largest number of skeletons” identified as Paleoamericans owing to their characteristic head shapes “have been found in Brazil, the home of the Surui, Karitiana and Xavante groups who show the strongest affinity to Australasians in genetic data.” However, Reich and his coauthors note that, without ancient DNA data from Paleoamerican skeletons, they cannot say whether or not the genetic affinities to Australasians they have documented are associated with the Paleoamerican cranial morphology.

So, was there a single wave of migration into the Americas with subsequent dribbles of “gene flow from sources related to East Asians and, indirectly, Australo-Melanesians” as Willerslev’s team argues? Or were there “at least two streams of migration,” one of which was a population “more closely related

to present-day Australasians than to present-day East Asians and Siberians”—or possibly even a direct migration of Australasians to the Americas?

Clearly, more genetic data are needed from ancient human remains, particularly those Paleoamerican skeletons from Brazil, and from the indigenous populations of North and South America before we will be able to resolve the apparent contradiction and determine whether migration from the Old World into the New occurred in one, two, or even more separate pulses. These


new data also will help resolve the question of whether the Australo-Melanesian genetic variants arrived in the Americas close to the Last Glacial Maximum, as argued by Reich’s team, or much later as Willerslev’s team suggests.

In spite of the differences between the results and interpretations of the two teams, they actually agree on many aspects of the genetic history of Native

Willerslev (left) with lab coworker.



UFFE GRAM WILKEN

Americans. The data obtained by both teams make increasingly clear, for example, that the First Americans were not Europeans who crossed the Atlantic Ocean during the Pleistocene epoch. Willerslev’s team explicitly rejects the possibility, whereas Reich’s team argues for a “more diverse set of founding populations of the Americas than previously accepted,” but that diversity does not extend to even a suggestion of a trans-Atlantic European contribution. 

—Brad Lepper

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Suggested Readings

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don, L. Osipova, M. I. Voevoda, O. L. Posukh, O. Balanovsky, M. Lavryashina, Y. Bogunov, E. Khusnutdinova, M. Gubina, E. Balanovska, S. Fedorova, S. Litvinov, B. Malyarchuk, M. Derenko, M. J. Mosher, D. Archer, J. Cybulski, B. Petzelt, J. Mitchell, R. Worl, P. J. Norman, P. Parham, B. M. Kemp, T. Kivisild, C. Tyler-Smith, M. S. Sandhu, M. Crawford, R. Villems, D. G. Smith, M. R. Waters, T. Goebel, J. R. Johnson, R. S. Malhi, M. Jakobsson, D. J. Meltzer, A. Manica, R. Durbin, C. D. Bustamante, Y. S. Song, R. Nielsen, and E. Willerslev 2015 Genomic evidence for the Pleistocene and recent population history of Native Americans. *Science* 349(6250); published online 21 July 2015.

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ARCHAEOLOGY UNDER THE GREAT LAKES

JAKE ROV has his own Facebook page and more followers than John O'Shea, professor of Anthropology and curator of Great Lakes Archaeology at the Museum of Anthropological Archaeology, University of Michigan. Who is Jake ROV? He's a remote-operated vehicle (and robot) built for capturing videos of underwater archaeological features. A prized member of O'Shea's team, Jake ROV is uncovering information about the prehistoric past preserved below the surface of Lake Huron.

At the end of the last Ice Age, melting glaciers created Lake Huron and the other Great Lakes. With the longest shoreline of the Great Lakes, the second largest surface area, and the third largest volume of water, Lake Huron is bounded on the west by Michigan and on the north and east by Ontario. About 9,000 years ago an exposed land corridor called the Alpena-Amberley Ridge (AAR) connected northeast Michigan to southern Ontario. Rock structures found on the AAR, now 35 m below Lake Huron, yield evidence for caribou-hunting strategies practiced for 500 years at the end of the Ice Age in North America.

