MAMMOTH TRUMPET

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The Nanodiamond Controversy, Part II: A Case of Mistaken Identity?

THE CLOVIS COMET REVISITED

THOSE DURABLE STONES we call diamonds have an ancient history of controversy. In recent years, they've even figured prominently in a debate over the fate of some of the earliest Americans. In this case, the stones in question are *nanodiamonds,* crystalline aggregates so small that millions can hide in a handful of soil. Tiny as they are, they've generated fierce contention in the First Americans field.

As we outlined in Part I, nanodiamonds have provided one of the more convincing lines of evidence for the Extraterrestrial Impact Hypothesis (EIH) since its formal introduction in October 2007. The gist of the EIH is that the Younger Dryas (YD) climatic reversal, which began roughly 12,900 calendar years ago, was the result of an extraterrestrial (ET) impact—most likely a low-density comet or asteroid striking the Canadian ice sheet. The "Clovis Comet" was also implicated in the extinction of the last of the Pleistocene megafauna and the abrupt disappearance of the Clovis culture.

Reaction to the EIH was immediate and polarized, with both the general media and the scientific literature soon a-buzz with the debate (**MT 23-1, -2, -3, -4,** "The Clovis Comet"). The hypothesis hasn't fared well in the years since, as other researchers have convincingly knocked down one line of evidence after another (**MT 25-2,** "The Clovis Comet Revisited"). Even some of the scientists involved in the original study have pulled back somewhat, especially in light of a recent controversy (which erupted between parts I and II of this series) challenging the credentials of a senior author of that study and the data he collected.

On the other hand, because the presence of nanodiamonds in the YD boundary (YDB) sediments is diffi-

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cult to explain except as the result of a cosmic impact, that particular evidence has always seemed solid. This assumes, of course, that the particles people have been calling nanodiamonds all this time really *are* nanodiamonds. But what if they're not?

When nanodiamonds aren't

The nanodiamond evidence has recently suffered repeated challenges, mostly from specialists in electron microscopy, geology, and materials science. Some critics have found nanodiamonds in YDB sediments, but not of a type that convinces them of an ET impact. Others have reexamined the sediments described by scientists of the EIH camp, claiming to have taken samples from the same strata at the same sites—and have found no nanodiamonds at all. In most cases, these researchers charge that their opponents have misidentified what they've actually found.

Consider a recent article by Tyrone Daulton, Nicolas Pinter, and Andrew Scott, who have emerged as leaders in the anti-nanodiamond assault. Daulton is a physicist specializing in materials science at Washington University in St. Louis; Pinter is a geologist at Southern Illinois University in Carbondale; and Scott is an applied paleobotanist at Royal Holloway University of London, U.K. The title of their report in the 14 September 2010 issue of the *Proceedings of the National Academy of Sciences* summarizes their stand: "No Evidence of Nanodiamonds in Younger Dryas Sediments to Support an Impact Event."

They were especially intrigued by reports of lonsdaleite, the rare hexagonal form of nanodiamond, because it's uniquely associated with the shock pressures produced by ET impacts. However, upon assessing YDB sediments from Santa Rosa and Santa Cruz Islands, California, and Murray Springs, Arizona, they found neither lonsdaleite nor the cubic nanodiamonds often identified in such sediments. This directly contradicts the results reported by geologist James Kennett and his team for Santa Rosa Island, as we reported in Part I.

According to the Daulton team, Kennett et al. misread what they actually saw. The culprits, say the Daulton team, are graphenes and graphene/graphane-oxide aggregates, tiny carbon particles that mimic nanodiamonds right down to the way they scatter X-rays and electron beams . . . almost. Careful analysis, however, reveals subtle differences that experienced researchers, they say, can use to differentiate the carbon aggregates from their nanodiamond look-alikes. They argue that the structures originally identified as cubic nanodiamonds are, in fact, graphenes, and that the purported lonsdaleite fragments are graphene/graphane-oxide crystals. Kennett vigorously denies this possibility, based on his own previous research and that of others—including the Belgian study discussed later in this article, as well as recent findings that haven't yet seen print.

To the nonspecialists among us, the possibility that EIH researchers may

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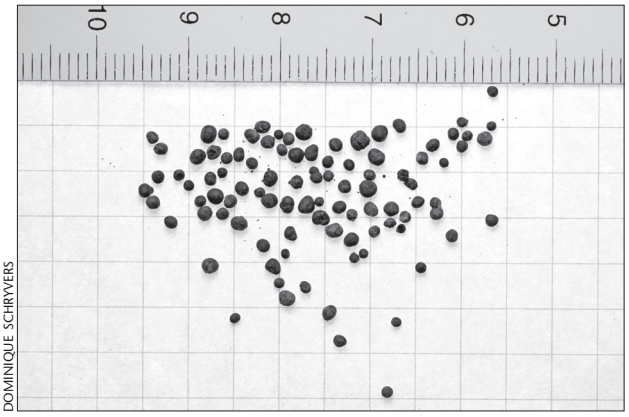
Many years may pass between the time an important discovery is made and the acceptance of research results by the scientific community. To facilitate communication among all parties interested in staying abreast of breaking news in First Americans studies, the **Mammoth Trumpet,** a science news magazine, provides a forum for reporting and discussing new and potentially controversial information important to understanding the peopling of the Americas. We encourage submission of articles to the Managing Editor and letters to the Editor. Views published in the **Mammoth Trumpet** are the views of contributors, and do not reflect the views of the editor or **Center** personnel.

–Michael R. Waters, Director

have misidentified atomic structures does seem plausible. As Daulton et al. trenchantly observe in their conclusions, "Our work emphasizes that rigorous analysis of electron diffraction patterns must be performed together with appropriate elemental quantification or other supplemental structural analysis . . . for the proper identification of diamond polytypes in carbonaceous materials."

A nail in the EIH coffin?

Daulton and his colleagues firmly believe that their findings mortally wound the EIH. Indeed, they cite the results as a key point in their upcoming *Earth-Science Reviews* paper, "The Younger Dryas Impact Hypothesis: A Requiem," along with a discussion of other research that discredits the EIH evidence. A related point, first outlined in *Geophysical Research Letters* by Scott, Pinter, and others in mid-2010, is that the carbon spherules commonly cited by the EIH camp as further evidence of a YD impact are in fact more consistent with charred fungal cysts called sclerotia, which the *GRL* team found in most strata they tested on Santa Cruz Island—*not* just in the YDB sediments, as reported by Kennett's team.



DOMINIQUE SCHRYVERS

Millimeter-sized carbon spherules, which are common to undisturbed European soils and often contain nanodiamond-like structures.

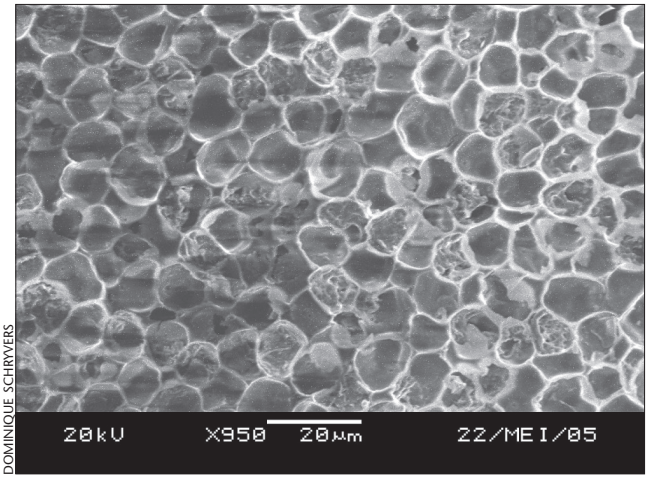
They performed lab experiments on fungal sclerotia to test the effect of burning them at the relatively low temperatures typical of wildfires. The results are intriguing, with the burnt sclerotia remarkably resembling the carbon spherules reported for YDB sediments. Scott et. al. note that the "structure in charred fungal sclerotia mirrors that in Pleistocene spherules at mm to nm scales." Furthermore, when burned the sclerotia form smooth spheres with thick rinds and, at temperatures above 550°C, hollow interiors; they also contain "ultrastructural morphologies resembling those interpreted by Kennett et al. . . . as nanodiamonds."

Scott et al. classify charred sclerotia as graphenes, and contend that EIH supporters consistently misinterpret them as carbon spherules. Kennett rejects that possibility. He admits that while these structures do resemble carbon spherules, they're not the same. Carbon spherules created in the lab from burning tree sap "show a continuous gradation in internal ultrastructure and composition between resin and carbon spherules," he explains. "The carbon spherules that we have identified are not sclerotia, and our mycological colleagues have agreed with this assessment. Scott has misidentified as sclerotia the particles we have identified as carbon spherules."

The *GRL* paper, which rests largely on Scott's expertise in paleobotany, appeared before the *PNAS* paper headlined by Daulton—prior to the assertion that graphenes are also sometimes misinterpreted as cubic nanodiamonds. In any case, determining the true genesis of these spherules is significant, since they often contain structures interpreted by the EIH proponents as nanodiamonds. If, in fact, "fungus, not comet or catastrophe, accounts for carbonaceous spherules in the Younger Dryas 'impact layer,'" as the title of the *GRL* paper claims, then one of the few surviving lines of evidence for the EIH has been dangerously undermined.

