MAMMOTH TRUMPET

Volume 30, Number 2 ■ April, 2015

The Anzick Children laid to rest

Tribal representatives witness Sarah Anzick bearing the casket containing the remains of two Early American children to a burial crypt on the Anzick farm in Montana where they were discovered in 1968. DNA analysis of one child, found buried with Clovis artifacts, revealed that his extended family were ancestors of 80% of all Native Americans. Dr. Anzick's son Benjamin is to her right. See the story on **page 11.** Photo by Shawn Raecke

Center for the Study of the First Americans
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MAMMOTH TRUMPET

Volume 30, Number 2 | Center for the Study of the First Americans | Department of Anthropology
April, 2015 | Texas A&M University, 4352 TAMU, College Station, TX 77843-4352 | ISSN 8755-6898

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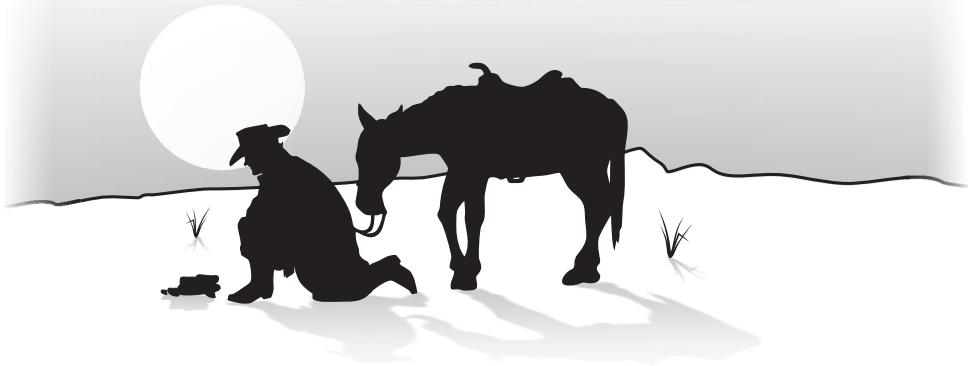
George C. Frison: Archaeologist on Horseback



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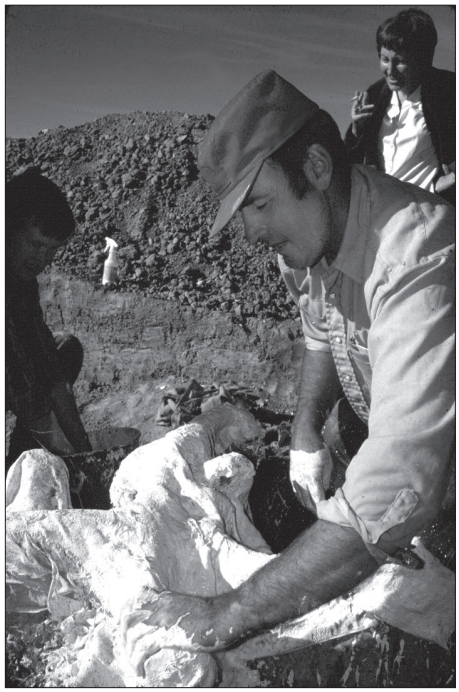
THE HARSH WILDERNESS of the Wyoming High Plains has become inseparably linked with the name George C. Frison. In the first third of his life, Frison was a successful cattle rancher and guide for elk and deer hunters. In the remaining two thirds he has been a scientist and scholar acclaimed as an authority on Clovis and Folsom lithic technology. He untangled the distorted model of Paleoamerican hunting strategy that had dominated North American anthropology, and he deserves a gigantic share of the credit for defining the cultural chronology of the Northwestern Plains and central Rocky Mountains. In 1997 he was elected to the National Academy of Sciences, the first person from Wyoming to receive the honor, and in 2005 the Society for American Archaeology presented him with its coveted Lifetime Achievement Award. Looking back on the accomplishments of his 90 years, which would be enough to satisfy any three or four men, Frison says simply, "I was lucky to be able to live in two different worlds and enjoy them both."

Youth in the midst of ancient artifacts

The Frisons were pioneer stock. In 1901 George's paternal grandparents journeyed 450 miles with their children in horse-drawn wagons, livestock in tow, from Colorado to the village of Ten Sleep, Wyoming, in search of land with good ranching potential. They took over a half section in the Bighorn Basin just as winter approached, and over the next decade the family ranch flour-

ished. In 1924 the son George S. Frison died in an accident just three months prior to the birth of his own son, George C. Frison. Young George's grandparents welcomed him to the ranch to live with them when he was just three years old.

It's easy to believe that Fate had a hand in shaping Frison's life. The Frison ranch was a favorite stopping place for native tribes traveling between the Yellowstone River in Montana and the North Platte River in Wyoming. Each river was about "ten sleeps" away from the village, hence its name. Traveling tribes left behind painted figures on rockshelter walls, parts of lodge poles and travois poles, stone artifacts, and once a platform in a large juniper tree that had served as an aerial burial. Checking cattle with his grandfather one day in 1929, five-year-old George found a beautifully made large spearpoint, which kindled a life-long fascination with Indian artifacts of the Great Plains. After that, his grandfather had to remind him constantly to keep his eyes on the cattle and not the ground as they rode through the pastures during the drought and depression years of the 1930s.



ALL PHOTOS: GEORGE C. FRISON

Frison casting bones at the Colby mammoth-kill site, Wyoming, 1973.

During these difficult years the Frisons supplemented the family diet with deer, elk, and antelope. George's grandfather taught him to hunt, thereby giving him the means to supplement his income in later years as a hunting guide.

After the grandfather was severely injured in 1935, he turned the operation over to his two sons, who eventually leased the land to sheep men. George finished high school in 1942, then studied for one quarter at the University of Wyoming and enlisted in the Navy on turning 18. His Navy years were spent aboard the attack transport *USS Navarro,* APA-215, in the South Pacific. With the end of the war he returned to his beloved open plains. In 1946 he married June Glanville, and the young couple set up housekeeping on the ranch, where Frison guided deer and elk hunters along with tending to his ranching duties. His life-long familiarity with the behavior of cattle and wild game would give him

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
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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

valuable insight into Paleoamerican hunting methods when archaeology later became his full-time passion. Meanwhile his abiding interest in Indian artifacts never waned. He joined the Wyoming Archaeological Society and collected many projectile points and fossil remains from sites near his home.

A career change

After undergoing surgery to relieve back trouble stemming from a war injury and aggravated by the hard work of ranching, Frison was forced to seek new long-range goals. At age 37 he enrolled at the University of Wyoming. He graduated with honors with a B.S. degree in 1964 and set his sights on graduate school. Having accumulated some archaeological field experience and published a few articles, he received a National Science Foundation grant to assist Dr. William Mulloy of UW in excavating a bison kill site and analyzing and writing up the results.

After graduating, Frison wanted to do serious archaeological research in the Northern and Northwestern Plains. Few other scientists shared his interest, however, because the region was thought to suffer from a barren prehistory prior to the introduction of the horse with European contact. This misconception in turn was responsible for a wholly erroneous model of the strategy Paleoamerican hunters used to procure big game, especially bison. How could hunters on foot and armed only with spears possibly kill a one-ton animal? Anthropologists proposed that hunters incapacitated the beasts by driving them into bogs. Frison, with his long experience in tending cattle and hunting big game, knew it would be impossible for hunters to butcher and retrieve the meat from a bison mired up to its belly.

The answer came to him in 1961 in a symposium on buffalo jumps at a meeting of the Montana Archaeological Society. He wondered whether knowledge of the behavior of bison might have made it possible for Paleoamerican hunters to slaughter the animals. His interest lay not so much in artifacts and tools discovered in the bone beds as in a drive-line system that would force a herd of bison over a jump-off, to be killed or crippled in the fall. Data gathered from field work at bone-bed excavations rounded out his dissertation in 1967, just three years after receiving his B.S., which earned his Ph.D. in anthropology from the University of Michigan.

Hello, Professor Frison

The timing was perfect, for the University of Wyoming had newly established a Department of Anthropology with two full-time faculty members. Frison was hired to fill one of the positions and appointed department head, a position he would hold for more than 20 years. In the early days, however, the Dean of Arts and Sciences regarded archaeology as "piddling research." Consequently Frison was required to fund his research through outside sources. A promising bison jump site at Glenrock, Wyoming, received funding from a National Science Foundation grant. Despite a heavy teaching load, Frison set out with a crew of University of Wyoming students to excavate the site.

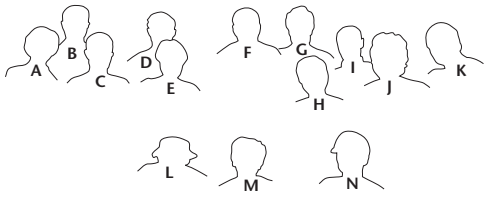
Frison *(top)* and Bruce Bradley excavating a 2-year-old male mammoth skull at the Colby mammoth-kill site, 1975.

When the state of Wyoming created the official position of state archaeologist, Frison became the first person to serve in that capacity. Now comfortable with a modest salary and travel budget, Frison concentrated on inventorying cultural resources in the state. The Medicine Lodge Creek site in northern Wyoming yielded stratified cultural deposits spanning about 10,000 years of prehistory. Studies of "Early Man," now classified as Paleoindian, became a specialized area of multidisciplinary study by geologists, paleontologists, palynologists, and soil experts.

Buffalo jumps

Bison kill sites in the northwestern Plains piqued Frison's interest in Paleoamerican hunting strategies. He often visited large herds of modern bison to observe their behavior when the animals were branded or worked in pens. These visits and his analysis of the Glenrock Buffalo Jump confirmed his belief that the bison herd had been driven nearly a mile through ever-narrowing drivelines, then past a right-angle turn at the last moment before being stampeded over the jump-off. His investigations of communal animal kill sites from then on yielded more and more information on the human groups involved, the time of year of the kills, the

Frison holding a male *Bison antiquus* skull recovered during uranium mining operations in the Shirley Basin area, southeast Wyoming, 1980.



Archaeologists at the Ludinovo mammoth site in Russia, 1989: A, D. Dincause; **B,** L. Davis; **C,** D. Meltzer; **D,** L. Binford; **E,** O. Soffer; **F,** G. Frison; **G,** C. Gamble; **H–J,** Russian escorts; **K,** J. Adovasio; **L,** C. V. Haynes; **M,** S. Krotova; **N,** B. Bradley.

age and sex of animals found in the bone beds, and associated tools and weapons.