A happy coincidence of events motivated O'Shea to explore submerged sites beneath Lake Huron. First, he had been doing shipwreck archaeology in the Great Lakes, which acquainted him with state-of-the-art underwater technology. Second, he learned

Sonar image of the Drop 45 drive lane used by hunters to maneuver caribou into the killing area (corral).

from literature on reindeer behavior that reindeer tend to migrate in columns and that herders in Siberia take advantage of this instinct to manage them. (Because European reindeer and North American caribou are the same animal, *Rangifer tarandus*, O'Shea reasoned that migrating Ice Age caribou exhibited

the same predictable behavior as reindeer today.) "At the same time," O'Shea recalls, "NOAA [National Oceanic and Atmospheric Administration] published their new high-definition bathymetric profile of Lake Huron. It showed this feature out in the middle of the lake known as the Alpena-Amberly Ridge, a continuous formation that would have been a solid dry-land causeway during the Lake Stanley era. So that's when I thought that there ought to be hunting structures out there and that we should be able to find them with these technologies."

Strength in synergy

O'Shea's team evolved into a multidisciplinary one: Elizabeth Sonnenburg plies her skill in reconstructing a paleoenvironment; Robert Reynolds applies artificial intelligence to simulate caribou migrations;

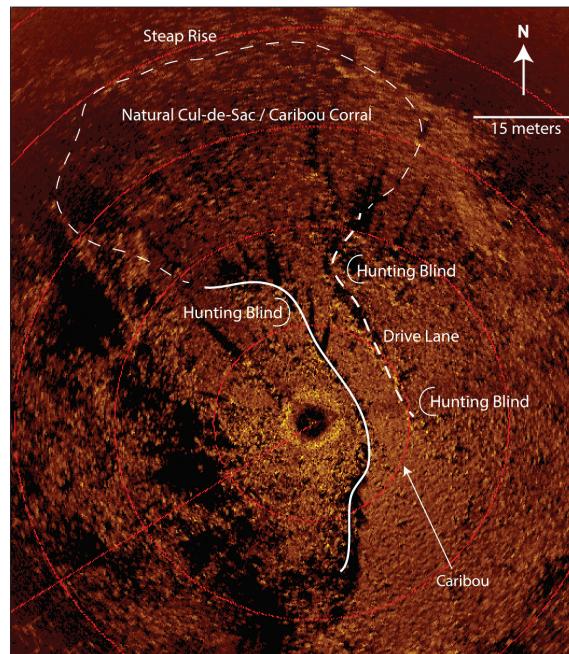
Ashley Lemke continues research on underwater sites that supported her dissertation; and a few marine engineers are assisting by refining such useful technology as sonar radars.

Sonnenburg, a project archaeologist at Stantec, first became interested in Great Lakes archaeology as an undergraduate at Lakehead University in Thunder Bay, Ontario, which lies on the edge of Lake Superior. When she was completing her Ph.D. a friend sent her an article that appeared in *Proceedings of the National Academy of Sciences* about O'Shea's underwater exploration of Lake Huron. Instantly she decided, "I need to be part of this project!" She

e-mailed John O'Shea with a message that said, "You need me!" He gave her a call, and that was that. Funding for her participation came from a postdoctoral fellowship issued by the Social Sciences Research Council Grant of Canada. Thanks to her efforts, her team has a paleoenvironmental picture of how the Alpena-Amberley Ridge appeared when high and dry 9,000 years ago.

Newly minted Ph.D. Lemke is the key operator of Jake ROV. After graduating from University of Texas at Austin, she participated in an underwater project searching for Paleoamerican sites in the Gulf of

Mexico. "I came to Michigan for graduate school in 2008 just as John O'Shea was starting," she says, "and I wanted to go under water." Learning of his project immediately piqued her interest. Today she marvels at the stroke of good fortune that put her in the right place at the right time.



ASHLEY LEMKE

Thanks to a series of National Science Foundation grants, O'Shea's team has conducted underwater research every summer since 2008.

Practicing archaeology underwater

What does it take to transition from terrestrial to underwater archaeology? "A lot of what we're doing is adapting techniques that we use on land to an underwater environment," O'Shea says. For every potential structure the environmental context is evaluated, its position on the submarine landscape and the presence of possible associated cultural material.

The process parallels that used in identifying terrestrial hunting structures. When it comes to sending down scuba archaeologists, though, O'Shea admits it's easier to train an archaeologist to dive than to teach a diver to be an archaeologist. The detailed knowledge anthropology students acquire—how to identify stone-tool debitage, for example—simply can't be learned in a 15-minute session.