Occam's Razor cautions that the simplest explanation is always the most likely: If you hear hoofbeats in the distance, expect to see horses, not zebras. The anti-nanodiamond team argues that it's nonsensical to theorize an ET impact 12,900 years ago when there are more plebeian explanations to account for the evidence. In their article dealing with fungal sclerotia, they also summarily dismiss "carbon elongates," proposed as additional evidence of ET impact, as being in actuality insect feces—which, they emphasize, are found in most of the strata examined, not just in YDB sediments.

Moreover, the *GRL* paper challenges the radiocarbon dates provided by Kennett et al. for the Arlington Canyon site on Santa Rosa Island. According to Kennett's team, the entire suite of dates was essentially contemporaneous throughout a 5-m profile. They interpreted this as evidence of mass wasting (i.e., a single large soil movement), hypothesizing that the firestorm from the purported impact caused a massive vegetation burn-off, leaving soil loose and easily eroded. The Scott/Pinter team reports that their radiocarbon dates, obtained from the same profile, varied across a timeframe of more than 5,000 years—thereby contradicting the possibility of a single mass-wasting event. According to Kennett, however, "Daulton et al. did *not* sample the same stratigraphic section at Arlington Canyon. They sampled in a different location and geologic setting. . . . It is therefore not surprising that they report a different radiocarbon age sequence."



DOMINIQUE SCHRYVERS

The interior of a European carbon spherule, revealing its spongy inner structure.

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Converging on a Central Place: Fluted and Stemmed Technologies in the Great Basin

ONE OF THE ENDURING MYSTIQUES of the Clovis culture—other than the romantic ideal of Clovis as exclusively hunters of the Pleistocene megafauna—is the apparent sameness of Clovis technology throughout the lower 48 and northern Mexico. This sameness has been a key foundation of the long-held claim that Clovis spread rapidly throughout its known range because the movement of individuals and groups was unimpeded by the presence of established, territorial groups. Because the same megafauna prey species were everywhere, Clovis migrations were also not slowed by the process of adapting to new ecosystems. Consequently, the speed of the Clovis expansion in the New World was much faster than the speed of technological development and selection for alternative technologies was absent because of the sameness of the diet. Hence, the fact that Clovis is the same everywhere is explained by the speed of migration, which is evidenced, in part, by the sameness of Clovis everywhere.


GEORGE T. JONES

Beck at Mud Lake, Nevada, October 2007.

On the East Coast, researchers have been chipping away at this notion for several decades, sorting out the temporal sequence of fluted-point variants. And on the Plains, it has long been clear that Folsom follows close on the heels of Clovis, and, the temporal ambiguities of Goshen and Midland points aside, in turn is replaced by a variety of stemmed points (such as Eden, Scottsbluff, Hell Gap, and Agate Basin) after about 12,000 CALYBP.

In the Great Basin, however, the sequence has never really been pinned down. The relationship between fluted points and stemmed points has often been assumed to follow the same sequence as on the Plains. However, there has always been a vocal minority of researchers, such as Alan Bryan and Ruth Gruhn, who have argued that stemmed points are as old as or older than fluted points in the Great Basin. Absent a series of sites each showing the two point types in consistent stratigraphic relationship with each other, the debate seemed far from resolvable.

Clovis look-alikes

Enter Hamilton College researchers Charlotte Beck and Tom Jones. Together they have spent nearly 20 summers under the great bowl of blue sky the covers central Nevada. Across the once lake-covered sagebrush flats of Butte, Jakes, Grass, and Long Valleys, most of the archaeological record of the last 12,000 to 14,000 years lies on the surface. Only in the middle of Long Valley, buried some 4 m below the surface near Sunshine Well, have early archaeological materials been recovered in stratified contexts. And it's here, while unearthing the remains of a solitary Yesterday's camel (**MT 19-4,** "When the Camel Died, Did Anyone Hear It?"), that Dr. Jones and Dr. Beck first suspected that the fluted points in their collections were not exactly like Clovis points from sites such as Dietz in the northern Great Basin of Oregon or Blackwater

Draw, Lehner, Naco, and Murray Springs in the Southwest.

"When we did the Sunshine excavations, and looked at the data over the years, we recognized that the fluted points that we'd collected just didn't seem like Clovis," Beck recalls.

So Beck and Jones decided to reanalyze every fluted point from sites in the Great Basin that they could get their hands on, or for which photographic or other reliable documentary evidence had been published. Assisted by undergraduate honors student Amanda Taylor, they measured basal width, basal concavity depth, maximum width, maximum length, thickness and front edge angle, as well as raw material and the number of flakes used to flute each side. Beck and Jones also conducted a cladistic analysis of the data to establish the possible ancestry of the points. What they discovered is that there is significant variation in size, shape, and other attributes among fluted points recovered in the Great Basin.

Some fluted points, based on their metrics, raw material preference, and also technology, closely resemble classic Clovis points from the Plains and Southwest. But approximately a third of the fluted points that they analyzed were narrower, shorter, thinner, and overall more "gracile" in form. Perhaps Clovis wasn't the same everywhere. They termed this more-gracile point "Sunshine fluted."

CHARLOTTE BECK

Jones points to an exposed hearth feature in the wall of Water Gap Arroyo in Coal Valley, Nevada, July 2008.

Although there are few dates associated with fluted points of either type in the Great Basin, all the available dates are "anomalously young" compared with dates for Clovis on the Plains. For instance, a Sunshine fluted point that they discovered in the assemblage from the Connley Caves (from the excavations of Stephen Bedwell in the late 1960s and early 1970s) is tenuously associated with a radiocarbon date of 9540 ± 260 RCYBP (10,514–11,204 CALYBP). Jones readily admits that this date is probably "too young by as much as 500 years," but he doesn't concede the date is off much more than that. Such an extremely young date falls outside the bounding dates for Clovis on the Plains (10,800–11,250 RCYBP; 13,250–12,800 CALYBP), but is in line with seemingly "anomalous" dates associated with fluted points from sites such as Danger Cave, Utah (10,080 ± 130 RCYBP; 11,400–11,960 CALYBP); the Sunshine Locality, Nevada (10,320 ± 50 RCYBP; 12,040–12,350 CALYBP); and Henwood, California (8470 ± 370 RCYBP; 9005–10,118 CALYBP).

"It has always irritated me that every fluted point in the Great Basin is called Clovis, and because of this, the dates are discounted as too young. I thought, maybe something is going on here," Beck recollects.

Older and younger fluted points

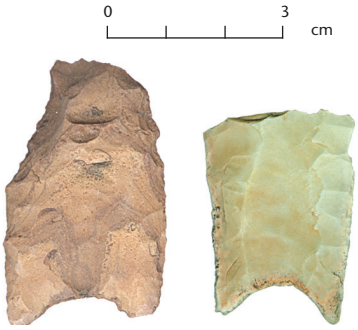
Beck and Jones hypothesized that perhaps Clovis in the Great Basin was time-transgressive. Perhaps, like eastern Clovis, there are older and younger forms. Perhaps, in parallel with what happens on the Plains, the more-gracile fluted-point forms are younger. But in an archaeological landscape where radiocarbon-dated fluted points are as rare as hen's teeth, how could this question be approached? An important study that influenced the thinking of Beck and Jones was the study of Clovis caches conducted by David Kilby, then a graduate student at the University of New Mexico (**MT 22-2,** "Snapshots in Time: New Insights from Clovis Lithic Caches"). Caches are collections of artifacts that were deposited together on the landscape by Clovis foragers, either stored as a stash of raw material and finished points for later use or deposited as part of a ritual offering, such as at Anzick, Montana. Caches have a limited distribution on the Plains, the Rocky Mountain front, and extending along the Snake River plain to the Columbia Plateau. Kilby discovered a geographic variation in Clovis cache contents. Caches in Texas, New Mexico, and Arizona almost exclusively contain blades or blade cores. The next group of caches to the north contains a mixture of blades, blade cores, and bifaces. To the north of these sites, almost all the caches contain only bifaces but not blades or blade cores. In the northernmost caches, bifaces become larger and more elaborate, traces of ocher occur, and at least one is associated with a human burial.

Beck and Jones noticed that a similar pattern occurs with blades in non-cache contexts. Sites with blades are common in the Southern Plains and the Southeast (particularly Kentucky and Tennessee), but sites to the west and north (such as Dietz) rarely contain blades. Blades appear to have been important components of Clovis technology in the Southern Plains and parts of the Southeast, but of little importance in the Northern Plains and Great Basin.

Importantly, the Clovis sites where blades are common date slightly before sites in regions where blades are rare. When Waters and Stafford analyzed Clovis dates in the West (**MT 22-3, -4,** "Clovis Dethroned: A New Perspective on the First Americans"), they included in their analysis only those sites where they felt the dates were secure and free of controversy. This produced a tight cluster of dates, mainly from the Plains, that showed no geographic patterning. But Beck and

Jones disagree with the exclusion of some sites, particularly the Aubrey site in Texas (**MT 6-2,** "A New Clovis Discovery in North-Central Texas"). If these other sites are included in the radiocarbon dataset and the dates are viewed within regions (East, Plains, Southwest), a south-to-north, older-to-younger gradient in Clovis site ages is evident. This matches the distribution of fluted points in the East and Northeast, where the assemblage content and point form gradually deviate from plains Clovis, and Clovis sites become progressively younger, with increasing distance from the Southern High Plains. Perhaps, as Michael Faught has argued (**MT 18-4,** "Rethinking Clovis Origins: A Conversation with Michael Faught"), Clovis is oldest in the Southern High Plains because that's closest to where it originated, somewhere out on the wide, once-bountiful coastal plain that is now submerged under the Gulf of Mexico.

