



# MAMMOTH TRUMPET

Volume 16, Number 2 • March, 2001

Center for the Study of the First Americans  
355 Weniger Hall, Oregon State University  
Corvallis OR 97331-6510

## Radiocarbon Dating on Trial

For nearly half a century radiocarbon dating has been the archaeologist's most valuable tool. The ability to assign unearthed materials a precise position on the historical time scale has empowered theories about human migrations, faunal extinctions, even the advance and retreat of glaciers. But scientists Richard Firestone and William Topping contend that many of those dates aren't as reliable as we think. The reason? They have found conclusive evidence of a nuclear catastrophe in the late Pleistocene—probably caused by a supernova—centered upon the Great Lakes of North America. A torrent of neutrons, which created an inferno deadly to plant and animal life and significantly melted the Laurentide Ice Sheet, also reset the radioactive clock in carbon-bearing materials. The result is that the dates we read are too young, they argue, in some cases by *tens of thousands of years!*



*Richard Firestone*



*William Topping (r.) with fellow Marine, Vietnam*

Firestone, a nuclear scientist with Lawrence Berkeley National Laboratory, supports their theory with evidence exhaustively compiled from sea sediments, ice cores, and concentrations of radioactive isotopes. Their report marks the end of a long journey for Topping; for more than 10 years he has traveled the breadth of his native Michigan, convinced, despite radiocarbon dating to the contrary, that he was looking at features more than 40,000 years old.

A primer on **page 7** will refresh your memory about radiocarbon dating and prepare you for Firestone and Topping's report, which begins on **page 9**.

**T**he Center for the Study of the First Americans fosters research and public interest in the Peopling of the Americas. The **Center**, an integral part of **Oregon State University**, promotes interdisciplinary scholarly dialogue among physical, biological and social scientists. The **Mammoth Trumpet**, news magazine of the **Center**, seeks to involve you in the late Pleistocene by reporting on developments in all pertinent sciences.

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Volume 16, Number 2  
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Center for the Study of the First Americans  
Oregon State University, Corvallis, OR 97331

Department of Anthropology  
ISSN 8755-6898

World Wide Web site <http://www.peak.org/csfa/csfa.html>

## Pleistocene Winds Blow from South America about the First Americans

In October 1999, the Clovis and Beyond Conference on early Americans was held in Santa Fe, New Mexico.

In December 2000, the southernmost part of the New World celebrated a new event on the Peopling of the Americas, this time focusing on the Southern Cone data. This international workshop, "The Colonization of South America during the Pleistocene/Holocene Transition," promoted by INQUA (International Union for Quaternary Research), was held at La Plata Museum, Faculty of Natural Sciences, University of La Plata, Argentina.

The very successful 2-day meeting was attended by archaeologists, biological anthropologists, and other Quaternary scientists. About 40 speakers addressed more than 150 people including many students.

**Laura Miotti addresses the La Plata conference on her area of expertise, the colonization of the Southern Cone.**

Respected authorities on the earliest Americans came from the U.S., Canada, Chile, Colombia, Uruguay, Brazil, France, Venezuela, and Argentina (more than 20), demonstrating that South American scientists are building new theories about the peopling of the Americas. Until recently, all models were constructed from a North American perspective.

The Clovis-First model postulated by North American archaeologists now seems inadequate to deal with the enor-

mous mass of variables—archaeological remains, environments and landscapes, linguistics, genetic pool—contained in South America. The First Americans in the Southern Cone model offers hope that we will someday understand this vast wealth of information. Thus the "Beyond" from the Clovis and Beyond Conference inspired this international workshop in Argentina.



### How were the Americas peopled?

Various models on the continental scale attempt to explain, using the evidence, ways the first people entered the American continent. One theory has been proposed by CSFA director Rob Bonnicksen, another by Ruth Gruhn and Alan Bryan of the University of Alberta.

Dr. Bryan's Circum-Pacific model for the colonization of the Americas, formulated in the '70s and for many years largely

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*Proposed bill limits scientists' access even more severely than NAGPRA*

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*Is a supernova the culprit responsible for radiocarbon dating errors? Two scientists present the evidence and argue their case.*

### 19 Folsom peoples knapped beautiful tools

*The second in Pegi Jodry's series focuses on ultrathin knives used to butcher bison—and what bison they were!*

# ANZICK SITE SKELETONS AND ARTIFACTS ARE THREATENED

by Bradley T. Lepper

The Anzick site in Montana is one of the most spectacular archaeological discoveries ever made in America. But instead of celebrating the distinction of having such a wonder in their fair state, the Montana State legislature is considering a law that threatens to consign it to oblivion.