Working under water is a challenge due to the cold temperature (around 35° F) and the limited endurance of a diver at the extreme depth of Lake Huron. O'Shea tells us that an underwater archaeologist nevertheless enjoys some advantages: "When you come home at the end of the day you don't have dirt under your fingernails, and you can watch the sunset over the lake." Excavating underwater is also easier than on an equivalent site on land because the team uses an air lift, which sucks sediment into a tube; debris is passed through sieves and collected.

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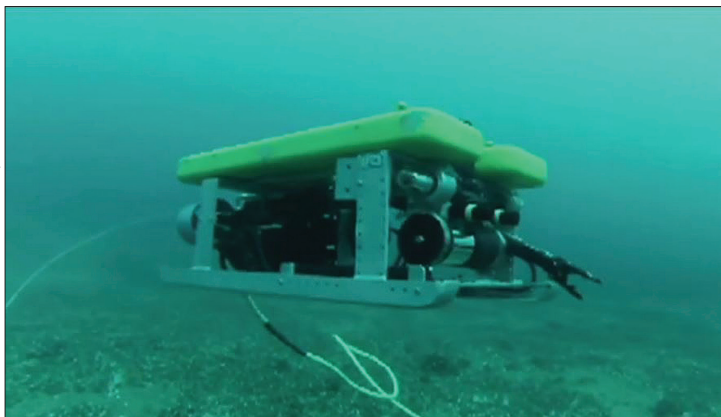
The plan of attack on underwater features

The strategy the team uses to explore the lake bottom involves logically progressing from a general view to a specific focus. The techniques first used are multi-beam sonar, which maps the bottom in detail, and side-scan sonar, which gives a 3-D view of features. The goal is to simulate the action of caribou moving over vegetation in ancient times, to get a view of what caribou

would have seen in ancient times. O'Shea explains that "with the coarse-grained side-scan you begin to see certain sites, structures, or locations. From this, you get something slightly more detailed." If they find something that shows promise, they put Jake ROV to work.

Lemke is Jake's pilot, and she believes the robot is absolutely essential to their work because, being unmanned, it can stay down for as long as needed to examine a site. "But once we're sure we have an archaeological site," she explains, "it can't do anywhere near the sampling that humans can do. It's the human-

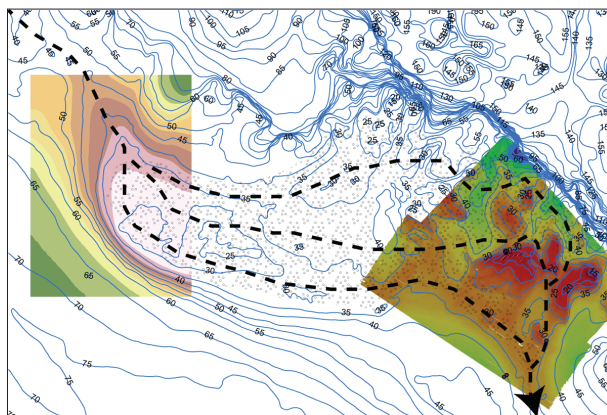
Jake at work. Propellers drive it above the lake floor, and a video camera displays the underwater terrain to the operator in the research vessel. On detecting a promising site, scuba divers perform physical tasks beyond the capability of Jake's robotic arm and pincers.



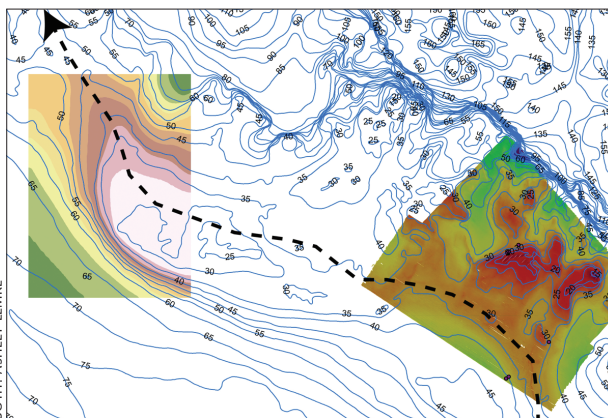
intuition side of things that you can never replace in terms of where you'd take samples and how you'd collect them."