If Clovis isn't in the Great Basin until later, is anyone there earlier? To address this question, Beck and Jones revisited the literature on Western Stemmed Point Tradition sites. Over the years, a small handful of radiocarbon dates had been obtained on Western Stemmed sites, such as Smith Creek Cave, Nevada, that were contemporaneous with Clovis on the Plains. The sites, however, were few, the dating wasn't very secure (large errors, weak association), and the dates got dismissed as erroneous by most researchers. But in the first decade of the 21st century, a handful of sites with early dates, including Cooper's Ferry in Idaho and Marmes Rockshelter in eastern Washington, showed that at least some of the larger, lanceolate-shaped Western Stemmed Tradition points were as old as Clovis on the Plains. Interestingly, the oldest Western Stemmed dates appeared to be mainly on the northwestern margin of the Great Basin.




CHARLOTTE BECK AND TOM JONES

Specimens of different lithic technologies of the Great Basin. All these projectile points are from Nevada. A, Clovis point from Coal Valley; B, Sunshine fluted point from the Sunshine locality; C, Lake Mohave stemmed point from the Sunshine locality; D, Cougar Mountain stemmed point from Esmerelda County.

Comparing fluted and stemmed points

Beck and Jones began to think that, given the consistently tight ages of Clovis sites and the discoveries of Western Stemmed Tradition (WST) sites with Clovis ages, it was time to reexamine the question of which culture had preceded which in the Great Basin.

The first thing they examined was the technology. Was either technology a logical outgrowth of the other? It seemed unlikely for three reasons. First, the technology used to reduce stone differed significantly between the two groups. Stemmed-point technology is entirely flake-based, whereas Clovis used a mix of flake and blade tools. When reducing bifaces, Clovis folks thinned them by sequentially removing large overshot *(outre passé)* flakes that carried past the midline and removed part of the far side of the biface (**MT 26-2,** "What It Means to Be Clovis"). WST knappers thinned their bifaces using collateral flaking, in which the flakes used to shape the biface carry only to the midline. Clovis knappers carefully conserved raw material by using overshot flakes as the basis for tools whereas WST knappers didn't use the waste flakes from biface thinning to make other stone tools. Some Clovis groups also created large blades which they made into scrapers and other unifacial tools. Even in Clovis sites where blades are absent, their approach for making tools is distinctly different from that of contemporary and later foragers.

Secondly, Clovis and WST knappers had decidedly different ideas about what kind of stone was suitable for making projectile points, a distinction that persists in regions where both cultures are present. Even in the Great Basin, Clovis and later fluted-point makers strongly preferred chert when they could find it, while WST knappers used chert only for their unique crescent tools, preferring volcanic rocks such as basalt and obsidian for most everything else.

Given these differences, it seemed very unlikely to Beck and Jones that either technology was an outgrowth of the other. The earliest WST points were contemporary with Clovis, and there seem to be no technological affinities between them that might suggest a common ancestor.

In fact, in eastern and southeastern Nevada, a curious thing appears in the surface assemblages documented by Jones and Beck: Sunshine fluted points are intermixed with stemmed points on the ground. According to Jones, "there's no intrasite spatial patterning that would separate out fluted and stemmed points at these sites." Beck notes that this is true of surface sites throughout the Great Basin.

A tale of multiple migrations

Perhaps, reasoned Jones and Beck, the young dates on fluted points in the Great Basin, the absence of blades in these assemblages, and the paucity of caches aren't flukes. Perhaps they are telling us that Clovis in the Great Basin really is on the young side. Clovis foragers migrated into the Great Basin in the centuries following their earliest appearance on

the Plains. Along the way, these foragers would have encountered and interacted with foragers already in the Great Basin and Pacific Northwest who carried large stemmed projectile points and thin crescentic bifaces.

In response to increasing aridity and sweeping environmental change at the close of the Pleistocene, humans and their prey spread increasingly thinly across the landscape. Over time, makers of fluted points favored more gracile forms, and then abandoned the technology altogether. Like a memory, bifacial, basally thinned, unfluted lanceolate points, such as Black Rock Concave Base, lingered in the toolkit into the early Holocene.

Jones argues that "if you do have Clovis pioneers moving in from the east and a population using stemmed point technology in or entering the Great Basin, it would not have taken long for the two populations to merge. In fact, stemming and fluting may be functionally distinct parts of a single toolkit."

In the last two decades, the story has become even more complex. Newly reported sites such as Friedkin in central Texas push blade technology in North America back to at least 15,500 CALYBP and provide clear technological antecedents to Clovis in the Southern High Plains and Southeast. At the same time, early dates are being reported from the Paisley Caves in Oregon (**MT 23-4, 24-1,** "Paisley Caves") that push human occupation in the Northwest almost as far back in time. The assemblages here are clearly not blade-based. Gazing southward, the Monte Verde assemblages with dates around 14,800 CALYBP show evidence for a third type of lithic technology, and there may be still other technologies emerging from the oldest deposits at sites elsewhere in South America.

According to Jones, "I think if it is the case that we have that kind of diversity early on, it must mean that it took a long time to accumulate that much technological diversity in the New World. So both fluted and stemmed points must occur many thousands of years after the first people appeared in the Americas. What I'm imagining is that we fill up a lot of the coastal landscape around or before 16,000 years ago. As sea levels began to rise, the coastal environments became unstable and people began to look to the interior for some ecological stability."

CHARLOTTE BECK

Jones prepares to excavate a site in Grass Valley, Nevada, July 2001.

Populations moving into the interior of North America from different points along the coast would have gradually converged on what was probably the last great unoccupied landscape in North America in the flat, dry lake beds between the craggy peaks of the Great Basin. And on some long past evening, foragers on the edge of their known world would have unexpectedly found other people already camped there.

We can't know what this first encounter was like, but Jones surmises that the palimpsest record of fluted and stemmed points in the surface record of this region is telling us that ultimately these populations may have merged. "It wouldn't have taken long for the two populations to become one. There are certain advantages to that."

–Ariane O. Pinson
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Suggested Readings

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Child of Beringia

Excavating at Xaasaa Na'.

ALL PHOTOS: BEN A. POTTER

EXCITEMENT WAS RUNNING HIGH at the excavation of an early occupation at the Upward Sun River, or Xaasaa Na', site in central Alaska. This is eastern Beringia, the pathway traveled by the first immigrants that made the journey from Asia to North America at the end of the Ice Age. When Ben Potter's team investigated the contents of a pit-hearth, Dr. Potter immediately called a halt: Beneath a layer of soil they found charred skeletal remains and a small burnt molar that Potter recognized as human.

A veteran of many digs in Alaska, Potter, a University of Alaska archaeologist, realized the significance of the discovery and notified the Healy Lake Tribe and other local Native groups before continuing. Working closely with tribal leaders, Potter and his team unearthed the cremated remains of a three-year-old child from the 45-cm-deep central pit-hearth. The discovery was a noteworthy find for the science of archaeology, as reported in the 25 February 2011 issue of *Science*. More than an opportunity for enlarging our knowledge of early Americans, however, it was the burial of a child laid to rest by its family and deserving of great respect.

"After the discovery of the first human remains," Potter explains, "we consulted with tribal leaders and others, following the guidelines of a Memorandum of Agreement that sets protocols for when human remains are found. The state troopers were also informed that the discovery was not a forensic case." At a conference that included Joann Polston, First Chief of the Healy Lake Traditional Council, and Jerry Isaac, president of the Tanana Chiefs Conference, the group set a cooperative course. Tribal leaders and archaeologists agreed on the importance of the discovery and the need to protect the site from vandalism. All were intrigued by the possible relationship between the ancient child and modern native populations. Native leaders visited the site, and with their consent archaeologists unearthed pieces of the child's skull, fragments of teeth, including some not yet erupted, ribs, pieces of upper arm bone, and many fragile bones from each hand. About 20% of the skeleton survived the ancient burning.