The Anzick site, named for Dr. Melvyn and Helen Anzick who own the property on which the site was discovered, is an ancient rockshelter along Flathead Creek near Wilsall. It was 11,000 years

widely reported that both children had been buried together with the deposit of artifacts. However, recent work by Montana archaeologist Larry Lahren, Smithsonian physical anthropologists Doug Owsley and David Hunt, and radiocarbon dating expert Thomas Stafford shows conclusively that the children died more than 2,000 years apart.

The bones found under the Clovis artifacts, those of an 18-month-old child, include fragments of the skull, the left collarbone, or clavicle, and three ribs. A series of radiocarbon dates obtained by Stafford in 1984 and again in 1991 indicate this child died about 8800 B.C. A more recent test, however, gave an older

age of about 9600 B.C., which is somewhat more consistent with the style of the artifacts found with the bones. Mystery shrouds the circumstances surrounding the death and poignantly short life of this child, but he or she must have been very special to someone, for the toddler was buried with an arsenal of flint weaponry.

The second set of bones, including several pieces of a skull not stained by red ochre, were found scattered on the surface of the ground near the pit containing the bones and artifacts. Owsley and Hunt determined that this skull was from a child six to eight years old. Radiocarbon dating indicated that she or he died about 6600 B.C.—more than 2,000 years after the death of the Clovis child.

The research of Owsley, Lahren, Hunt, and Stafford corrects a widespread misunderstanding that the Anzick Clovis-age burial included two children. We now know the two burials represent unrelated

## Mammoth Trumpet Statement of Our Policy

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

*Robson Bonnicksen, Director*

ago that a group of Paleoamericans dug a shallow pit in the back of this rockshelter and deposited about 100 of the finest Clovis artifacts—gigantic flint knives, spearpoints, and bone rods—ever crafted. According to two of the discoverers, this mass of Paleolithic cutlery had been stacked together like playing cards. Beneath the deposit of flint tools, the amateur excavators found the remains of a small child. The bones and many of the tools had been covered with red ochre, an iron mineral that, when made into pigment, has been used for rituals and other purposes since the Upper Paleolithic era all over the world.

In addition to this burial feature, the discoverers of the site also found the bones of another child, but these were not covered with ochre. It has been



**The Mammoth Trumpet** (ISSN 8755-6898) is published quarterly by the **Center for the Study of the First Americans**, Department of Anthropology, Oregon State University, Corvallis, OR 97331-6510. Phone 541-737-4595. Periodical postage paid at Corvallis, OR 97333. e-mail: csfa@orst.edu.

POSTMASTER: Send address changes to:

### **Mammoth Trumpet**

355 Weniger Hall, Oregon State University,  
Corvallis, OR 97331-6510

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The **Center for the Study of the First Americans** is a non-profit organization. Subscription to the **Mammoth Trumpet** is by membership in the **Center**.

events. And the refinement in our understanding of the young age of death of the Clovis child increases our astonishment at the extravagant offering of flint included with the burial. This toddler was neither a great hunter who earned such glorious equipment for use to slaughter

mammoths in the afterlife, nor the offspring of a king or chief for whom such riches of flint came with high-born rank. This was the child of hunter-gatherers who probably granted status grudgingly and then only to those who proved their worthiness over many years.

Science is not likely to solve every mystery associated with this most ancient burial in North America. However, our understanding of the way of life of this child and its family and band is clearer because the bones and artifacts

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IN  
MEMORIAM

**RICHARD STOCKTON  
"SCOTTY" MACNEISH**

1918–2001

Richard Stockton "Scotty" MacNeish, renowned archaeologist and longtime resident of Andover, Mass., died from automobile accident injuries on January 16 in Belize. He was 82 years old. Known from his excavations throughout the Americas and China, MacNeish was elected to the British Academy in 1973 and the National Academy of Sciences in 1974. Last April, he received the prestigious Fryxell Award from the Society for American Archaeology in acknowledgment of his pioneering work in interdisciplinary research.