If the area being investigated appears to bear evidence of human modification, the team then uses an apparatus called scanning sonar. Mounted on a tripod and free to rotate through 360 degrees, in seconds it produces an accurate map that would take divers days to execute. O'Shea explains that "we try to link the ROV directly with the simulation. The goal is to produce a split

side screen, half the screen showing the underwater environment surrounding the area that Jake is viewing, and the other screen showing the area of interest from the same perspective as Jake is viewing it." The team can thus direct divers to specific locations, where



The central causeway of the Alpena-Amberley Ridge showing the route, plotted by computer simulation, taken by migrating caribou in the fall (left) and spring (below).



BOTH: ASHLEY LEMKE

they take high-definition photos with go-pro cameras. According to O'Shea, this coordinated employment of ROV and computer simulation is "a new-frontier-type of thing."

The divers also take samples from various structures. At the Drop 45 location—a drive lane consisting of two parallel rock-lined paths that funneled caribou into a drive lane overseen by V-shaped

blinds perched on a hill—samples were taken the length of the drive lane at 2-m intervals, “very much as you would do on land,” O’Shea says.

Reading the story from submerged sites

“Drop 45 was an accident,” Sonnenburg confesses. They had been using a sector-scanning sonar, which is mounted on a tripod and rotates 360 degrees, and they had drifted slightly off course. Drop 45 wasn’t on their planned route. “It was a bit serendipitous that we managed to locate it,” she remembers. “As soon as the images came in, our jaws dropped. It was a Holy Grail kind of thing.” Until the team refined their techniques and knew what to look for, they had little evidence that these submerged features had actually been modified and used by humans. Says Sonnenburg, “Drop 45 was the definite *yes!* We knew we were dealing with something shaped by humans, and here was the proof.”

Drop 45 and other structures

O’Shea with Jake ROV.



ASHLEY LEMKE

helped the team understand the early hunter-gatherers living here 9,000 years ago and their prey, migrating caribou. “Hunter-gatherers had an intimate knowledge that caribou follow straight lines and knew the best way to exploit this behavior,” Lemke says, “and they had an understanding of their local environment as well. Not only are they exploiting caribou behavior, they’re in the best places to do that in terms of the natural environment around them. They are tied to those resources, organizing themselves and their economy around those things.”

Hunter-gatherers, keen observers of the creatures that shared their world,

Lemke.



ASHLEY LEMKE

doubtless noticed the distinctive pattern of migrating caribou: Unlike bison, which migrate en masse on a broad front, caribou when migrating organize themselves into columns. Hunters turned this instinct to their advantage by constructing stone-lined drive lanes, funnel-shaped constrictions, closed hunting blinds, and open V-shaped blinds. It’s interesting to note that many of these structures are directionally dependent, effective only if animals are moving in a certain direction. (The exception is funnel drives, which were used in all seasons and provided meat for humans the year round. Leading into the funnel was one long drive line into which people chased caribou. Blinds on the periphery of the funnel concealed waiting

hunters). This physical aspect of hunting structures reveals whether a structure was used during semi-annual caribou migrations and, if so, the season of use.

Determining seasonality

O’Shea notes that “one of the interesting findings is the suggestion that things worked differently in the fall and spring.

One of the big advantages of the AAR is that it would have provided a level of predictability for the hunters that’s really uncommon.” In the fall, during large migrations, smaller family units used these structures, probably waiting until they were completely surrounded by animals; the caribou were simply traveling through, and the immediate family group took enough meat to see them through the winter. On the other hand, spring hunting blinds tend to be larger, more complex structures used by many cooperating families. A site like Drop 45 would have been used in the spring, for instance. “Coming out of a hard winter you’re hungry,” O’Shea reasons, “and you need more people operating these sites, but you can then also get enough caribou to feed them all.”

The region surrounding the AAR would have been peopled with smaller groups in the fall because, O’Shea explains, one place can’t support large groups of people in winter. “Everyone has to disperse and spread out. Preparing for winter, you tend to break down into smaller family units, and in the spring people tend to come out

and aggregate again. The terrestrial sites that we tie our underwater sites to are consistent with this kind of pattern.” Furthermore, in autumn the hides and sinews of the caribou are in good condition. “If you’re going to spend the winter making clothes and sleds,” O’Shea explains, “these are the animals you need. In the spring they’re in less good condition, and it’s a less suitable time for storage, too. In the fall, a lot of the meat actually freezes in these caches.”