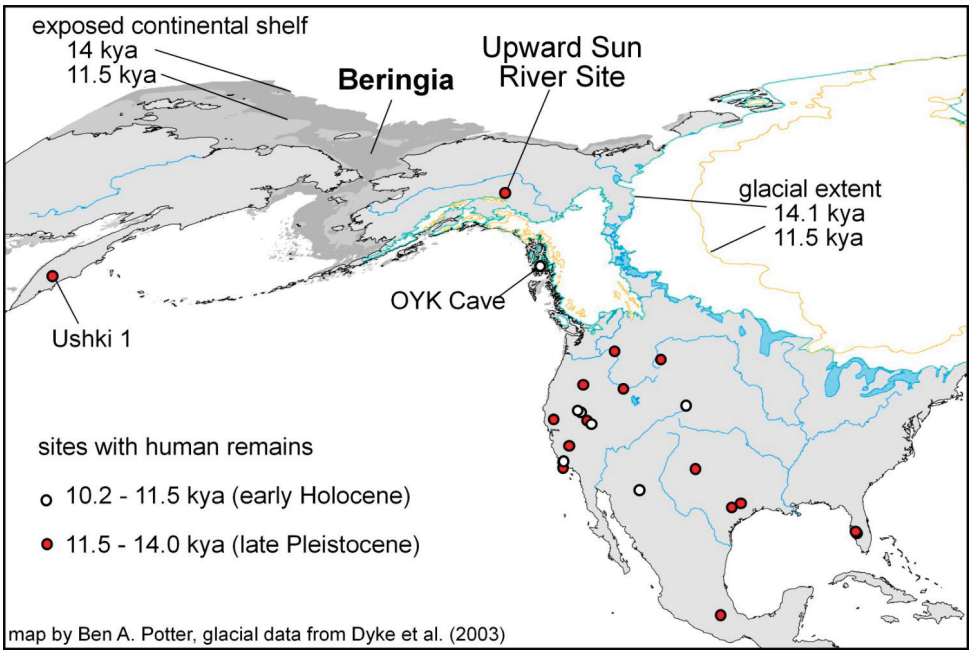
What do we know about the infant?

The state of dental eruption places the child's age at about three years, according to Dr. Joel Irish, a dental anthropologist at the University of Alaska Fairbanks. Some of the child's molars were still inside the protective jawbone, which probably accounts for their escaping destruction. Scientists are currently working to extract DNA from the bones to determine the child's ancestry and sex. They are especially interested in searching for a genetic link to living Native populations. Initial examinations reveal a slight "shoveling" of permanent incisors and unerupted canines, characteristics the child shares with Northeast Asians and Native Americans.

Human burials from the late Pleistocene and early Holocene in North America are a rarity, and none had been previously discovered in the North American Arctic and Subarctic. The dwelling was also the first structure discovered from that time period. Its location on the Tanana River floodplain is particularly significant because of what it tells us about the culture and life ways of early residents of Beringia, the land bridge that once connected Alaska with Siberia and created a pathway for human migration into North America.

Decoding Beringia

The history of Beringia rests squarely on the periodic rise and fall of the oceans. In the 1930s scientists began to better understand the relationship between the formation of glaciers and falling sea levels, recognizing that as ice sheets and glaciers formed, they bound up such an immense volume of water that the level of the oceans receded. The Bering-Chukchi Platform that became the Bering Land Bridge when sea levels lowered was a relatively flat plain, most of which today is less than 100 m below sea level. During the Pleistocene it was alternately exposed and flooded with changes in climate and glacier mass. The Last Glacial Maximum exposed an area of dry land more than 1,000 km wide, which allowed Asian species, including humans, to advance into new territory. When the Bering Land Bridge flooded for the last time during the early Holocene, the biological region known as Beringia ceased to exist.



Four separate occupations

Since 2006, Potter and his team have worked on four separate occupations or components of this same site, first discovered when a railroad survey turned up artifacts. The four components date from 11,420 ± 60 to 8850 ± 50 RCYBP (13,300 to 10,000 CALYBP). Component 3, dated at 11,500 CALYBP, contains the house and the child's skeletal remains, which shed new light on the lives of people who settled in Beringia.

"It was pretty exciting when we found the first pieces of human cranial bone," Potter remembers. "I knew from previous radiocarbon dating of the site that the remains were at least 10,000 years old or older and that they represented the first human remains from this time period. Campsites are common in the area, but this was the first intentional burial, the first house, the first human remains. It showed us a whole piece of the settlement system that we had no record of."

Excavating the burial: *(left-right)* Irish, Joshua D. Reuther, and Potter.

After receiving permission to continue the excavation, Potter enlarged the feature with eight new 1-by-1-m squares. The feature that housed the bones was oval shaped and sloped downwards from its outer edges. A surface hearth would normally be shallow and lens-shaped, not concave like this feature, and at first the scientists wondered if it might be a cache pit. But as the dig progressed, the upper portions revealed only one charcoal-rich, oxidized layer. Large amounts of charcoal and animal bones around the outer edges led them to infer that it was a pit-hearth. They spent several days removing the contents of the pit in 5-cm increments before reaching the bottom of the feature.

Human survival in the Arctic

That humans could survive in this brutal climate is a testimonial to the ability of *Homo sapiens* to adapt to cold. Beringian people learned to make clothing that fitted close to the body to protect from temperatures that probably dipped to -40°C and to build shelters that held wind and snow at bay. Radiocarbon dating of charcoal from the poplar used as fuel in the child's cremation pinpoints the date of the child's death at approximately 11,500 CALYBP, just after the Younger Dryas chronozone, the final cold spell of the Ice Age. During the Younger Dryas the population of Beringia diminished, probably influenced by dropping temperatures and glacial advance, only to increase again about 12,000–11,000 CALYBP when temperatures warmed. (Potter, an expert on radiocarbon dating, published a paper in 2008

entitled "Radiocarbon Chronology of Central Alaska: Technological Continuity and Economic Change," which synthesizes 30 years of empirical data on radiocarbon-dated components and identifies major patterns of technological and cultural change in the area.)

Led by Potter, the researchers at the Upward Sun River site studied the stratigraphy of the location and found no signs of mixing in the layers of sediment associated with the cremation and house, which corroborates the accuracy of the date. A total of 20 radiocarbon samples taken from the pit and surrounding strata confirm the age of the find.

Potter *(foreground)* and crew at total station work in the evening.

A circular dwelling

Previous discoveries in central Alaska from this time period were either temporary hunting camps where Paleoindian hunters pursued big game such as wapiti and bison, or specialized sites used for toolmaking or as kill sites. In contrast, the dwelling at the Upward Sun River site appears to have been a summer home occupied by a group that included women and children. The site is situated atop a sand dune topped by a layer of loess, fine silt accumulated over time by wind action. With its floor dug out to approximately 27 cm below ground level, the outline of the circular subterranean house showed six apparent postmolds, reddish stains with sharp edges, where wooden posts had once supported the walls and roof. Four of the postmolds were located along the edges of the pit hearth, where poles shaped a smoke hole in the center of the house.

The lower reaches of the central pit-hearth contained a thick layer of charcoal and ash laced with burnt bones of fish, hares, ground squirrels, and birds. These taxa and contextual data suggest the pit-hearth was used to cook food and dispose of refuse. The presence of the remains of immature ground squirrels as well as salmon identifies the season of use as summer. Although preserved salmon bones are rarely found because they decompose easily, bones of nearly 300 specimens were found in the pit.

The end of a short life

It's very difficult to determine the cause of the child's death. After the child died of whatever causes, the body was laid on its

back in the pit-hearth and cremated using poplar wood piled on top of it. After the cremation, the occupants covered the remains with soil and abandoned the dwelling.

The coloration of the burnt bones helped Potter and his associates draw inferences about the cremation. The bone fragments varied from black to gray-brown to white, the lightest color indicating the greatest exposure to heat. The posterior occipital (back of the skull) was black, likely because it was in contact with the ground during the cremation and remained cooler. Most other parietal and frontal bones were lighter in color, indicating exposure to intense heat. The smallest frontal bones were absent. There is a sharp line of demarcation on the bones of the cranium where the color changes from black to gray-brown. The lower limbs were probably flexed.

Examining material in the lab, Potter *(left)* and Irish.

Native peoples who consulted with archaeologists at the Upward Sun River site have named the child Xaasaa Cheege Ts'eniin, native Athabaskan for Upward Sun River Mouth Child.

Lithic artifacts

More than 350 lithic artifacts were also recovered from the floor of the dwelling, many of them small flakes related to tool resharpening. Retouched and modified flakes were strewn about the floor and in the pit-hearth. Four larger bifaces, thicker and asymmetrical, were likely used as knives rather than projectile points. The small number of formal tools and the faunal data indicate that the house was likely a seasonal base camp. The pit-hearth contained no obvious grave goods. This contrasts with the only other known ancient burial site associated with Beringia, at Ushki Lake, on the Kamchatka Peninsula in the Russian Far East, where researchers discovered two child burials, also buried (but not cremated) in pits within houses. One burial is associated with ocher and many lemming teeth, interpreted by N. Dikov to represent grave goods.

Excavation of the Upward Sun River site was funded by the National Science Foundation with added support from the Office of Polar Programs. The primary focus at the beginning was on an earlier component of the site, originally called the Little Delta Dune site, which has been dated to 13,000 CALYBP, but on the last day of that excavation, the tooth was discovered and set Potter and his colleagues on a new track toward discovering unprecedented mortuary and residential behaviors of the occupants of ancient Beringia.

Digging in central Alaska is an activity understandably confined to the short Alaskan summer. Potter and his team hope to be out there again in late May searching for more clues to the lives of the First Americans.