"The investigation and analysis of the Glenrock Buffalo Jump left no doubt in my mind that bison were the major source of livelihood for human populations throughout Northwestern Plains prehistory," Frison says. This early work led to excavations of other sites. The Kobold Buffalo Jump in south-central Montana yielded Late Plains Archaic and Late Prehistoric projectile points and indications of ritual activities. The Ruby site, a bison-procurement complex in eastern Wyoming, confirmed his belief that prehistoric hunters thoroughly understood bison behavior: Postholes found there indicate a corral hidden by a bend in the drive-line; another, partially roofed structure festooned with male bison skulls with frontal ends pointing outward suggests the handiwork of a shaman whose purpose was to entice the bison into the corral.

Lithic tools, another area of interest

Investigating each new bison-procurement site contributed further to Frison's knowledge of bison skeletal elements and the way the animals were butchered using stone tools. His chance to gain practical experience using stone tools came when an archer in South Dakota received permission to kill a young bull with bow and arrow. Frison found skinning and butchering the animal hard work that required very sharp flaked-stone tools.

When Frison began investigating the Agate Basin bison-kill site in Wyoming, he asked his friend, Dennis Stanford, now Paleoindian archaeologist at the Smithsonian Institution, to consult on site. Excavations in 1975–1981 revealed Folsom, Agate Basin, and Hell Gap bison bonebeds with associated lithic and bone assemblages. Analysis began in 1980 under a one-year fellowship at the Smithsonian to study and analyze the materials. The results were published by Academic Press in 1982.

In the next decade Frison went on to investigate many other bison kill sites in Wyoming, Colorado, and Montana. "In retrospect," he tells us, "I have to think of the 1970s and its Paleoindian bison kills as the halcyon days of High Plains archaeology. Research funding was adequate, and there was limited interference from federal and state regulators. The results brought about significant improvements in data recovery and analysis and helped transform Paleoindian archaeology into a multidisciplinary science."

Significant milestones in the academic career of George C. Frison

1975	Received Honorary Lifetime Membership in the Wyoming Archaeological Society
1975	Received Asa Hill Award for Outstanding Archaeological Research and Interpretation, presented by the Nebraska Historical Society, Lincoln
1981	Elected President of the Society for American Archaeology
1985	Received the University of Wyoming George Duke Humphrey Distinguished Faculty Award
1995	Received Distinguished Service Award from the Plains Anthropological Society
1997	Elected to the National Academy of Sciences
1997	Received Paleoindian Archaeologist of the Century Award at the "Clovis and Beyond" Conference, Santa Fe, New Mexico
2010	Received American Quaternary Association Distinguished Career Award
2010	Received University of Wyoming Medallion Service Award

Early-Paleoamerican studies

During Frison's tenure as Wyoming State Archaeologist, early-Paleoamerican studies were the main area of focus among researchers. In 1973, the Hanson site with Folsom points and extinct bison was discovered in the Bighorn Basin of northern Wyoming. Lithic technology was then emerging as a valuable interpretive tool, and Frison became acquainted with Bruce Bradley of Exeter University, UK, who had studied lithic assemblages in France. Bradley and Frison working together at the Hanson site produced a large flaked-stone tool assemblage, which they interpreted using a modified version of the tool classification Bradley had learned in France. In 1980 they published a book through the University of New Mexico Press on the Hanson Folsom Site.

The Agate Basin site in Wyoming, first discovered in 1939,

continued on page 9

Sourcing Clovis Toolstone

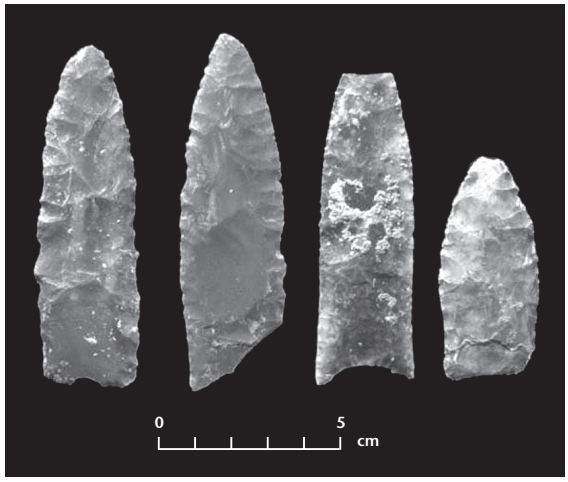
Chert outcrop at the Gault site.

ALL PHOTOS: CHARLES A. SPEER

WE'VE ALL BEEN HERE, standing in the late afternoon sunlight in the midst of a cluster of lithic debitage. A gray chert flake is passed from hand to hand. "This is definitely Edwards Plateau chert," says the archaeologist to my left, "the texture is so smooth and there are no inclusions. It's just like the material I was knapping last summer. Long-distance transport of chert isn't characteristic of the Archaic out here, so I think that means we probably have a Paleoindian site, possibly Clovis." There's excitement in his voice.

"But," objects the archaeologist to my right, "I was hiking last weekend west of here and came across an outcrop of gray chert just like this. I think this is local raw material. Local acquisition of lithic raw material is an Archaic trait, so that suggests this is unlikely to be a Clovis site." Disappointment etches all our faces. Dang, probably not Clovis. Or is it?

A generation ago, archaeologists argued in a similar way about obsidian, which exhibits large intra- and intersource variation in color and texture. The application of X-ray fluorescence (XRF) to obsidian, and aggressive efforts by Steve Shackley (Geoarchaeological XRF Lab), Craig Skinner (Northwest Research Obsidian Studies Laboratory), and Richard Hughes (Geochemical Research Laboratory) in characterizing obsidian sources throughout the western U.S., has made possible accurate, low-cost sourcing of obsidian artifacts. Similar-looking pieces were discovered to come from different sources, different-looking pieces from the same source, thus virtually eliminating estimates of provenance based on physical characteristics. This information has been used to elucidate patterns of prehistoric mobility and trade throughout the region and south into Central America, and is playing a role in differentiating Clovis mobility from that of its contemporaries in the northern Great Basin.



Clovis projectile points sourced using LA-ICP-MS.

Chert has proved a harder material to source. Chert is formed by a solution-precipitation process in sea waters with high concentrations of radiolarians, diatoms, silicoflagellates, and other microscopic silica-shelled organisms. When these microorganisms die, their shells can accumulate as a silica-rich ooze that may crystallize and dissolve repeatedly before burial completely removes the material from contact with the water. The chemical attributes and other properties of the resulting chert are affected by the kinds of constituent organisms, their abundance, and the idiosyncratic history of their transformation into chert. A chert outcrop is the accumulation of many different formation episodes, each epi-

sode resulting in a chemically distinct end product even if the end products aren't visually distinct. There isn't one Edwards Plateau chert, there are many.

Finding the right tool for the problem

Enter Charles (Andy) Speer, recently minted Ph.D., currently a post-doctoral researcher at Texas State University under Michael Collins. Dr. Speer became interested in chert sourcing after a dozen years as a flintknapper. He was first interested in the changes in cherts when they are heat treated. As a master's candidate, he focused on the mechanical and chemical changes of heat treatment, determining what temperatures work best for different cherts. "I took a lot of mechanical engineering classes," he tells me over the phone during a break at the Plains Conference, "and I could see lots of potential applications for engineering in archaeology."

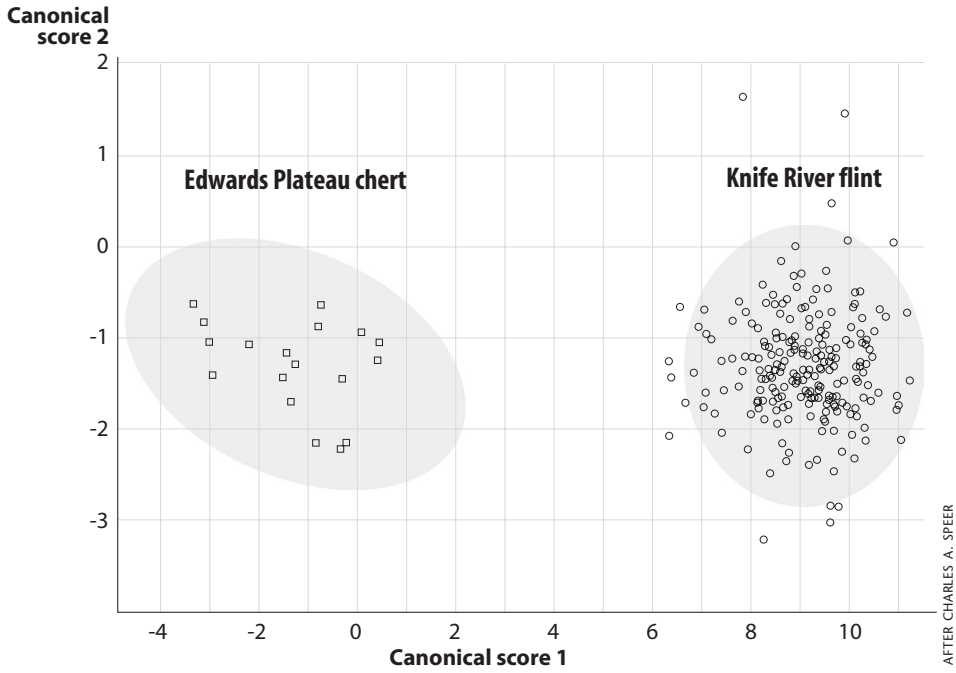
Speer flintknapping at the Gault site, Texas.

Speer increasingly relied on his engineering background as his interests expanded to include the chemical differences within and between chert sources. He read broadly about methods that had been tried, but none had proven successful or sufficiently inexpensive for use on large archaeological samples. So Speer began exploring other techniques for characterizing materials that could be applied to chert. In the end, he settled on laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) as the tool most likely to provide accurate chemical-composition data at a reasonable cost (**MT 26-2,** "Bonnie Pitblado: In Pursuit of Paleoamericans"). He mentioned his interest in chert sourcing to Dr. Collins, who encouraged him to pursue it.

At the 2007 Society for American Archaeology meeting in Austin, Texas, Speer ran into Laure Dussubieux, who was displaying a poster describing her LA-ICP-MS work at the Field Museum in Chicago. Speer discussed his idea for using LA-ICP-MS as a method for sourcing chert, and Dr. Dussubieux invited him to use her lab at the Field Museum's Elemental Analysis Facility. Three months later, Speer was in Chicago with geologic samples from various outcrops of Edwards Plateau chert and samples of visually similar Knife River flint from North Dakota.