We can share O’Shea’s astonishment that these seasonal hunting patterns were deduced by students who had never even taken a course in anthropology. Graduate computer-science students in Robert Reynold’s simulation lab at Wayne State University called O’Shea one morning to tell him they had determined in which season each hunting structure was used. O’Shea, incredulous, replied, “How do you know that? You’ve never seen a caribou! You don’t know anthropology, you live in urban Detroit. How could you figure this out?” Sure enough, the students showed O’Shea that the geometry of the structures demonstrated that they only worked if caribou moved in a specific direction. “What made me really happy,” says O’Shea, “was that these kids who were doing the simula-

tion were actually discovering things about the past through the process of doing the simulation itself. They were over the moon!" Lemke confirms that "they were contributing things we didn't even know."

Reconstructing a paleoenvironment

"It's because we have this virtually intact underwater environment that we can see these seasonal patterns," Lemke tells us, "and there's enough sediment for Lisa [Sonnenburg] to do environmental reconstruction, so we have preserved wood and pollen." Their job is made easier by the fact that any sediment is contemporary with the use of the sites. "That's what's unusual," says O'Shea. "In normal underwater archaeology, particularly coastal areas, you'd have thick sediments overlaying your archaeological sites because it's a high-energy environment, and here you have neither. You don't have a source of modern sediment."

Sonnenburg's specialty is sedimentology and micropaleontology. "I look at microdebitage, the tiniest pieces of stone-tool fragments you can find—less than 1 mm in size. It dovetails nicely with the sedimentology analysis," she explains. When you cut a piece of wood, you get sawdust as a by-product; when you make a stone tool, you get stone fragments. "That's what I look at, and what my Ph.D. focused on, and that's how I was able to find one of these submerged sites; that's how we found the first evidence of anthropogenic tool manufacture on the AAR, looking at these tiny microflakes," Sonnenburg says. *Mammoth Trumpet* readers will recall the invaluable contribution Sonnenburg's microdebitage analysis made in locating a submerged Paleoamerican site in southern Ontario (MT 27-1, "Microdebitage analysis makes big contribution to archaeology").

Besides aiming to prove that certain hunting structures on the AAR were, in fact, human modified, Sonnenburg examined the micropaleontology, specifically looking for testate amoeba. These single-celled organisms, which live at the sediment-water interface, build tests, or shells, that can be preserved in sediments for millennia. Because different species thrive in different environments, their presence is a sensitive indicator of changes in temperature or salinity. Sonnenburg was able to

detect interesting patterns. "In some places," she recounts, "we didn't find testate amoebae at all, which told us something. In other areas we were finding those you only find in sphagnum bogs. We asked, 'What is a wetland amoeba doing here in 30 meters of water?' Well, once upon a time there was a sphagnum bog there, and some of that sediment and material is still there and has been preserved."

Paleoenvironmental investigations have been done along the coastline of Lake Huron, but Sonnenburg discovered that what was happening along the shoreline was quite different from processes occurring in the middle of the lake. She believes that the AAR limestone ridge possibly created its own weather patterns. "Because it separated the two basins when the water levels were low," she elaborates, "we have two distinct isotopic signatures that come from the lake, depending on which side of the ridge it's on: One indicates a lot of glacial meltwater input; the other behaves as though it was possibly hypersaline. There are interesting things going on from a paleoenvironmental perspective. It's truly a unique area, even if there was no archaeology there."

Sonnenburg hopes to go out with the team for a week this summer. "I can't be as attached to the project as I'd like," she admits, "but I want to keep my feet wet, pardon the pun."

Life in macroscale

For eight years the team's mission has been to locate hunting sites and identify different structures and their purpose. In terms of the

Sonnenburg.