–Martha Deeringer

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Suggested Readings

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THE COASTAL MIGRATION THEORY, which proposes that the first migrants to the Americas skirted the coastline from Beringia in small boats, has long been a second-string player. It sits bench-warming, preempted by the time-honored theory that these new arrivals traveled by land through the Ice-free Corridor, a gap in the glaciers, into the core of the American continents. In recent years, however, this A-team has suffered a slump. The Ice-free Corridor is thought to have opened around 14,000 years ago, but archaeological sites in both North and South America are producing dates older than this. How could these early people have crossed glacier-covered Canada to reach habitable land? Whistle blows. Time out. Send in the second string. Suddenly the idea of migrants arriving in watercraft rather than on foot has more merit then we originally thought.

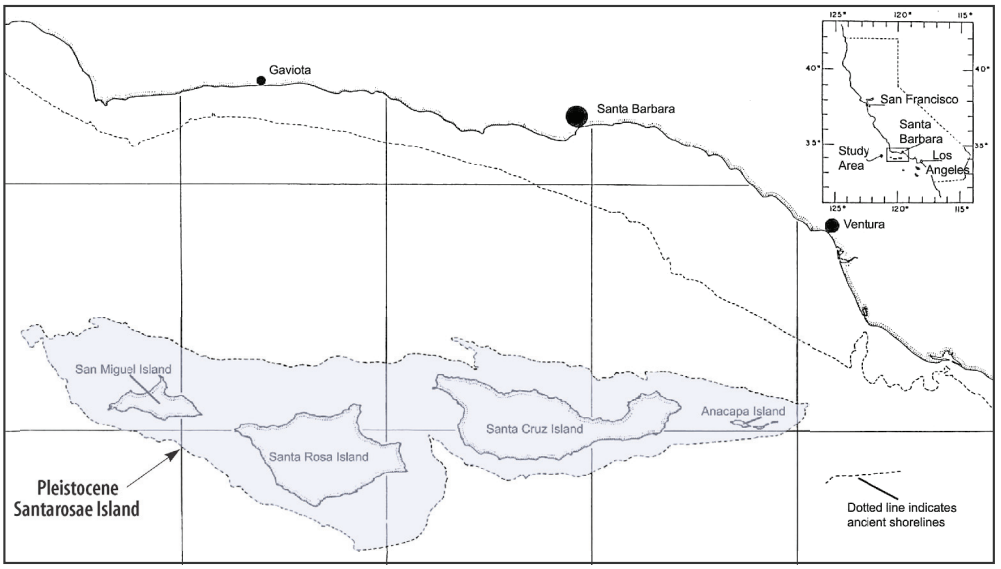
Where's the proof? Well, quite a few scientists are looking. Some, like Jon Erlandson of the University of Oregon, Eugene, have a jump on the rest of us. He has researched the history of human aquatic adaptations the world over. Dr. Erlandson's chosen area of operation, however, is the Channel Islands off the coast of California. He inherited this hunting ground from previous researchers, most notably Phil C. Orr of the Santa Barbara Museum of Natural History, who scoured the islands for two decades. Not all Dr. Orr's conclusions were widely accepted, but Erlandson has taken Orr's more secure findings, expanded on them, and discovered on the islands a wealth of sites dating to the early Holocene and terminal Pleistocene. It could be possible that these islands hold a site that predates the Ice-free Corridor. Without coastal sites of such antiquity, the Coastal Migration theory doesn't hold much water.

Ancient mariners and their albatrosses

Though Erlandson's geographical focus is the Channel Islands, he has researched aquatic-linked sites around the globe. He narrowed his search by looking into sites occupied by anatomically modern humans, as well as their hominid ancestors, whose culture depended on aquatic subsistence. That is, whose lifestyle relied on food supplies associated with bodies of water, including fish, shellfish, aquatic mammals, sea birds, and seaweeds.

In the Old World the most deep-rooted traces come from Olduvai Gorge in Tanzania, where remains of fish were found in association with Oldowan tools likely used by *Homo habilis* two million years ago. *Homo erectus* is also linked with aquatic subsistence in sites that span three continents (Africa, Asia, and Europe) and date from 1.4 million to 400,000 years ago. With the appearance of archaic *Homo sapiens* the grand tour stretches from South Africa to England, and from Portugal to Lebanon, spanning the period of 350,000–30,000 years ago. Anatomically modern humans spread over still more of the globe. Evidence for late-Pleistocene seafaring has been found on islands off Southeast Asia, western Melanesia, and Japan, and multiple voyages were required to colonize Australia about 50,000 years ago.

Considering the New World, South America claims the oldest



Map of the Northern Channel Islands, showing the approximate size of Santarosae Island during the Last Glacial Maximum.

evidence for coastal people. Seaweed foraged from coastal waters was found at Monte Verde in Chile, which possibly dates to about 14,000 CALYBP. Several sites ranging as far north as Alaska and as far south as Peru date to around 13,000 calendar years ago.

Why are all these sites worth mentioning? Most of our planet being covered with water, it seems reasonable that our ancestors should have enjoyed a long history of exploiting it for travel and as a source of food. Coastlines also provided a variety of foods from marine, estuarine, and terrestrial habitats. Oddly enough, the common thread of thought in the scientific community runs exactly counter to that notion. Sherwood Washburn and C. S. Lancaster contend that "for early man, water was a barrier and a danger, not a resource." According to University of Alaska archaeologist David Yesner, "A real commitment to maritime life-ways did not precede late Upper Paleolithic times." If this is true, then the Coastal Migration theory is all washed up. And by the way, how do we explain the peopling of Australia?

That's where all these data Erlandson has collected come into play. He wants to rid our ancient ancestors of their hydrophobic reputation. Authorities with a landlocked perspective describe marine resources as foods of "last resort." Erlandson disagrees, maintaining instead that savvy, opportunistic hunter-gatherers like our ancestors would hardly have ignored the bountiful resources manifestly available in marine environments. He summons abundant archaeological and historical data to support his claim. And as for water posing a hazardous roadblock for early hominids and humans, even seemingly limitless oceans didn't stop them from spreading out of Africa and into neighboring continents.

JON M. ERLANDSON

Channel Island Barbed points, crescents, and other artifacts from SRI-512 .

This mind set, that our distant forebears feared and avoided water, may have the unfortunate consequence of distorting the database of materials recovered from early sites. Erlandson has catalogued scores of sites where evidence of Pleistocene use of marine resources at sites had gone unnoticed by previous investigators. He fears that our preconceived notions are blinding us to contradictory evidence.

The greatest obstacle to investigating ancient maritime lifestyles is undoubtedly nature itself. Present sea levels are higher than they were in previous eras. The coasts we walk today were often miles inland when the first immigrants arrived, and in most cases sites that were situated on the coast during the Pleistocene now lie offshore. To locate such sites we must start probing the ocean floor. Despite the extraordinary money and effort required, some scientists have already begun surveying offshore waters (**MT 26-1,** "Prehistoric Florida Submerged: Finding Cultural Clues on the Continental Shelf; **MT 24-3,** "Putting Muscle into Coastal-Entry Research"). Erlandson emphasizes the importance of overcoming the tendency to excavate large, well-defined sites while neglecting short-term camp sites often left behind by mobile hunter-gatherers. He also suggests extending the scope of our research to locations that would have attracted these people farther inland, such as sources of fresh water, caves, or quarries of desirable chert. These are the methods he and his colleagues are currently employing on the Channel Islands.

Mammoths Orr middens

Lowered sea levels during the Pleistocene and early Holocene exposed a large island called Santarosae about 10 miles out to sea. With the melting of glaciers and rising sea level, the lower portions of the island disappeared beneath the surface about 10,000 years ago and what was one island became four. What remains above sea level has no shortage of archaeological sites. Before Erlandson took up his search, Orr published his findings on the islands. The information that received the most attention was the discovery made jointly by Rainer Berger and Orr of possible cultural fires associated with mammoth bones, perhaps dating as far back as 40,000 RCYBP, but insufficient documentation failed to convince the archaeological community.

Indisputable evidence leaves no doubt, however, that pygmy mammoths *(Mammuthus exilis)* did exist on the islands. Recent research reveals that the youngest mammoth remains are only a few centuries older than the earliest human evidence, making it appear possible that man and mammoth coexisted there. Although he has never located a site with explicit evidence of human-mammoth association like that claimed by Orr, Erlandson, a cautious scientist, allows that such evidence may have been lost to erosion. He has no faith, however, in Orr's date of 40,000 RCYBP.

Not all Orr's information was off base. In 1959 human remains were found near Arlington Springs on Santa Rosa Island. This partial skeleton, curated in the Santa Barbara Museum of Natural History and given the name Arlington Man, was found in association with charcoal, which was C-14 dated to approxi-

mately 10,000 RCYBP. The age was extended even further 40 years later by geochronologist Dr. Tom Stafford, who declared Arlington Woman—reexamination of the remains determined that Orr had misidentified the subject's sex—"the oldest skeletal remains, at least among the oldest, found in the New World" (**MT 14-3,** "Channel Island Woman May Be Oldest Yet").

There's a postscript to this story: A new forensic analysis by physical anthropologist Patricia Lambert in 2006 concluded that Orr was right about the sex after all (**MT 22-1,** "Arlington Springs—The Story Isn't Over Yet"). The 13,000-year-old human remains were restored to the male domain, likely to remain there for good this time.

JON M. ERLANDSON

Team member Dr. Todd Braje screening soil from a test unit in shallow 12,000-year-old midden deposits at SMI-678.