Speer describes the process to me. In LA-ICP-MS, the first step is laser ablation. To ablate means to remove or destroy, especially by cutting, abrading, or evaporating. In this case, a fine-tuned laser removes a minuscule amount of material from an area the size of a pinpoint (100 microns) from the surface of a chert flake. "Laser ablation," he says with pride, "does such minimal damage to the artifact you would need a microscope to see it."

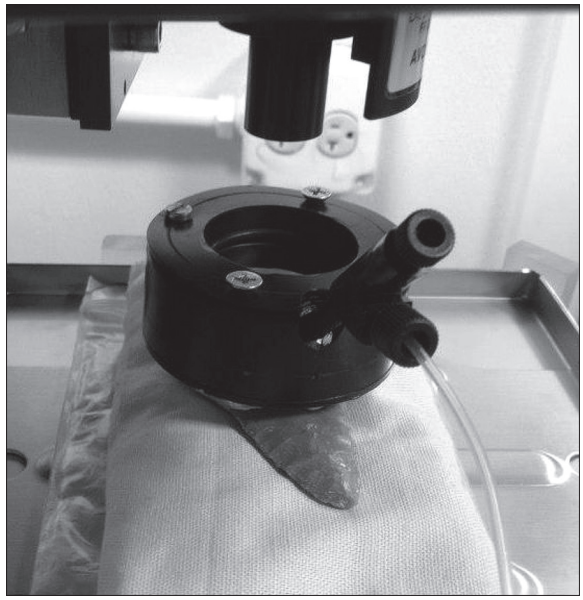
The vaporized material is carried via helium-argon gas to the ICP/MS. Here the sample encounters argon plasma between 8,000K and 10,000K (roughly 8,000°C–10,000°C) and is ionized (ablated molecules are broken into their individual atomic elements). The resulting ions are passed through the mass spectrometer, which determines the abundance of each element in the sample. For each piece of chert, 10 individual point locations are analyzed. At each location 9 measurements are made, but the first 3 (representing weathered material) are discarded. The remaining 6 measurements at each of the 10 locations are averaged together to determine a mean content for each of 58 elements. "The key," says Speer, "is the testing of standards in the machine. The standards are



Canonical plot showing 95 percent confidence ellipses of macro-regional geologic samples of Edwards Plateau chert and Knife River flint.

hyper-pure pieces of glass of known chemical composition. Every three samples, we test two standards in order to prevent instrument drift."

Minimizing drift is critical because the elements of interest are exceedingly rare in the samples. As with obsidian samples analyzed with XRF, the chemical makeup of chert samples can be divided into major components (such as silica, which is the dominant component in all cherts) and trace elements. Trace elements are chemical elements (such as lithium and beryllium) that only occur in some cherts, and when they do, occur in very small quantities, typically less than 1,000 parts per million (ppm). As in XRF, in LA-ICP-MS it's the relative abundance of trace elements that distinguishes sources. In Speer's analysis, 44 trace elements were used to distinguish among chert sources.



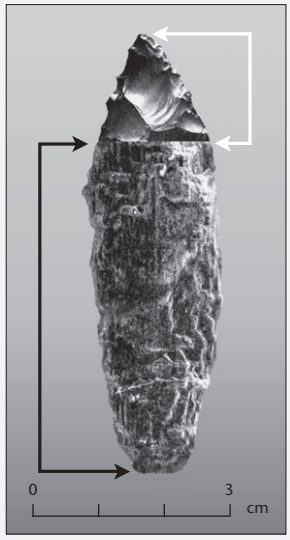
Fitting a Clovis point onto an external laser-ablation chamber.

Speer's next innovation was to make sense of all this information statistically. A 44-way statistical analysis is a daunting task that he solved through both canonical and linear discriminant analysis. Canonical discriminant analysis is a technique that groups data by similarity, in this case chert samples grouped by similarity of composition. Canonical discriminant analysis was used to determine whether each source was chemically distinct. If samples were grouped by composition, would the Edwards Plateau chert samples have a composition distinct from Knife River flint samples? It turned out that they did. What about samples from different parts of the Edwards Plateau source? Yes, the analysis showed that each subregion was compositionally distinct. Even at the local scale, different outcrops proved to have detectable differences in composition.

Now that Speer knew the chemical composition of his sources, his next challenge was to determine whether his compositional data would allow him to correctly trace unknown samples to their proper sources. Speer had held back a portion of his geological samples from the canonical discriminant analysis for this purpose. Using linear discriminant analysis, Speer was able to trace samples to Edwards Plateau or Knife River sources 100% of the time. Among the Edwards Plateau samples, he achieved 96.4% success in identifying which region of the Edwards Plateau a sample came from. And of those that came from local outcrops near the Gault site, 70% could be correctly classified to different local outcrops. The comparatively lower success in distinguishing among local outcrops may be due to the chemical similarities among the local outcrops. Larger samples may be required to discriminate at this scale.

Our mistake…

In our story in the January 2015 ***Mammoth Trumpet*** on the scientific survey of Kennewick Man's skeletal remains ("Kennewick Man: Ambassador from Our Ancient Past"), we showed the hip bone with the embedded fragment of a Haskett point *(below, arrow)*. We mistakenly identified the embedded fragment as the tip of the point bounded by the white brackets *(above right)*. In fact, the fragment embedded in the hip bone is the portion bounded by the black brackets, which is a 3D print-out of the actual fragment scanned in situ. The tip may have shattered on impact. The missing tip bounded by the white brackets was superimposed on the image by a Smithsonian graphics artist to suggest the appearance of the original Haskett point. *–Ed.*



BOTH: CHIP CLARK, SMITHSONIAN INSTITUTION

Elucidating Clovis toolstone use and mobility

Speer's enthusiasm for his new technique was infectious. "I talked to Mike Collins about testing the archaeological materials from the Gault site," he remembers, "and he let me test the debitage and the blades at Chicago. Then I wanted to test every projectile point at the Gault site, and Mike said, 'Okay,' because I convinced him there was no visible damage, which really convinced him to take a leap of faith."

Back at Chicago, whole projectile points—especially points as large as Clovis points—posed a new challenge for Speer. The conventional LA sample holder, or chamber, measures 60 by 30 mm, too small for Clovis artifacts. "I needed to come up with a different way to hold the point," Speer recalls. Working with Dussubieux, Speer developed a simple, small external chamber that could be attached to the Clovis points with rubber putty. As a research tool, the external

A tribute to

LARRY D. AGENBROAD

1933–2014

LARRY was one of the most remarkable people I have ever known. He was a superb archaeologist, a great geologist-paleontologist, a terrific teacher, and a very close friend. Larry really enjoyed working with people and teaching, and had a fabulous sense of humor.

It was a pleasure to be on Larry's dissertation committee and to tour the lower San Pedro Valley with him. He discovered the Cerros Negros Pleistocene deposits with one of the very few mastodon localities known in Arizona. When I needed an assistant director for field work at the Murray Springs Clovis site, Larry was the obvious choice, and the same again when we reopened the Lehner Clovis site with Bruce Huckell in 1974. Larry and I hosted field trips on the geoarchaeology of the San Pedro Valley for the Geological Society of America in 1968, Friends of the Pleistocene in 1968, and AMQUA in 1976. We walked many arroyos together.

One time while at Chadron Junior College Larry invited me to go turkey hunting so I could try my 1881 Springfield forager shotgun. When I finally got a big bird in my sights I heard Larry say, "Shoot a hen and you're in big doo doo!" So much for turkey hunting in the pine breaks. As a consolation he took us and our families to a Mountain Man Primitive meet nearby. They were shooting cap-and-ball and flintlock rifles at a huge steel target so a hit would make a resounding clang. I thought I'd get out my 1873 Springfield rifle and join the fun, whereupon I was told in no uncertain terms by a big guy in buckskins that cartridge guns were not permitted. I said, "But it's a black-powder gun." "No way!" was the reply.

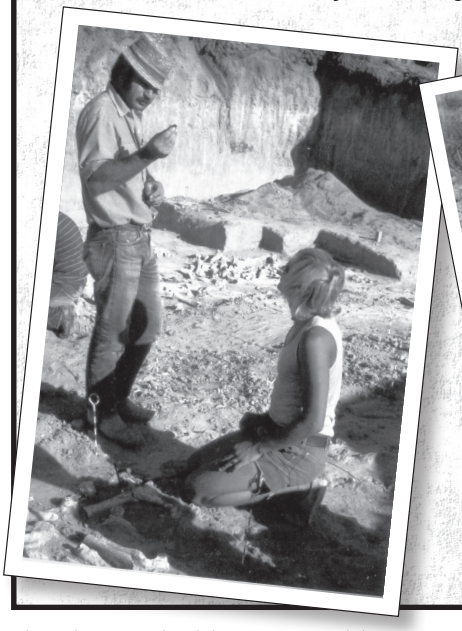
One time before visiting one of his excavations I stopped in town to get some supplies. When I got back to my vehicle I discovered I had locked my keys inside my 1979 Subaru station wagon. As a locksmith was using a slimjim to unlock my door, I heard a very familiar voice behind me say, "Ahaa! Someone locked his keys in his caaar!" There was Larry and Wanda in their jeep on a similar shopping mission.

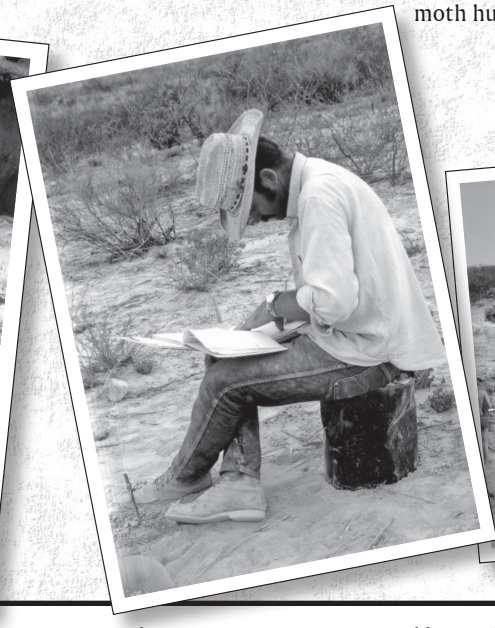
He became an authority on mammoth occurrences throughout the world and participated in the investigation of many, including several in Siberia.