ASHLEY LEMKE

paleoenvironment, Sonnenburg declares, "They've got what they need." Now the team can start asking more anthropological questions. They have already located a stone ring associated with radiocarbon-dated charcoal that suggests a campfire. Other findings will contribute toward a collective understanding of where people were living and their lifestyle beyond hunting. "We want a well-rounded picture of life," Lemke says, "and we're hoping to do some work on land, too. We've been able to make some predictions from the underwater record and sea-

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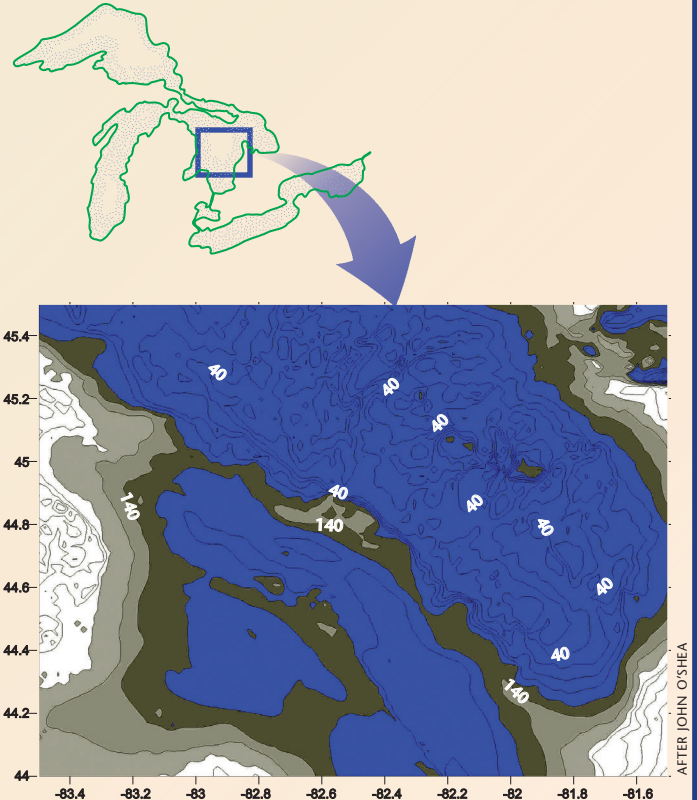
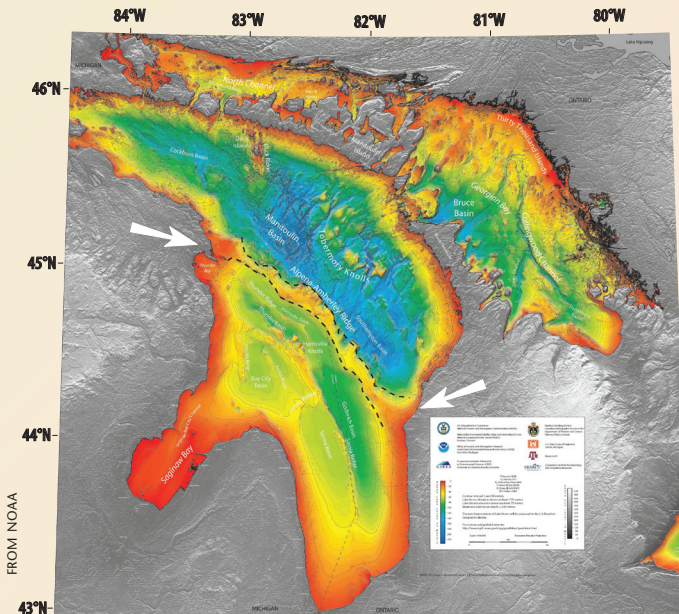
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The History of a Submerged Land Bridge

The Great Lakes owe their existence to a back-and-forth contest between glacial ice, whose enormous weight depressed the land mass, and meltwater, which filled depressions while the land was rebounding with the release of the weight of the vanishing glacier.


In the period 9900–7500 CALYBP, ancient Lake Stanley occupied a fraction of the area now displaced by Lake Huron. The level of water in Lake Stanley varied between 121 and 96 m below the present surface of Lake Huron. Whenever the depth fell lower than 86 m below the current level, a narrow land bridge, the

The central Lake Huron basin during the Lake Stanley ► phase. Areas in white are currently above water. The mean water level today in the Great Lakes is 176 m a.s.l.