Out of the doldrums

Flying under the radar tuned to the bones of people and mammoths, something else in Orr's report caught Erlandson's attention, something plausible and interesting: Pleistocene shell middens. Perhaps within a mound of abalone shells accreted ages ago lay the evidence of boat people whose arrival predated the opening of the Ice-free Corridor.

When Erlandson went searching for them in 1989, relocating Orr's middens took time. It's easy to see how unglamorous features like shell middens would get overshadowed by human skeletons and mammoth bones. Eventually Erlandson found the middens Orr had documented and was delighted to have four or five early-Holocene middens to write about. None of the samples from these middens, however, placed human inhabitants on the island during the Pleistocene. Erlandson reasoned that erosion may have taken its toll in the 30 years since Orr documented these sites. If so, then the island and its sister islands could hold other sites of similar age. Erlandson continued his search.

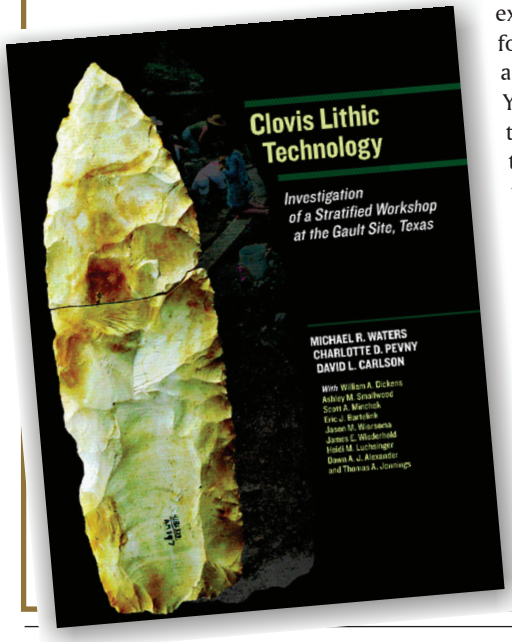
Why the dogged hunt for such sites? The oldest sites in lower North America at that time were Clovis, and for the most part they lay well inland. These twin facts support the theory of the Ice-free Corridor migration route and corroborate the notion that the First Americans had little interest in adapting to life in a coastal environment. Both these buttresses of conventional thought could be shaken, however, by finding a site old enough on the Channel Islands. Paleoamericans would have needed boats to reach Santarosae. And if they had the technology to build such boats and the maritime skill to cross open waters, then the Coastal Migration theory becomes undeniably plausible. It's the hope of finding this vindicating evidence that has kept Erlandson looking.

Patiently Erlandson has combed the islands and become an expert on middens, whether made by eagles and other animals, or by humans. Holocene sites have popped up left and right, and eventually one dating to the Pleistocene emerged, a site on nearby San Miguel Island known as Daisy Cave, which yielded evidence of occupation at approximately 11,500 CALYBP. Arlington Man has also sparked new interest. John Johnson of the Santa Barbara Museum of Natural History and Tom Stafford recently

continued on page 19

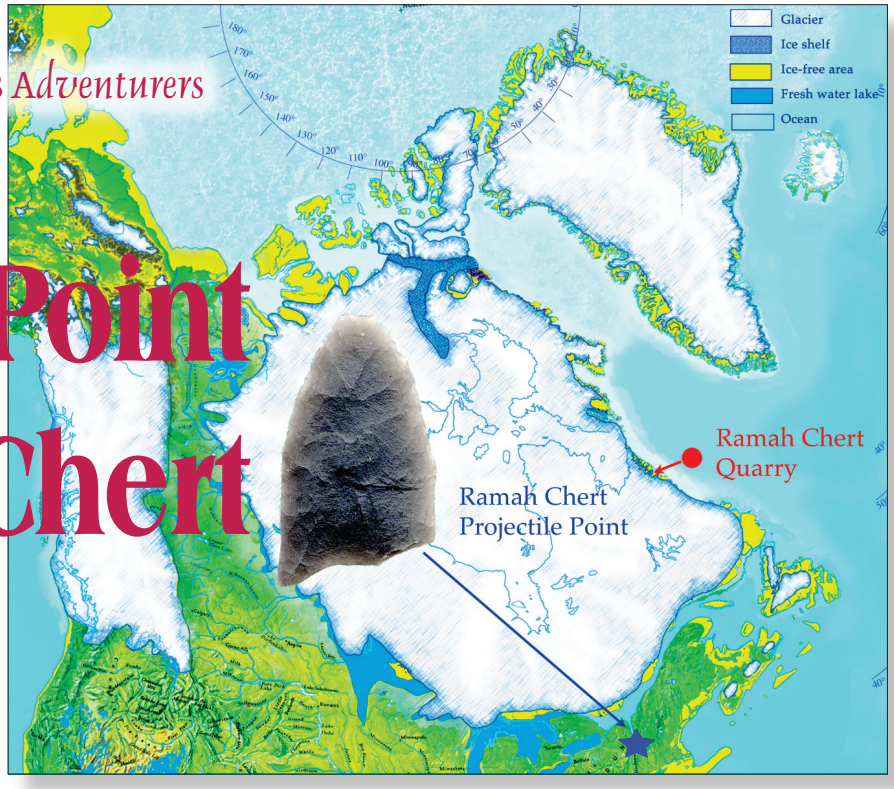
A Clovis Site, Top to Bottom

PLENTIFUL GAME, abundant freshwater, and an inexhaustible quarry of the finest toolstone drew mobile hunter-gatherers year after year to the Gault site on the banks of Buttermilk Creek in central Texas. Ten years ago a team from Texas A&M University began excavating the Lindsey Pit, the area of this former campsite and workshop richest in artifacts and with the clearest stratigraphy. Years of fieldwork yielded 67,000 lithic artifacts and 5,700 pieces of faunal remains that illuminate human life at the end of the Ice Age in the culture we know as Clovis. Primary authors are Michael Waters, Charlotte Pevny, and David Carlson. Nine coauthors, each a specialist in a specific aspect of archaeology, geoarchaeology, use wear, or lithic analysis, interpret the evidence and relate their findings to those from other Clovis sites. Replete with photos and illustrations, all in color, this is a detailed account of the rigorous scientific examination of one of the most important Paleoamerican sites in North America. See the rear cover for ordering information.



Another Ghost of Courageous Adventurers

The Fluted Point of Ramah Chert



The Manley projectile point. The map shows the immense distance and formidable obstacles separating the glacier-bound Ramah chert quarry in Labrador and the location in Vermont where the artifact was found.

A JOURNEY BEGINS WITH ONE STEP—or one stroke of a paddle. The amazing story of a possible 1,000-mile journey made 12,000 years ago begins with a projectile point made of exotic chert. Its significance now realized, this artifact challenges long-held assumptions about Paleoindian occupation of the Champlain Valley.

The point is a fluted projectile point made of translucent chert that was found in the 1920s by James Manley, Sr., in Franklin County, Vermont. During his undergraduate studies, young Stephen Loring, today a museum anthropologist and arctic archaeologist with the Arctic Studies Center at the Smithsonian National Museum of Natural History in Washington, D.C., routinely catalogued it together with other specimens. "Originally I thought it was an unusual raw material from a yet undiscovered stone source in Vermont," says Dr. Loring. "Twenty-five years later I was able to reexamine it when the Manley collection was auctioned and realized I was looking at Ramah chert from northern Labrador."


STEPHEN LORING

The rugged north coast of Labrador near Saglek just south of the Ramah chert quarries.

A toolstone that's hard to miss

Artifacts made of Ramah chert figure significantly in late-Archaic assemblages along the Atlantic Coast of New England as far north as Maine. Readily distinguished from other lithic raw materials, Ramah chert is a semi-translucent, light gray stone with parallel black bands of differing thicknesses throughout the stone. The strikingly beautiful Ramah chert has superb flaking qualities that make it an exceptional raw material for manufacturing flaked stone tools. It only occurs in a narrow geological bed that stretches approximately 30 km between Saglek Fiord and Ramah Bay (where the strata of high-quality chert are most accessible) in the rugged Torngat Mountains of northern Labrador.

Confirmation of the toolstone source came from Derek Wilton, professor of Earth Sciences at Memorial University in Newfoundland, who did some detective work using chemical analysis. Silica, the most common element in the Earth's crust, constitutes 99.9% of rock. The atomic matter in the remaining 0.1% of any rock, according to Dr. Wilton, produces a "lithic fingerprint" that can accurately pinpoint the origin of the rock. Using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), Wilton obtained a match with other samples from the Ramah Bay quarry site.

The age of the Manley point is defined by its morphology: It's a classic fluted point of the Michaud-Neponset style, a type of projectile point unique to New England that is well dated to the later half of the Younger Dryas period, 12,000–11,800 CALYBP. "The chemical signature of the projectile point unequivocally proves that it came from Ramah Bay in northern Labrador," says Loring. "The question is, How did it get from there to Vermont 12,000 years ago?"