Larry's work at Hudson-Meng is an important contribution, but when it comes to the creation of The Mammoth Site, Larry was the right person at the right place at the right time. It will always be a monument to his creative ability.

In the summer of 2002 The Mammoth Site put on a roast for Larry entitled "How do you roast a paleontologist?" For this, his boys and Wanda, I put together the photos below. I will miss my fellow mammoth hunter very much.

–Vance Haynes
10 November 2014





chamber worked but required large amounts of argon gas to process each sample, adding appreciably to the cost of each sample.

Analyzing Clovis points proved the value of Speer's approach. Based on visual characteristics, 26 of 33 Gault Clovis-period projectile points appeared to be made on chert from outcrops within 30 km of the Gault site. Speer's analysis, however, suggested that only 21 of these points (64%) were actually made from Edwards Plateau chert. Of all 33 artifacts, 12 (just over a third of the total) were made on material that didn't appear to source to the Edwards Plateau. Of the 21 Edwards Plateau artifacts, 15 could be traced to a particular region within the Edwards Plateau. Of these 15 artifacts, 6 were traced to outcrops at Callahan Divide and Leon Creek, more than 100 miles northwest and south-southwest, respectively, from the Gault site. The chemical composition of the remaining 9 projectile points matched chert from outcrops closer to the Gault site; 2 of these 9 points were made on cherts from the immediate site vicinity.

Based on the sourcing data, Speer discovered that Clovis points manufactured from Callahan Divide and Leon Creek sources are more likely to be reworked to the point of exhaus-

tion, whereas those on local chert are typically whole with only small amounts of damage. Speer thinks this indicates Gault was a regular stop for Clovis foragers whose hunting route lay along the southern margin of the Edwards Plateau, and that one of the main attractions at Gault, in addition to hunting and other activities, was the opportunity to replace worn-out tools.

Next steps

Speer is excited about the potential future applications of LA-ICP-MS in archaeology generally. As a post-doctoral researcher with the Texas State University Prehistory Research Project, his primary mission has been to establish a state-of-the-art LA-ICP-MS facility. While aggressively pursuing funding for the facility, he continues to innovate. He's working to develop a better laser-ablation chamber for analyzing large artifacts, one that will minimize the amount of helium-argon gas needed to transport ablated material to the ICP/MS. He also has a lot of work to do in collecting and analyzing geological samples from various chert sources in the southern Plains and adjacent regions. This will enable him to source a larger share of artifacts and more thoroughly analyze mobility at Gault and other sites. Further down the line, the technique has promise for distinguishing between primary and secondary chert deposits, for increasing the accuracy of obsidian-hydration measurements, and for enhancing the lithic analyst's capability in many other ways.

There isn't enough time in Speer's day, however, to do all the things that could or should be done. "I need some students to do my research," he complains jokingly, "I'm running out of time in the day. I need a lot of data collected and analyzed, and I just need some students to do this for me!" Above all, he misses teaching, which he did a lot during his studies at the University of Texas at San Antonio. In five or ten years, he would like to be teaching at a university and running a state-of-the-art elemental-analysis laboratory dedicated to analyzing materials from archaeological sites. "Working with students is a goal of mine, in tandem with developing a lab because professors mentor students and give them research problems to work on. It's foolish to think one person can do it all. I want to help other people learn and help them make a contribution to scientific knowledge."

–Ariane Pinson
Renaissance Science Consulting, http://rensci.com

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Suggested Readings

Speer, C.A. 2014 Experimental sourcing of Edwards Plateau chert using LA-ICP-MS. *Quaternary International* 342(2014):199–213.

——— 2014 LA-ICP-MS analysis of Clovis period projectile points from the Gault site. *Journal of Archaeological Science* 52(2014):1–11.

——— 2013 Clovis Mobility at the Gault Site: A Chert Provenance Study using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Ph.D. dissertation, Department of Anthropology, University of Texas at San Antonio.

Archaeologist on Horseback

continued from page 4

proved to be much larger and more complex when Frison excavated new areas there. Not only were there bison bones in the Folsom level of the site, bone needles, a possible elk-antler tool used to flute Folsom projectile points, and other artifacts were found that were very similar to those found at the Lindenmeier site 175 miles to the south in Colorado. The radiocarbon dates of 10,780 ± 150 RCYBP for the two sites were nearly a perfect match.

During a surface investigation of the Colby site in the badlands of the Bighorn Basin in Wyoming, where a Clovis point had been discovered several years earlier, Frison came upon mammoth-tooth fragments. A few feet away he found a mass of fragments from a complete but badly decomposed mandible. The site, which became known as one of the major Clovis-age mammoth kill sites in North America, yielded partial remains of eight mammoths, including intact skulls and a fetus, and three more Clovis points. This discovery confirmed that the site had witnessed human activity and put to rest the old belief that the Northwestern Plains contained few prehistoric sites of interest. The National Geographic Society got wind of the discovery and sent a feature writer and illustrator to cover the findings at the Colby site.

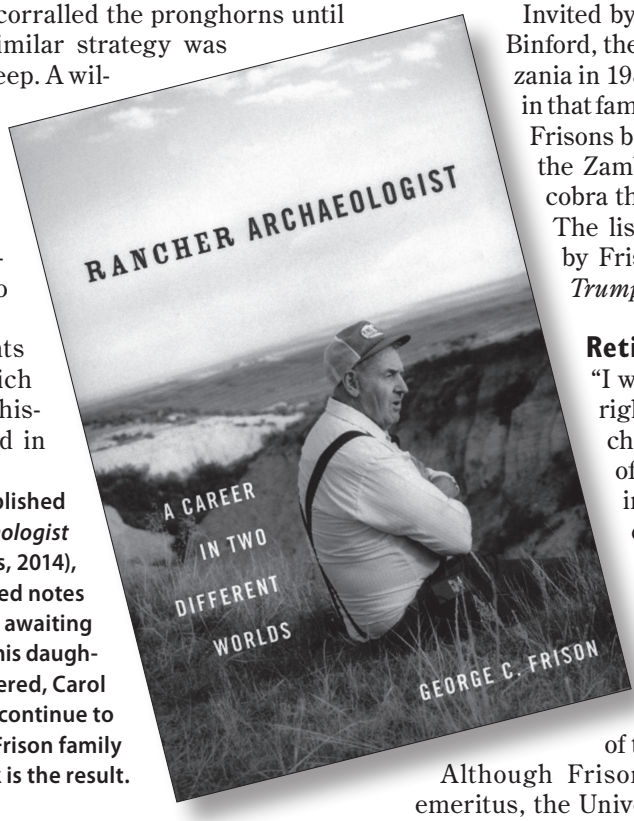
Frison continued to pursue his interest in Clovis sites and Clovis caches in such varied locations as Arizona, Colorado, Montana, Idaho, and the Pavo Real and Gault sites in Texas. Much later he used replicas of Clovis weapons and tools to satisfy himself that Paleoamericans could have killed mammoths by penetrating the rib cage of several mature female elephants, culled from a herd in Zimbabwe, using a thrusting spear and atlatl and dart. With considerable difficulty, he skinned one side of a mature female elephant and stripped the meat using flaked-stone tools.

Not only megafauna deserve attention

Although bison were unquestionably the chief prey for human hunters on the short-grass plains of North America, another species, the pronghorn, inhabited areas where the grass cover was sparse. Pronghorns, the fastest animals in North America, are sometimes referred to as "stinking goats" because of the strong smell males acquire during rutting season, which gives their meat an unpleasant flavor. Shoshonean groups that occupied much of this area devised other strategies to hunt these smaller animals.

Frison helped investigate a site north of Rock Springs, Wyoming, which yielded a large number of pronghorn bones, small projectile points, and related tools. Bones and artifacts were concentrated in former lodges where butchering had been done. Although no evidence of a trap remained, the large concentration of bones strongly suggests that one was used. Frison believes it included a wing leading into a circular trap with a brush fence, which corralled the pronghorns until they could be killed. A similar strategy was likely used on mountain sheep. A wilderness area of northwest Wyoming yielded a mass of cordage, fragments of a net likely used to capture mountain sheep. Carbon from a charred stick incorporated into the net dated to 8860 RCYBP.

Smaller projectile points used as arrowheads, which characterize the Late Prehistoric period, were recorded in Wyoming at the Wardell Bison Trap in western Wyoming. The Beehive Butte site in north-central Wyoming yielded evidence of more-varied animal food sources including mountain sheep, mule deer, bison, and cottontail rabbits. Both sites produced large assemblages of well-made projectile points and tools of flaked stone, ground stone, and bone.



Frison's recently published memoir, *Rancher Archaeologist* (University of Utah Press, 2014), began as a series of jotted notes penned by a nervous father awaiting the return from surgery of his daughter, Carol. As she recovered, Carol encouraged her father to continue to document incidents from Frison family history. This book is the result.

And the rest of the world . . .

At around the age of 50, George and June Frison decided to travel to other places of archaeological interest that they longed to see. They visited South America (Frison marveled at the stones of Machu Picchu, which fit so tightly together that he couldn't insert the blade of his pocketknife between them; Egypt, where they rode camels around the pyramids near Giza (Frison would gladly have exchanged his camel for a good saddle horse); Moscow in the USSR, where Frison presented papers on Paleoamerican sites and studies at the XI International Union for Quaternary Research Congress (the Cold War was still in business, which meant the 40 Americans in attendance were pestered by many government restrictions and tight surveillance).

Now experienced international travelers, the Frisons toured archaeological sites in France, Spain, Easter Island, and China (where they viewed Emperor Qin Shi Huang's terra cotta warriors and explored the sites of Peking Man). In 1989 Frison arranged for a group of nine American archaeologists and a British colleague to visit several Russian Upper Paleolithic sites (it was too soon after the Chernobyl disaster for them to visit mammoth sites they had hoped to see in Ukraine).

Invited by Tim White, Donald Johanson, and Lewis Binford, the Frisons traveled to Olduvai Gorge in Tanzania in 1986 to explore the possibility of future work in that famous location. The beauty of Africa drew the Frisons back (they found the African rain forest and the Zambezi River far more picturesque than the cobra that slithered across the road before them). The list of other sites and projects investigated by Frison could fill several issues of *Mammoth Trumpet*.

Retirement (sort of)

"I was fortunate to be in the right place at the right time to be initiated into High Plains archaeology," Frison says. "The area was kind of the last frontier in American archaeology in the lower 48 states, and the door was wide open for someone with an innovative approach. Research funding was favorable, and the area proved to have a number of archaeological sites waiting to be revealed, worthy of funding, and containing data that established a prehistoric chronology that has withstood the test of time quite well."