◀ Lake Huron today. The Alpena-Amberley Ridge (dashed lines and arrows), which was exposed in the Lake Stanley phase, was a thoroughfare for caribou and hunters.

Alpena-Amberley Ridge (AAR), was exposed, which connected the shoreline near Presque Isle in Michigan with Point Clark in Ontario. The AAR became a regular route for caribou in their spring and fall migrations, and an opportunity for savvy Paleoamerican hunters to exercise their skill in ambushing the valuable food source.

See MT 25-1, "Finding traces of early hunters beneath the Great Lakes," for a further account of the geology of the AAR and ancient Lake Stanley. 

sonality, so we're going to try to connect the underwater record to the land record." After all, she points out, that's actually what the prehistoric landscape looked like. Originally the ridge and shore were all one dry landscape where people were living.

Future spinoffs are quite promising. O'Shea recently spoke to programmers who are talking about making a simulator of this project as an educational tool for schools. O'Shea envisions

the day when "schoolchildren will be able to walk around the landscape, and sit in the hunting blinds and watch as caribou come by. You can also simulate time because as the lake levels gradually rise, the environment changes, and so the simulation also characterizes where the lake is at a given time. As an educational tool, it's dynamite!" 

—Katy Dycus

Suggested Readings

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For a video overview of the project, log onto <http://www.scitechnow.org/videos/what-lies-beneath-the-great-lakes/#>

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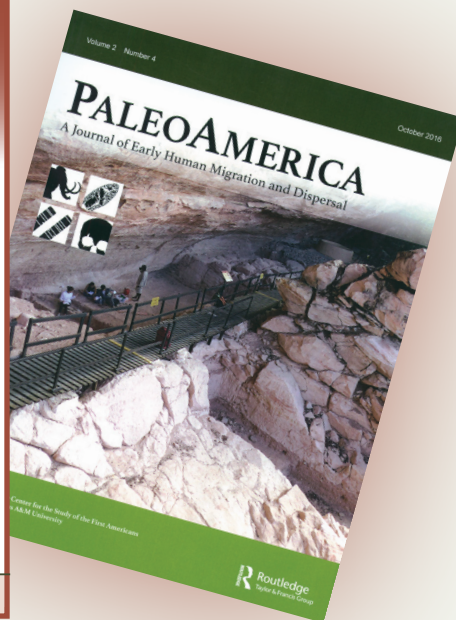
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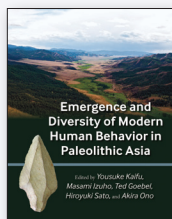
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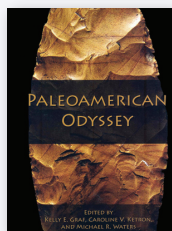
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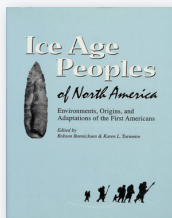
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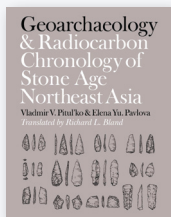
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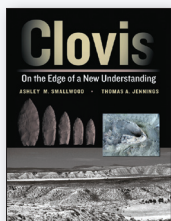
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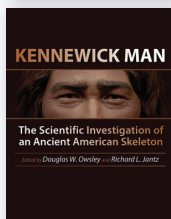
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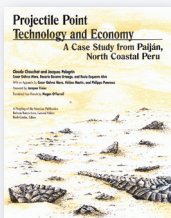
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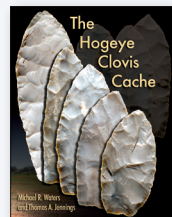
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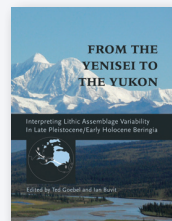
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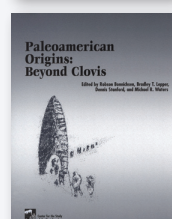
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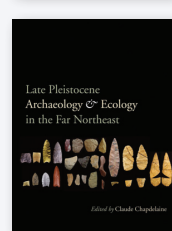
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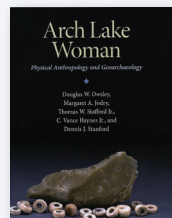
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