Another Ghost of Courageous Adventurers

Loring and Wilton tackle the mystery of the single Ramah chert artifact found in Vermont in their forthcoming paper *Another Ghost of Courageous Adventurers*. The original Ghost of a Courageous Adventurer was an amazing knife that commemorated a remarkable journey by a group of young Tlingit men into the Alaskan interior. According to legend, a group of men of the Wolf clan ascended the Tlehini River and went overland across the Chilkat Pass to the headwaters of the Alsek River through a glacier to Russell Fjord. Embedded in driftwood along the Yakutat shore was iron, a material yet undiscovered by the Tlingit. Venturing inland, they received a piece of walrus ivory from an inland tribe in exchange for their gift of flint and pyrite. Sometime after their return the knife was created as a tangible reminder of the remarkable journey and of the lives that were lost. It became an important piece of clan property and was passed down, along with the story it told, from generation to generation. Measuring 15½ inches overall, the Ghost of Courageous Adventurers is believed to be made from the very pieces of ivory and iron found during the expedition. The ivory pommel is carved like a human skull and inlaid with blue iridescent abalone to represent the ghosts of the courageous adventurers.

STEPHEN LORING

Milton, Vermont. Sandblows, relic shorelines of the Champlain Sea, in Milton and neighboring Fairfax contain traces of Paleoindian occupations.

The Manley fluted projectile point, Loring and Wilton are convinced, is evidence of another extraordinary journey made by a different group of adventurers, Paleoamericans, who first discovered a source of amazingly exotic toolstone. In his 2002 article "And They Took Away Stones from Ramah," Loring notes that Paleoeskimo peoples preferred specific exotic chert sources even if there were sources of acceptable substitutes closer to home. We know that Paleoindian toolmakers in quest of fine toolstone either traveled overland—sometimes, especially in the case of Clovis and Folsom cultures, distances of hundreds of miles—or they traded for it. To obtain Ramah chert, the makers of the Manley projectile point had to undertake a journey of more than 1,000 miles—*over water.*


STEPHEN LORING

Wilton standing beside chert strata at Mugford Tickle, northern Labrador, 2006.

Ancient topography and the Champlain Sea

Blame the Ice Age for their hardship. Roughly 20,000 years ago, a sheet of ice a mile thick covered the entire Lake Champlain basin, including most of New England and New York State. On retreat of the glacier, marine waters from the St. Lawrence flooded the basin and created the Champlain Sea. Its existence is verified by whale fossils found in Montreal and in Charlotte, Vermont, where in 1849 railroad workers found a 12,000-year-old beluga whale skeleton. Covering Quebec, Ontario, Vermont, and New York, the Champlain Sea was home to a variety of marine life including beluga whales, cod, seals, and shellfish.

At the time the Manley point was made, continental glacial ice still covered Canada north of the Champlain Sea. "The coast would have been open," Loring tells us, "like Greenland today, with glaciers covering the near-interior." Meltwater and ice, and ice from fjords would have prevented foot travel along the coast. In such a forbidding environment, passage on foot from Vermont to Ramah Bay was impossible.

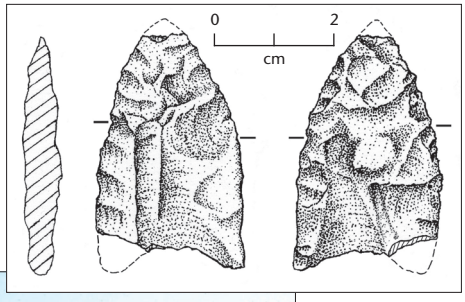
The only means of travel was therefore by boat. For Paleoindians to cross the Champlain Sea and navigate coastal waters, a voyage of 1,000–1,600 miles from the Champlain Valley to northern Labrador, they would need watercraft and substantial maritime skills. For Loring and Wilton, the Manley fluted projectile point is silent testimony that such a voyage was indeed accomplished.

Heavily worn down from resharpening, the point has been used many times, which to Loring is further evidence that the point is emblematic of an amazing journey. Native American hunters place special value on tools used to perform a sacred act, killing a splendid prey animal, for example, and we can assume that early hunter-gatherers likewise would have revered a magnificent projectile point whose toolstone was the prize won after an epic journey over water. The exotic nature of Ramah chert and the clear evidence of repeated use of the Manley point

lead Loring and Wilton to the conclusion that it is the Ghost of a Courageous Adventurer, a personal talisman that accompanied its owner on a daring voyage of over 1,000 nautical miles.

Support for alternative migration possibilities?

The fact that the toolstone used to make this Paleoindian projectile point could only have been procured by travel over water dramatically alters perceptions of Paleoindian adaptations to periglacial conditions in the Far Northeast, for such a voyage testifies to their marine adaptation and competence in building and piloting watercraft. Proponents of the Solutrean migration hypothesis say Loring's discovery reinforces the possibility that the earliest settlers in the Americas could in fact be Paleolithic people from Europe. Smithsonian anthropologist Dennis Stanford believes that migrants in small skinned watercraft, perhaps similar to those used by the Inuit, may have made the passage along the ice packs from France to North America (**MT 17-1,** "Immigrants from the *Other* Side?").



▲The Manley projectile point.

BOTH: STEPHEN LORING

◀ Stemmed projectile points and a large biface of Ramah chert from the Maritime Archaic site at Nulliak, northern Labrador (ca. 4000 CALYBP). Ramah chert was a highly desirous lithic raw material for many of the Indian and Paleoeskimo peoples who lived in Labrador thousands of years after the pioneering Paleoindians discovered the Ramah chert outcrops. Similar stemmed projectile points were traded from Labrador to New England during the Late Archaic and appear as associated burial goods in the Moorehead Ceremonial Complex (Red Paint Indian) sites in Maine and the Maritimes.

For his part, Loring is unwilling to make the cognitive leap from a waterborne passage between Vermont and Labrador, to the transatlantic migration of Solutrean sailors from Europe—whose supposed journey predates the Manley point by 5,000 years.

Despite Loring's reluctance to endorse the Solutrean migration hypothesis, his theory nevertheless lends weight to a growing body of evidence that Paleo peoples employed the marine environment as a means of travel. Dr. Stanford bases his theory in large part on striking similarities that exist between Clovis stone tools in North America and those found in France and Spain, particularly bifacial knapping and the intentional use of overshot *(outre passé)* flaking—a specialized technique for reducing the thickness of a tool without reducing its width (**MT 26-1,** "What It Means to Be Clovis"). Bifacial pressure-flaked tools and points disappear from the European record 15,000 years ago and appear 13,000–12,000 years ago in North America.

STEPHEN LORING

Large herds of migrating harp seals would have been a prominent feature of the late-Pleistocene North Atlantic and Champlain Sea. This photograph, taken off the northern coast of Labrador near Hebron in July 2002, testifies to the potential of the North Atlantic environment for sustaining ancient hunters with a maritime adaptation.

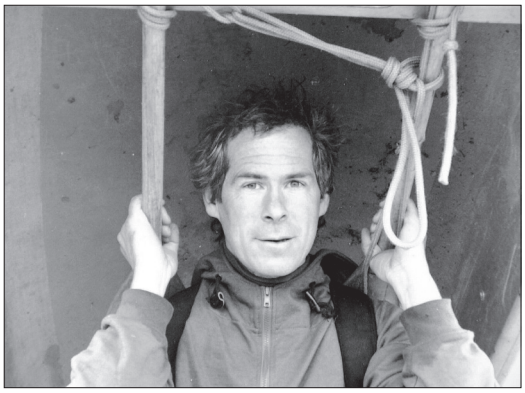
Two scientists in less than perfect accord

For Stanford, Loring's discovery lends credibility to his Solutrean migration theory because it necessarily implies that Paleoindians were sophisticated mariners. Stanford agrees that the only way to get to the quarry would have been by boat. He contends that a journey by boat to northern Labrador from the south would require traveling against the Labrador Current, an impossible feat unless the voyagers knew how to tack. "It would be hard to get there and back in one summer unless you knew how to sail," says Stanford. "I don't know how many miles of marine glaciers need to be circumvented to get to the quarry, but my guess would be hundreds if not over a thousand miles."

Loring counters that skin boats, "like the umiaks paddled by the Inuit (and presumably the Paleoindians) were paddled, not sailed for the most part, and would have hugged the shore." Moreover, the trip may have been made only once and may have taken years to complete. He disregards the imperative of completing the round trip in one summer.

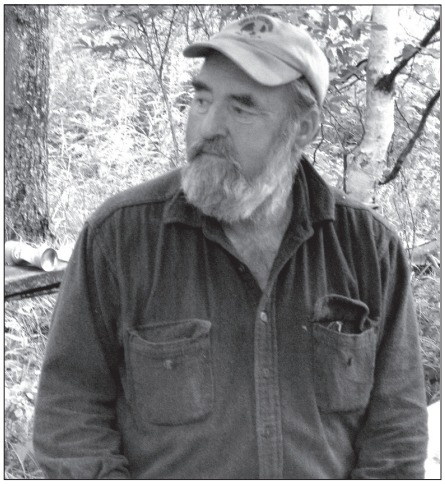
Loring and Stanford agree that Paleoindians living in the Champlain Valley must have had marine technology enabling them to make watercraft and travel appreciable distances. They differ on the aspects and implication of the voyage. Stanford believes that a host of other factors suggest that they (and by implication, their Solutrean forebears) were experienced in long-distance maritime travel. Loring considers it within the realm of possibility that Paleo boat travelers from Europe might wash up in a new world, but a bit farfetched to

conclude they would be making multiple trips. "It's one thing to say Vermont Paleoindians had access to the Canadian Arctic," says Loring. "It's quite another to say they were regularly going back and forth."