Although Frison is now listed officially as professor emeritus, the University of Wyoming supports him with an office and facilities to complete projects. At 90, he's happy to let younger archaeologists get down on their knees in the trenches. He has trained hundreds of students to carry on his work. Retirement has required an adjustment, but many of the puzzles of Paleoindian archaeology still don't have definitive solutions, and as long as this is the case, George C. Frison will continue his efforts to solve them. "To me," he says, "it sure beats putting together picture puzzles down at the senior center."

–Martha Deeringer

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Suggested Readings

George C. Frison is the author or coauthor of publications too numerous to list here.

We Are All One: Anzick Children Reburied

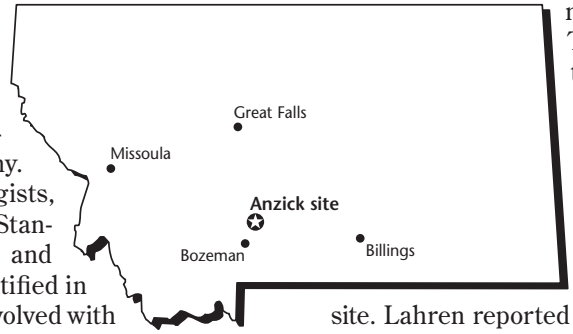
Participants at the Anzick reburial.

MICHAEL WATERS

THE ANZICK SITE, 24PA506, has been a focus of professional and avocational archaeologists since its discovery in the 1960s. It was a focus for Native Americans over 12,000 years ago, probably intermittently in intervening years, and is once again because of the ancient children buried there.

Anzick is a complicated archaeological site owing to its original deposits and its 20th-century discovery and subsequent investigations. The site, which lies at the base of a prominent sandstone bluff, appears to represent at least three and perhaps four different events of human activity. In the first event an assemblage of red ocher-covered Clovis points, bifaces, and antler rods was deposited at the base of the talus slope. In what may be either one or two separate events at least two children, one covered with ocher, were buried at the site. Finally, quantities of bison remains suggest that the site was the base of a post-Clovis bison jump.

The site occupies land owned by veterinarian Dr. Melvyn Anzick and his wife, Helen, a mile south of the village of Wilsall. One of their five children, Dr. Sarah Anzick, is a senior molecular biologist who has grown up with the Anzick archaeological site. The family in concert has managed the site, and Sarah campaigned most vigorously to have the human remains reburied in a Native ceremony.



A number of senior archaeologists, including Larry Lahren, Dennis Stanford, the late Robson Bonnichsen and Dee Taylor, and many of those identified in "Suggested Reading," have been involved with the site and collection for more than 45 years. In 1971 I first visited the site and saw and selectively illustrated the artifact collection, and I have been involved with the site and collection ever since.

Log on to **www.anzicksite.com** for information about the site.

The archaeological site

The Anzick site was first found in 1961 when an ocher-covered biface was found in a rodent dirt pile by a local teenager. He also found human "knuckle" bones that weren't kept. In May 1968, while excavating talus from the base of the bluff for use in constructing a drain field, workers Ben Hargis and Calvin Sarver discovered red ocher-covered flaked-stone tools, worked antler rods, and a few human bones in their front-end loader. They and their wives hand-sorted the stone and bone tools, which were divided among the Anzick, Hargis, and Sarver families. The families retain ownership today.

University of Montana archaeologist Dee C. Taylor and a small crew in summer 1968 cleaned up the former excavation. After talking with Hargis and Sarver, Taylor concluded that the association between Clovis-era artifacts, human remains, and site stratigraphy couldn't be demonstrated, and that there wasn't any demonstrable relationship between those materials and the bison bone remains. Taylor retained the human remains at the University of Montana until his death in 1991, when they were transferred to his son Mark G. Taylor, Department of Anthropology at Northern Arizona University. In 1999 Mark Taylor returned the remains to the Anzick family.

In 1999 Larry Lahren, Doug Peacock, and Mark Papworth reinvestigated the site. Lahren reported that Hargis and Sarver recollected that the ocher-covered child's remains and the Clovis tool assemblage were found in a 1-by-1-m area in a gray clay-and-sandstone unit within the sandstone outcrop. In 2001 Doug Owsley and David Hunt learned from Lahren that the artifacts had been

found in a pit dug laterally and downward into a 2-ft-thick band of weathered sandstone. The ocher-covered human remains lay toward the bottom of the cache. The second child's remains were found 15–20 ft east of the Clovis-era artifacts on the surface of the talus slope.

The Clovis-era artifacts

In 2006 Lahren reported that the Anzick Clovis-era artifact collection included 8 Clovis projectile points, 6–8 antler rods (depending on whether or not the fragments are from one, 2, or 3 original rods), 86 bifaces, 6 flake unifaces, an endscraper, and 2 pieces of shatter flakes; almost all the artifacts were found covered with red ocher.

BRETT FRENCH/BILLINGS GAZETTE

Mike DesRosier (Amskapi Pikuni) sprinkling red ocher on the reburial casket, with Eske Willerslev on the far left, Shane Doyle (Apsaalooke) next to him, and Larson Medicine Horse (Apsaalooke) *(arrow)*.

The Clovis points are about 6–15 cm long, the bifaces 10–25 cm long. The chert and porcellanite stone tools come from at least 6 sources, some local, others 90– 200 km distant from the Anzick site. The rods are long straight shafts of antler with tapered ends, at least one of which is elk.

The stone and bone assemblage is considered to be a cache, which Scott Jones considers to be a functional toolkit. Depending on how we interpret relatively associated tools and human remains, the assemblage may be either a burial cache or an insurance cache buried by mobile hunters; either might have been marked by offerings of red ocher with the buried tools.

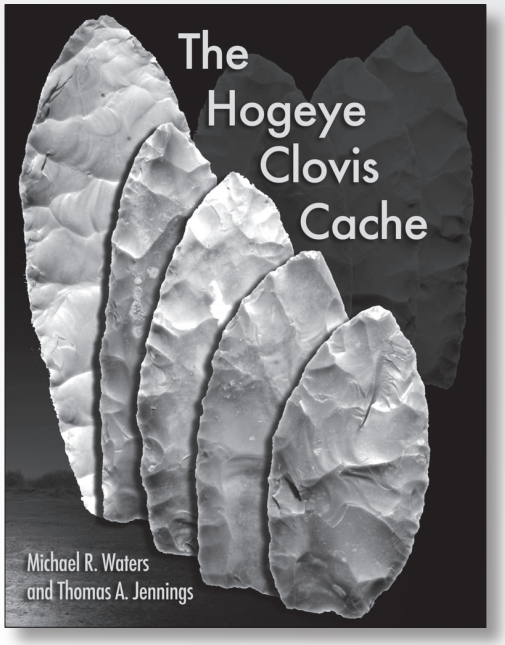
The Anzick artifact collection has been excluded from Montana's Human Skeletal Remains and Burial Site Protection Act under a provision (MCA 22-3-291) that applies to "any lithic material or other artifacts or nonhuman derivation removed from the Anzick site . . . on or before July 1, 1991." Casts of the artifacts were made in the early 1970s by the National Museum of Natural History, which retains the molds. These casts are available for research use. The Montana Historical Society also has a set of molds and casts.

The Anzick human remains

Two sets of ancient human remains, all of them fragmentary, were found at the Anzick site. Geochronologist Tom Stafford of Stafford Research Laboratories, Inc. tested them in 1983 and 1988 and found they had different chemical profiles. The ocher-covered remains (Anzick-1) included at least 28 cranial fragments that refit, 3 ribs, and the left clavicle of a male, age 1–2 years. The bleached bone fragments found on the talus slope (Anzick-2) included 4 articulating pieces of the posterior left and right parietals and the occipital squamous bone of a 6- to 8-year-old child. All these bone fragments were recently reburied in a single ceremony.

DNA analysis revealed that the Anzick-1 child belonged to a population that is directly ancestral to many contemporary Native Americans, but is more closely related to Central and South American Native Americans than to Northern Native

"If only all Clovis caches were investigated and reported in this level of detail."
–David Kilby, Eastern New Mexico University



MORE THAN 50 projectile points, preforms, and knives cached by Clovis hunters lay buried at the toe of a gentle slope in central Texas for 13,000 years. After the artifacts were unearthed in 2003 in a commercial sand-mining operation, alert citizens brought them to the attention of Texas A&M geoarchaeologist Mike Waters. With coauthor Tom Jennings, Waters excavated and dated the geological layers to reconstruct how the cache had been buried.

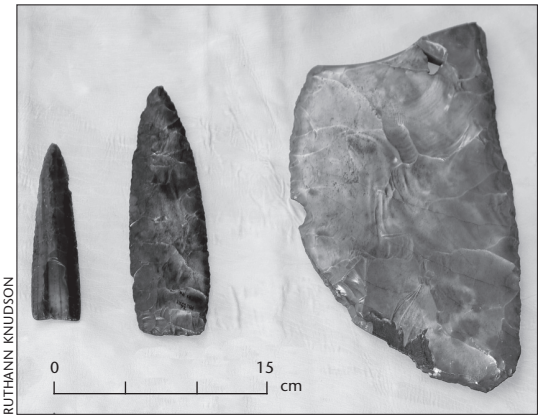
The site also yielded evidence of later occupations that shed light on successive cultures from Folsom to Late Prehistoric. Especially well described are the cached Clovis artifacts in various stages of completion. Profuse illustrations in ***The Hogeye Clovis Cache*** (59 color photos and 33 drawings) are virtual freeze frames of bifaces captured at various stages along the lithic-reduction trajectory by which Clovis toolmakers shaped stone blanks into tools or weapons. Lithics analysts will value this book as a how-to manual for the Clovis flintknapper. See the outside rear cover of this issue for ordering information.

Americans (**MT 29-2,** "Clovis child answers fundamental questions about the First Americans"). DNA couldn't be extracted from the remains of the Anzick-2 child.

Dating the Anzick site

In 1994 Stafford reported an average date of 8600±90 RCYBP for the bleached calvarium (skullcap) of the Anzick-2 child. In 2014 he reported a date for Anzick-1 of 10,705±35 RCYBP (ca. 12,707–12,556 CALYBP). Nearly a decade earlier Julie Morrow and Stuart Fiedel had Anzick-1 dated by Beta Analytic, which reported a date of 10,780±40 RCYBP (12,880–12,910 CALYBP).

Beta Analytic dated two of the Anzick antler rods to 11,040±60 and 11,040±40 RCYBP (13,010–12,900 CALYBP). Stafford's date on one rod is statistically identical to these.



RUTHANN KNUDSON

A Clovis point, preform, and the large biface from the Anzick site.

All the dates reported for the Anzick-1 child and the bone tools fit comfortably within the Clovis time frame of 10,800–11,050 RCYBP (12,800–13,250 CALYBP) (**MT 22-3,** "Clovis dethroned: A new perspective on the First Americans").

Direct or indirect association?

Although the Anzick-1 infant and the tool assemblage were found in close proximity, questions nonetheless remain about their contemporaneity. Were they buried at the same time?

Both the tool assemblage, with its Clovis points, and the remains of the Anzick-1 infant were found coated with red ocher. Therefore it has often been assumed that they were deposited at the same time in a burial ritual. It's possible, however, that they were buried separately, each burial commemorated with red ocher accompaniments. The discrepancy in age between the antler rod and the Anzick-1 remains lends weight to the argument for separate burials.

After talking with the original site discoverers in 1968, Taylor declared that the association of all the discovered material couldn't be confirmed. After a 30-year hiatus, however, the discoverers were able in 1999 to specify details about the depositional environment of the finds that lends credence to the assumption that all the items are indeed associated. Given the suspicion that surrounds the accuracy of eyewitness testimony over time, it's a judgment call today whether to rely on Taylor's evaluation and the dating discrepancy and therefore to question the purported association, or to accept the 1999 testimony of the discoverers and the omnipresence of red ocher as proof of direct association.

It isn't difficult to imagine how the presence of ocher could provide misleading clues. Clovis hunters in the northern Plains may have explored enough to identify outcroppings of rock (or learned the location from indigenous people) that would yield toolstone of the size and quality to be knappable into large bifacial preforms. They may have cached these valuable artifacts in a remarkable location as insurance for future use—and celebrated their stash with ocher (**MT 22-2,** "Snapshots in time: New insights from Clovis lithic caches"). In subsequent generations and trips, if this same population of people lost a child during their travels, they may have buried that child in the same remarkable place, again commemorating the death with red ocher. In a porous talus slope, ocher particles could migrate throughout the deposits and obliterate the original context.

Anzick family consideration of reburial

For many years the Anzick family believed that the Anzick children should be reburied, but only after the remains had been scientifically analyzed. They believed that the remains held important information about Native American genetics and health that justified a minimum measure of relatively destructive scientific analysis.

When the family acquired the children's remains in 1999, Sarah Anzick sought the advice of tribal members about the long-term treatment of the remains. At that time she attempted to extract DNA from the remains without success. Subsequently she became part of a team led by Eske Willerslev of the Center for GeoGenetics at the Natural History Museum of Denmark, University of Copenhagen, which successfully extracted and analyzed DNA from the Anzick-1 child, as reported above. Once

MICHAEL WATERS

Anzick reburial Native celebrants, with Sarah Anzick in the center.

the Anzick-1 child had surrendered its secrets, the family enlisted the help of Shane Doyle, enrolled Apsaalooke member, to assemble members of several tribes to rebury the children on the landscape where they were originally found. The ceremonial reburial was scheduled for 28 June 2014.

The Anzick family provided a small wooden casket to hold all the remains and laboratory samples taken from them. Bud Anzick, assisted by Stockton and Lilly White, excavated a crypt close to the original discovery site and constructed a concrete shell to house the casket.

RUTHANN KNUDSON

The reburial location on the Anzick farm, November 2014.

Montana reburial law and review process

Montana has a Human Skeletal Remains and Burial Site Protection Act (MCA 22-3-801ff) that was passed in 1991 and amended in 2001 with a Montana Repatriation Act. Although the law applies to all unidentified human skeletal remains on state or private lands, it wasn't retroactive. Therefore the Anzick children's remains, discovered in the 1960s, weren't covered by the law.

The Montana Burial Preservation Board, which consists of tribal and non-tribal representatives, was unaware of the Anzick children's remains prior to hearing of the intended ceremonial reburial. The Board requested information about the site, its human remains, and the proposed reburial. Sarah Anzick and Shane Doyle appeared before the Board in May, again in June 2014, and invited its members to participate in the reburial ceremony. The Board members were frankly overwhelmed with the scientific knowledge that had been gleaned from the children, with their painstaking treatment over the past 46 years, and with the plans for their reburial. Although Tribal Board members had mixed reactions to the presentation, the Burial Preservation Board concluded that Montana laws didn't apply to the Anzick remains. The majority agreed to allow the reburial to proceed so the children would be laid to rest.

A Native American reburial of the Anzick children

The ancient Anzick children were buried in a Native ceremony the morning on 28 June 2014. Present were about 50 Native and non-Native participants. The day was cloudy and drizzly, with a western wind that made the participants grateful for Pendleton blankets and warm jackets.

The ceremony was hosted by the Anzick family, including Mel and Helen Anzick, Sarah Anzick and husband Bob Balcom and young son Benjamin Balcom Anzick, and eight other family members. No members of the Hargis or Sarver families were present. Prior to the event, the Anzick family attorney drew up an agreement that was signed by all media representatives who attended the invitation-only ceremony.

Armand Minthorn (Umatilla) conducted the 2-hour Native reburial ceremony at the site, with support from Gerald Lewis (Yakama), Larson Medicine Horse (Apsaalooke), Sister Clissene Lewis (Yavapai), and Francis Auld (K'tanaxa) as well as many other tribal representatives. Sarah Anzick presented

continued on page 20

THE CLOVIS COMET

New Developments in the Proxy Evidence, Part II

IN MANY WAYS historical science is like investigating a crime scene. Solving its mysteries requires us to interpret vague clues, usually those left behind by natural processes. The problem is, most datasets are open to multiple interpretations—especially when they derive from indirect, microscopic evidence.

Such "microproxies" lie at the heart of one of the most contentious controversies to bedevil the First Americans scientific community in recent decades. Scientists supporting the Younger Dryas Impact Hypothesis (YDIH) believe a series of meteoric impacts or airbursts about 12,800 CALYBP devastated the Clovis culture, contributing to megafauna extinctions and a cold climatic reversal called the Younger Dryas Interval. They base their hypothesis primarily on their interpretation of multiple lines of microproxy evidence.

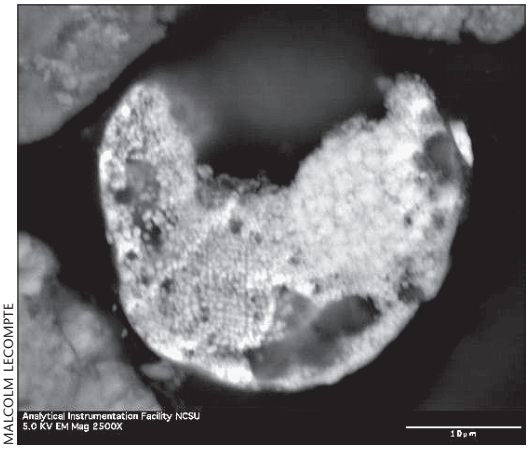
That the Younger Dryas occurred is widely accepted. The YDIH is not.

In recent articles, we've taken a look at potential cratering evidence (**MT 29-3,** "The Clovis Comet: The Cratering Evidence"), as well as three types of proxies cited as evidence for the YDIH: microscopic charcoal/soot, Black Mat deposits, and carbon microspherules (**MT 30-1,** "The Clovis Comet: New Developments in the Proxy Evidence, Part I"). In this article, we'll review the arguments for and against three more purported YDIH microproxies: glassy material, including glassy carbon; magnetic grains; and magnetic microspherules (MMSps).

Glassy material

Two types of glassy materials are occasionally found in Younger Dryas Boundary (YDB) sediments. The first is glasslike carbon that formed in wildfires at 500–1200°C, and sometimes contains nanodiamonds. The second is melt-glass, which may be composed of sediment that melted at temperatures of 1200°C to >2200°C. YDB melt-glass has been found to contain two iron-rich microspherule types, one with a relatively smooth surface and the other with a grainy, raspberry-like surface. Geologists typically call the latter framboids (*framboise* is French for raspberry) and the former magnetic microspherules (MMSps).

The origins of the framboids and MMSps occasionally found in and around YDB sediments are debatable. Several natural processes, however, can produce both types. MMSps can form in a high-temperature environment (>1,500°C) followed by rapid quenching; framboids apparently grow slowly over time at ambient temperatures.



MALCOLM LECOMPTE

Cross section of a perforated rare-earth-enriched microspherule, showing the variable crystal pattern.

At the famous Murray Springs Clovis site in Arizona, one of several sites repeatedly tested by YDIH researchers, a team led by Mostafa Fayek of the University of Manitoba recovered glassy material replete with magnetic particles (including framboids) from the bottom of a sample of the YDB Black Mat sediments provided by site investigator Vance Haynes, widely regarded as one of the top First Americans researchers in the world. Dr. Fayek notes that the chemical composition of the Murray Springs glass is consistent with that from other meteorite impact sites, and that the glass has "an unusual chemical composition (very high in iron), which is consistent with material fused during a hypervelocity impact event. "

Micrograins and microspheres recovered from the valley floor and the roofs of local houses aren't embedded in glass and

have very different chemical compositions. Furthermore, the Murray Springs melt-glass was fractured in ways suggesting a massive shock event. "We researched all other possibilities, and nothing terrestrial fit," says Fayek.

Dutch geologist Annelies van Hoesel isn't convinced. She doesn't find it necessary to invoke an impact to account for the glassy materials she's seen in YDB sediments and their European equivalents. But, as she's quick to admit, "the glassy material I've investigated is not really comparable to the material that Fayek has discovered. I'm looking at glassy carbon-rich material of an organic origin, whereas Fayek is looking at iron-silica glass."

MOSTAFA FAYEK

Fayek.

Her research suggests that at least some glassy carbon material can form from the organic materials in sediments at temperatures present in a hot wildfire. And although she doesn't reject the YDIH out of hand, she thinks that "most of these markers cannot be considered evidence proving an extraterrestrial impact."

But she's intrigued by the lechatelierite reported for some sites by YDIH proponents. Lechatelierite is a distinctive form of fused sand that sometimes exhibits flow textures that form at temperatures above 2,200°C—the boiling point of quartz. "The reported lechatelierite comes close, but can also form through lightning strikes," Dr. van Hoesel points out. "Ideally, you'd like to find a combination of clearly impact-related material at multiple sites."