STEPHEN LORING

Loring portaging a canoe in northern Labrador, 2001.

One reason why Loring discounts Stanford's hypothesis is that skin boats aren't suitably constructed for such a harsh environment. How long, he wonders, could a small watercraft made of wood and seal or walrus skin survive immersed in the icebound Atlantic Ocean? Boats made of skin must be dried out after a period of just a few weeks in the water. Loring doubts that umiaks could endure a voyage of the duration needed to travel from France to North America.


MARGARET JODRY

Stanford in Kamchatka, 2009.

Not easily dissuaded, Stanford counters with an alternative to the umiak. Irish boats made of bovid skins soaked in sheep tallow are good for several months in the water, he points out, rather than weeks. He suspects that Paleo people were adept sailors and would likely have developed technology for building watercraft on a par with Irish bovid boats.

A planned journey, or a quirk of human nature?

"Why would a Paleoindian take a boat that far north and in such waters?" asks Stanford. "Maybe they knew that the source was there. The bottom line is that this is the best circumstantial evidence for early marine travel in the Atlantic."

For his part, Loring believes it unlikely that Paleoindian travelers were aware of the existence of the quarry of Ramah chert, considering the forbidding topographic nature of the Champlain Valley and the presence of an ice sheet directly above the Champlain Sea. Drawing upon the vast history of exploration throughout Canada, Loring suggests that the best explanation for why a group of Paleoindians would travel over 1,000 miles to northern Labrador is simply the inquisitive nature of humans to see what lies around the bend. "The original Courageous Adventurers did not have a reason for their amazing journey, it just happened," says Loring.

Although Loring doesn't agree with Stanford's assertion that Paleoindians necessarily created and used advanced marine technology capable of challenging an ocean, the inescapable fact that other instances of Ramah chert didn't arrive in New England until 7,000 years after the Manley point appeared in Vermont supports Loring's conclusion that the point is Another Ghost of Courageous Adventurers. Our knowledge of the topography of the Champlain Valley at the end of the Ice Age lends credence to his crediting Vermont Paleoindians with the skill and daring to complete a 1,000-mile journey by boat, navigating icebergs and strong currents through periglacial waters.

Perhaps the artifact confirms the irrepressible curiosity of humans to see what lies just out of sight. What's remarkable is that a scientist gifted with the acumen to recognize its significance appeared on the spot at precisely the right moment in history. MT

–Amy Guest

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The story of the Ramah chert fluted projectile point is told on the Arctic Studies Center Website: http://www.mnh.si.edu/arctic/html/Labrador/index.html

A Story of Ancient Mariners

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redated the skeleton, this time directly on a sample of bone, and found he lived around 13,000 years ago. This places him squarely in the Clovis timeframe, but whether he was a member of the Clovis culture or merely a Clovis contemporary is unknown.

Neither the Arlington Springs site nor Daisy Cave produced any diagnostic artifacts. Other sites proved more helpful in that department. One on Santa Rosa Island dates to 12,000–11,350 CALYBP. Two sites on San Miguel Island, CA-SMI-678 and CA-SMI-679, date to 12,250–11,200 CALYBP and approximately 11,900 CALYBP, respectively. These dates are tantalizingly close to Clovis age. With co–principal investigator Torben Rick of the Smithsonian Institution and other collaborators, Erlandson published these results in the March 2011 issue of *Science*.

ERIK ERLANDSON

Erlandson standing on a seacliff along the south coast of Iceland, where he has pursued research on Viking-age sites.

The showpieces of these three sites are crescents and stemmed barbed points. Crescents are exactly what they sound like, semicircular lithic tools often thought to have been used to hunt waterfowl or other birds as a transverse point used to break a wing or stun a bird while in flight (**MT 25-3,** "Studying Crescentics: Form or Function?"). On the mainland of California and into the Great Basin, crescents are generally thought to date to the early Holocene. Many from the Channel Islands have been found on the surface, the result of eolian erosion caused by historic livestock overgrazing, or in other undatable contexts. What Erlandson finds interesting about those found in datable contexts is that many were found in sites up to 12,000 years old, and none younger than 7,500. This leaves us to wonder if the manufacture and use of crescents began on the coast and later spread into the interior.

Channel Island Barbed points range in size from large dart points to what many would consider to be arrow points. Erlandson suggests they were used "to hunt a variety of marine animals, from seals, to otters, birds, and perhaps even for fishing." They have a long tang, unlike Clovis or Folsom tools, and share traits with points found along the Pacific Rim from Japan to South America. Erlandson notes the similarity to points from the Incipient Jomon period in Japan (16,000 CALYBP). "I'd probably chalk that up to coincidence," he says, "except for the fact that broadly similar points have also been found in Late Pleistocene contexts on Sahkalin Island, in Kamchatka, the Pacific Northwest, California, and throughout South America."

Uncharted waters

When the facts are chalked up, the results are puzzling. The oldest human evidence is Arlington Man: Pleistocene in age, but a millennium younger than the opening of the Ice-free Corridor. Tool assemblages from various sites on the island aren't Clovis, and they all fall after the Clovis time range. In view of the fact that the antiquity falls short of the earliest Clovis date, Erlandson says it's possible this lithic technology descended from Clovis. Yet it looks nothing like Clovis, but shares similarities with technologies developed around the Pacific Rim—a constellation of coastal environments. As for the Coastal Migration theory, the Pleistocene shell middens found on the Channel Islands speak of a Paleocoastal people who not only subsisted on fish, shellfish, sea birds, and aquatic mammals, but had the maritime technology to pilot watercraft across 10 miles of ocean from the coast to the islands.

Erlandson's portfolio of evidence isn't solid proof that Paleoamericans descended from Beringia along the coast by way of boats, but it certainly points in that direction. And as for those hydrophobic First Americans, that idea seems sunk.

–K. Hill

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The Clovis Comet Revisited

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An alternative origin

Meanwhile, another research group admits the presence of cubic nanodiamonds in YDB sediments from a site in Belgium, but refuses to accept an ET impact as the origin. Rather, they credit a clever but purely terrestrial mechanism with the formation of these particles.

In a 2010 article in *PNAS*, "Nanodiamonds Do Not Provide Unique Evidence for a Younger Dryas Impact," He Tian, Dominique Schryvers, and Philippe Claeys report that the nanodiamonds they found occurred exclusively in the YDB "black mat" layer at Lommel. They observed no lonsdaleite or intact carbon spherules; however, many of the nanodiamonds were embedded in amorphous flecks of carbon that might represent the fragments of spherules pulverized by mechanical weathering. Others were present as thin particles.

JAMES KENNETT

James Kennett preparing to examine methane seeps on the ocean floor off the coast of Santa Barbara, California, 2005.

The Lommel team argues that the nanodiamonds could have been created in "carbon onions," spherical structures made of stacked graphene sheets that can act as nanoscopic pressure cells. These structures differ from the carbon spherules observed in other YDB deposits in that they're smaller than those micron-sized spherules, which are, in any case, mostly spongy structures of amorphous carbon. Physicist Nick Schryvers describes carbon onions as "only a few layers of graphite, which limits them to the nanometer range and gives them a real and unique crystallographic structure." As a result of the natural packing and curvature of the graphene sheets, the internal pressure inside carbon onions can reach an astonishing 100 gigapascals across submicroscopic distances—more than sufficient pressure for diamond synthesis. Apply enough energy, and plain carbon might transform to diamond without the need for an ET impact. As the Lommel team notes, the morphology of their nanodiamonds suggests that the particles were formed gradually in place.

Ultimately, the Lommel team concludes that "the present variety of crystalline structures observed in the black Younger Dryas boundary in Lommel does not provide sufficient evidence to conclude an exogenic [ET] impact as the origin of these structures." They don't exclude the possibility of an impact, as the anti-nanodiamonds crowd does; they simply don't see the need for such a hypothesis.

How the Lommel carbon onions might have formed remains unclear, although Tian et al. suggest they could be produced by "a variety of processes," including wildfires. Indeed, other researchers have observed similar carbon onions in both natural and artificially produced charcoal. Even so, as Dr. Kennett points out, there's no evidence that carbon onions containing nanodiamonds can form in forest fires; indeed, the experimental data indicates otherwise, because the fires simply don't provide enough energy.

Whither EIH?

With the publication of their recent series of articles, Daulton, Pinter, and Scott apparently consider the EIH matter closed—to the point where they politely declined to be interviewed for this article. Other researchers are more ambivalent, as the Lommel research demonstrates. But James Kennett considers the issue far from settled. "The YDB cosmic impact hypothesis has *not* yet been sufficiently tested," he insists. "At the moment, an impact is the only known event capable of producing the wide range of evidence that we see. If some other causative process is at work, it must account for all the evidence. So far, nothing else does." There are many, however, who would beg to differ.

Diamond is the hardest substance on Earth—but it shatters if struck hard enough at the proper angle. That hasn't happened yet with the EIH nanodiamond evidence, but it seems that cracks are beginning to show. Whether they'll heal, or fly apart at the next blow, remains to be seen.

–Floyd Largent

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