YDIH proponents argue that the other materials found with the lechatelierite *do* indicate an impact, but many scholars remain unconvinced because not all or even most of the microproxies are found at all proposed YDIH sites.

TIM WITWER

Lecompte *(standing)* with collaborator Dale Batchelor at work at the North Carolina State University Analytic Instrumentation Facility. Batchelor is using a Focused Ion Beam to cut open a suspected impact microspherule to expose its interior, while performing SEM imaging and elemental mapping of the interior.

Magnetic grains

Iron-rich grains are common at proposed YDIH sites. These irregularly shaped particles of magnetic material, which resemble microscopic grains of sand or salt, have been reported for YDB strata throughout North America. Not only have they been found at better-known sites like Murray Springs, Arizona and Arlington Springs, California, Brian Redmond and Kenneth Tankersley report up to 2.5 g of metallic grains per kg of sediment at deeply stratified Sheridan Cave, Ohio. They were recovered along with carbon spherules, MMSps, and nanodiamonds, and were absent in the strata above and below the YDB.

Of all the kinds of microproxies cited as evidence for an extraterrestrial impact, magnetic grains are among the most elusive and arguably the least convincing. According to Fayek, "The black mat at Murray Springs had the highest number of grains, and was the only stratum that had particles consisting of magnetite framboids in a glassy matrix." That wasn't true for three sites recently reinvestigated by Malcolm LeCompte and his colleagues. In 2009, Todd Surovell of the University of Wyoming reported finding few, if any, magnetic materials at seven archaeological sites where YDIH proponents had previously found both in abundance (**MT 25-2,** "In the Crucible of Scientific Inquiry: The Clovis Comet Revisited").

Dr. LeCompte and his team performed new analyses of sediments from three of Dr. Surovell's sites, as outlined in a 2012 paper in the *Proceedings of the National Academy of Science* (*PNAS*): Topper, South Carolina; Blackwater Draw, New Mexico; and Paw Paw Cove, Maryland. In each case they found copious magnetic microproxies in the YDB, but could neither confirm nor refute a statistically significant peak in magnetic grains at the YDB levels.

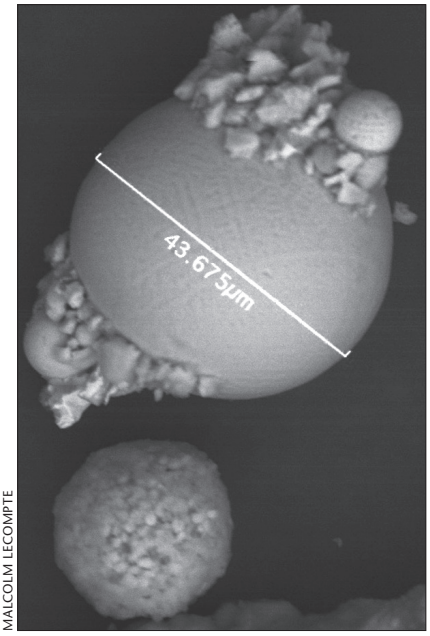
Magnetic grains were also problematic at Lake Cuitzeo, Mexico. In another 2012 *PNAS* article by Isabel Israde-Alcántara and 15 other YDIH proponents, microproxy evidence was presented in the form of materials extracted from a lake-bottom core. In the previous article in this series (**MT 30-1**), we noted among the criticisms leveled against the Lake Cuitzeo data that the YDB was estimated by statistical methods rather than pinpointed. In this case, the grains peaked in strata *below* the YDB and are chemically distinct from associated MMSps. They're interpreted as local volcanic detritus, not impact relics.

Although the evidence doesn't exclude them completely as YDIH impact markers, the case for magnetic grains seems weaker at this point than in the past.

Magnetic microspherules

Meanwhile, the most photogenic and easily recognized YDIH impact markers, magnetic microspherules, continue to intrigue. Controversial since they were first reported in the original YDIH *PNAS* publication in February 2007, they've been found in YDB sediments by many teams investigating the hypothesis—not just proponents, but also opponents and neutral researchers. The real issue here is what they are, and whether they also occur in non-YDB sediments.

These microproxies are mostly spherical, though some are prolate, broken, stretched, and occasionally teardrop and dumbbell-shaped. They're often shiny, revealing their high metal content. Many are hollow or seem to be, and are interpreted as having been formed as a spray of vaporized molten metal. Electron microscope imaging reveals dendritic (branching) crystallization patterns on their surfaces, typical of high-temperature formation and quenching experienced in hypervelocity impacts or airbursts.

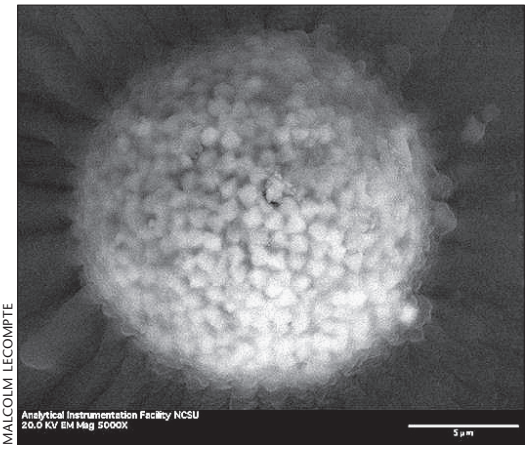


MALCOLM LECOMPTE

Magnetic microspherule cluster next to a smaller framboid from a Canadian site. Note the dendritic cross-hatched surface pattern on the MMSp and the more uniform, small individual crystal structures that compose the surface and volume of the framboid.

Critics call these spheres "cosmic rain," derived from the micrometeorite particles that continuously enter the atmosphere. Earth sweeps up tons of interplanetary material each day as it revolves around the sun. But YDIH proponents note that the elemental mix in these spheres is terrestrial, indicating they were created from materials already present in the Earth's crust. Cosmic materials have different elemental mixes.

In their Sheridan Cave article, Redmond and Tankersley reported up to 100 MMSps/kg of sediment in the YDB deposit. Although this incidence is low, no MMSps were recovered in any other sediments at Sheridan Cave. At Lake Cuitzeo, researchers isolated a peak of MMSps at a depth of about 2.8 m below the surface, in the estimated YDB layer. Their concentration reached as high as 2,000/kg. No underlying layer contained spherules, and the concentration in some overlying layers was as high as a few hundred/kg.



MALCOLM LECOMPTE

A framboidal magnetic microspherule from the Topper site in South Carolina.

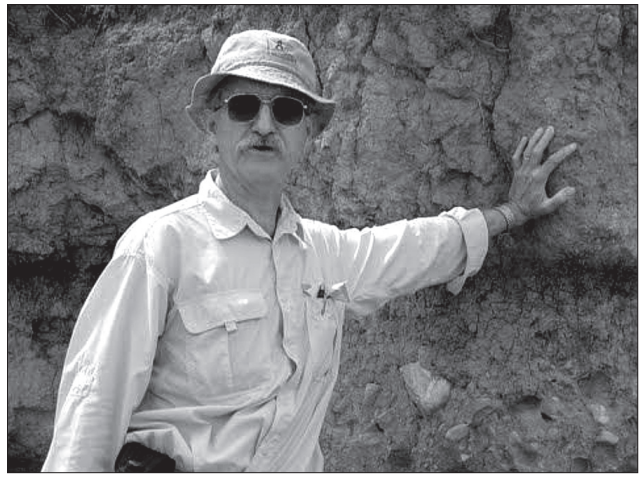
The presence of MMSps in the YDB deposits of so many sites seems compelling at first . . . but as with the magnetic grains, some scientists haven't been able to replicate the results of the 2007 study. This is true of Surovell's 2009 study, for example. The re-review by LeCompte's crew, however, found a relative abundance of MMSps at Topper, Blackwater Draw, and Paw Paw Cove. Concentrations ranged from 260/kg at Topper to more than 640/kg at Blackwater Draw. The very different results have sparked a heated controversy about methodology that doesn't belong in these pages.

Nicholas Pinter, a YDIH critic, suggests LeCompte and his colleagues have mistaken slow-growing terrestrial framboids for MMSps. But LeCompte disputes this, noting that electron microscopy easily reveals the differences. His microspherules, he argues, lack the surface and interior structures of framboids. "I perform SEM imaging and EDS chemical analysis on every spherule I collect and count," LeCompte states. "If I don't have that data and confirmation, I don't count it. I never assume it's an impact spherule. To date, I've collected SEM data on roughly 500 magnetic spherules." Furthermore, he notes, chemical analyses demonstrate that the chemical composition of MMSps is consistent with melted terrestrial but often non-local materials, so they can't be cosmic rain. For example, in a 2013 *PNAS* paper, "Origin and provenance of spherules and magnetic grains at the Younger Dryas boundary," Wu et al. identified impact markers in northeastern Pennsylvania whose osmium isotope ratio composition suggests that YDB melt-glass containing MMSps was ejected from an ET impact that occurred 1,000 km away in Quebec, Canada. Holliday says, however, that Wu et al. based their conclusions on purported impact markers from undated sections.

The Murray Springs black mat, Fayek notes, also contains MMSps whose chemical make-up is consistent with microspherules found at known meteorite-impact sites. They tend to have framboidal surfaces, which Fayek thinks may represent shock features. While Fayek refers to them as magnetic spherules, they may have originated from a hypothetical impact body itself, rather than from terrestrial blowback—making them significantly different from other YDB magnetic spherules. LeCompte agrees, but notes that they're different from typical YDB impact microspherules he has seen. Indeed, these microspherules are often cracked and seem structurally complex, with internal layering and strong fracture patterns; often they comprise clusters of framboid grains. Their unusual features could be due to the weathering that occurs in natural soils, but Fayek thinks that unlikely.

Like the glassy material and framboidal grains, Fayek's team concludes the spherules are the result of a hypervelocity impact. So far, they state, particles like these haven't been found in cosmic dust, though they occasionally appear in dinosaur bones, iron ore, and fulgurites—though not with framboidal textures. Finally, they point out that framboidal materials embedded in glassy matrixes have been found in some types of meteorites.

Vance Holliday, a veteran geoarchaeologist at the University of Arizona, remains skeptical about the ET origin of MMSps and carbon microspherules. As he points out, "A variety of terrestrial and cosmogenic processes can produce the spheres. There's a more or less constant rain of cosmic particles of various kinds on the Earth's surface. My colleague Vance Haynes recovered them from the roof of his house here in Tucson. Those are likely man-made, combined with naturally occurring deposits. In spite of the YDIH claims, neither carbon spherules nor magnetic spherules are unique to cosmogenic processes." Nor is he convinced that MMSps are as ubiquitous in YDB strata as some individuals claim.



SCOTT DRANE

Holliday at the Murray Springs site.

"On the other hand," he says, "they *have* been identified in strata above and below the purported impact zone. Direct dating of the [carbon] spheres at the Gainey site [the type site of the Clovis-like Gainey points, and subject of a key section in the YDIH literature] shows they're late Holocene in age." It's not possible to carbon-date MMSps, but Holliday goes on to say, "There are serious problems in trying to reproduce the results of the original analyses that show big spikes in magnetic spheres." LeCompte counters that, in the absence of a definitive chemical analysis, their nature and source remain unknown.

The way forward

Let's face it: This set of microproxies isn't a clincher. Re-examination of some well-known YDIH sites has revealed no notable peaks in magnetic grains. The response to the glassy material encasing microproxies at some sites has been unenthusiastic outside the YDIH camp, though the lechatelierite is genuinely intriguing. The abundant magnetic microspherules are also compelling evidence for the YDIH, though some scientists have been unable to find more than a few in YDB sediments.

Something widespread and possibly unprecedented seems to have occurred around 12,800 CALYBP, but exactly what it was remains uncertain. As Holliday puts it, "I don't care whether there was or wasn't some sort of extraterrestrial event at 12.8k. Most of my career has focused on understanding the late Pleistocene. I just want to know what happened. If there was an ET event at 12.8k, it appears to me that it had no discernible impact on people, plants, animals, or landscapes."

LeCompte, meanwhile, believes that any explanation for what happened at the beginning of the YD Interval other than an ET impact must account for YDB peaks in the full assemblage of proxies. He cites a 2013 *PNAS* paper ("Evidence for deposition of 10 million tonnes of impact spherules across

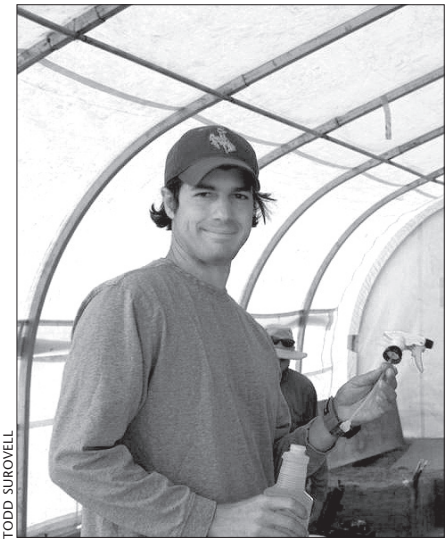
Editor's Note

In the previous installment in this series (**MT 30-1**), principals debating the occurrence of a catastrophic extraterrestrial impact as the instigator of the Younger Dryas Interval cite evidence obtained from proxies (carbon spherules and nanodiamonds). Physicist Mark Boslough of Sandia Laboratories and his colleagues (critics of the hypothesis) published a radiocarbon date they obtained on a carbon spherule collected and isolated from the Gainey site in Michigan by a member of the Richard Firestone team (the hypothesis proponents). Boslough tells us he informed the proponents of this result. It was in March 2011, *after these events,* that he learned of young radiocarbon dates Firestone had previously obtained on similar spherules. Boslough assures us that he never questioned the validity of every radiocarbon date ever published by the Firestone team. Thus the claim made by geologist Ted Bunch of Northern Arizona University, that Boslough knew beforehand of Firestone's dating results, that Boslough rejects all dates obtained by the Firestone team, and that Boslough therefore acted in a "disingenuous" manner, is not substantiated by the facts. *–JMC*

four continents 12,800 y ago") by James H. Wittke and 27 other authors, including many top YDIH advocates, in support of his thesis. He notes confidently that "this variable assemblage consistently appears at about 40 different sites on four continents dated to about 12,800 calendar years ago within the limits of radiocarbon dating. Maybe some as-yet-undiscovered process created this assemblage, but that seems extremely unlikely."

Dr. Holliday doesn't agree. "All of us on both sides of the YDIH debate agree that one of the linchpins is accurate, precise, direct numerical dating of the zones producing the impact proxies. But accurate, precise, and direct dating of claimed zones with purported impact indicators is almost non-existent." In response, Dr. LeCompte points out, "Yes, some sites are not well dated, but the Wittke paper has dozens of site dates directly on the YDB layer dating to 12,800 cal BP within the limits of 14-C dating."

Holliday counters, "Dave Meltzer and colleagues published a paper in *PNAS* (2014) that looked at the 29 sites claimed to have dated zones with purported impact indicators. Of those 29, 27 have no or only indirect age control. Only the original two directly dated sites (the Murray Springs, AZ, and Blackwater Draw, NM, archaeological sites) from the 2007 study provide direct, accurate, precise radiometric age control.


TODD SUROVELL

Surovell at Barger Gulch, Colorado, 2007.

"LeCompte is demonstrably wrong here. They have not countered the data and interpretations of the *PNAS* paper by Meltzer et al. Moreover, YDIH skeptics have countered most claims by impact proponents in published comments in their articles or in full peer-reviewed papers. The burden of proof is on them to substantiate these claims and counter our evidence and conclusions, but they haven't done so. "

LeCompte strongly objects to this statement. "We have countered every claim of the critics," he insists, "and they simply ignore that." Regarding the dates, LeCompte counters that a dating paper from the YDIH group is being readied for submission.

So for the moment there's still no consensus. But as Todd Surovell notes, "Things will sort themselves in due time. That's the nature of science."

–Floyd Largent

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Anzick Children Reburied

continued from page 14

the small casket including the Anzick children's remains to Larson Medicine Horse, who lowered it into the crypt with songs accompanied by drumming. During the ceremony Minthorn repeatedly stated, "We are all one," expressing his concern about these ancient children and the information they have given to the world. Permeating the ceremony was a general sense of kinship with the ancient families of the reinterred children.

Several Native and non-Native members of the Montana Burial Preservation Board were present, as well as the Director of the Montana Historical Society. Eske Willerslev represented the Center for GeoGenetics, and Mike Waters represented the Center for the Study of the First Americans. Participants included members of at least seven tribes. Mike DesRosier (Amskapi Pikuni) sprinkled red ocher into the reburial crypt, and all the ceremony participants added dirt to the crypt before it was filled over. Several days after the ceremony, the Anzick family resodded the reburial location.

A palpable sense of completion, power, and fulfillment was shared by everyone. The children had provided their descendants with information about their common heritage, and were now reinterred in a comfortable place.

Following the ceremony, the Anzick family hosted a lunch at the Wilsall community park and most of the ceremony participants joined in the celebration of the cross-cultural event.

As Armand Minthorn said, "We are all one."

–Ruthann Knudson
Knudson Associates, paleoknute@paleodesigns.com

Suggested Readings

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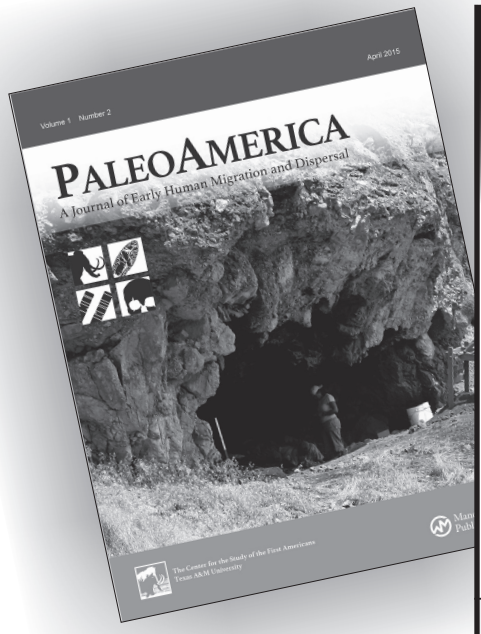

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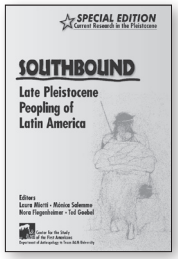

Southbound: Late Pleistocene Peopling of Latin America, Laura Miotti, Monica Salemme, Nora Flegenheimer, and Ted Goebel, editors. 36 articles discussing the late-Pleistocene archaeology and Paeloecology of South America. 2010. 218 pages. Paperback ISSN 8755-898X.

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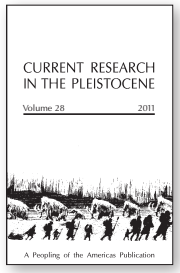

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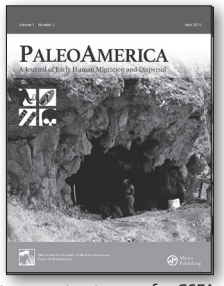

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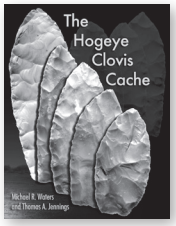

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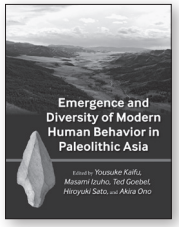

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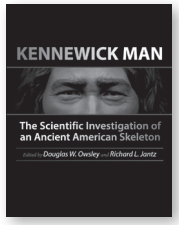

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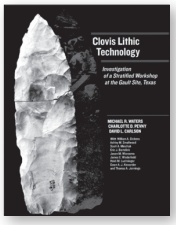

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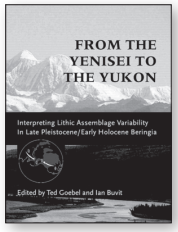

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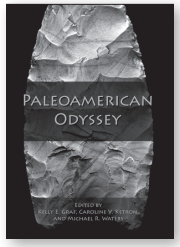

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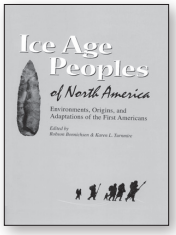

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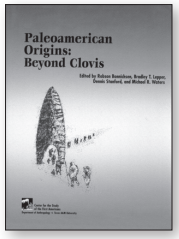

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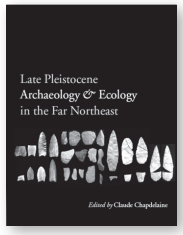

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