Born in Harlem and raised in Eastchester, N.Y., Scotty was educated at Colgate and the University of Chicago, from which he received a B.A. (1940), M.A. (1944) and Ph.D. (1949). A dedicated field archaeologist, Scotty interspersed his schooling with excavation experience in central New York, Monument Valley in Arizona, and northeast Mexico, as well as at numerous sites in Illinois, Pennsylvania, and Kentucky. In 1949, Scotty became Senior Archaeologist at the National Museum of Canada and over the next dozen years directed fieldwork from the Maritimes to the Yukon. He served as Chairman of the newly established Department of Archaeology at the University of Calgary from 1964 to 1968.

Much of Scotty's most famous work was conducted through the Robert S. Peabody Museum of Archaeology at Phillips Academy in Andover, Mass., where he served as director from 1969 to 1980. In 1960, Scotty joined director Doug Byers and curator Fred Johnson

to explore the origins of agriculture and complex societies in the Americas. Initial work focused on the Tehuacan Valley in Mexico. Five seasons of fieldwork documented 12,000 years of cultural development, notably the process by which maize (corn) was domesticated. The Tehuacan Project is still considered one of the most



ROBERT S. PEABODY MUSEUM AT PHILLIPS ACADEMY, ANDOVER, MASS.

significant interdisciplinary programs undertaken in 20th-century American archaeology. During the 1970s, MacNeish focused similar research efforts in the Ayacucho Valley of Peru and in Belize.

After retiring from the Robert S. Peabody Museum in 1982, Scotty taught briefly at Boston University and then continued his research through the Andover Foundation for Archaeological Research (AFAR). In 1993, MacNeish, along with colleagues from Beijing University and the Jiangxi Institute of Archaeology, investigated the origins of rice agriculture along the middle reaches of the Yangtze River. Three seasons of fieldwork have added substantial new information to our understanding of this subject.

Scotty was known as much for his personal style as for his science. A man of strong and often controversial opinions, he relished the sharp give and take of scholarly debate. Perhaps this pugnacious approach is explained by the fact that he was a Golden Gloves boxing champion as an undergraduate. Life was seldom dull around Scotty, and his gruff exterior hid a generous teacher and loyal friend.

In many ways, Scotty was the real Indiana Jones, a man passionate about knowledge rather than treasure, a consummate storyteller with the life experiences to back it up. His work has challenged and inspired others for more than a half century and will continue to do so for some time to come.

Scotty MacNeish is survived by his wife, Phyllis Diana (Walter), and two sons, Richard Roderick "Rod" and Alexander Stockton "Sandy." Scotty is also survived by his first wife, June Helm.

**Scotty in the field in Belize, c. 1980.**

Condolences may be sent to the MacNeish family, 3 Longwood Drive, Andover, MA 01810, or e-mailed to MacNeish2001@yahoo.com. Contributions in Scotty's memory may be sent to The Richard Stockton MacNeish Fund, c/o the Robert S. Peabody Museum, Phillips Academy, Andover, MA 01810. Funeral services will be private. A memorial service will held at 3 p.m. Saturday, April 28, at the Cochran Chapel of Phillips Academy. For information, telephone the Robert S. Peabody Museum at (978) 749-4490.

*James Bradley, Director  
Robert S. Peabody  
Museum of Archaeology,  
Andover, Massachusetts*

# The First Americans: Were They Australians?

Sound far-fetched? Not to **Professor Augusto Cardich**, senior research archaeologist at the Universidad Nacional de La Plata. His investigations at the Los Toldos Cave in Patagonia, which yielded a radiocarbon date more than 12,000 years old, have drawn the attention of the scientific community to this very interesting area in southern South America. During the recent conference at La Plata, Professor Cardich told the audience about his search to explain the initial peopling of the southern Argentinean by colonists who crossed the south Atlantic. Assisted by translator Amelia Barreiro, Rob Bonnichsen and Ruth Gruhn interviewed Professor Cardich during a lunch break.



**Rob Bonnichsen** This morning, Dr. Cardich presented a very interesting paper in which he proposed that the New World might have been settled by one or more migrations from Australia. We have a publication called the **Mammoth Trumpet**, and I think our readers would be interested in hearing that argument.

You made a discovery early in your career: Los Toldos. Can you describe that discovery, and your search to explain it?

**Professor Augusto Cardich** Well, when we first found the last layer of that site, corresponding to the 11th level, which had never been discovered before, we extracted some very interesting materials and tried to compare them with other lithic instruments from previously known industries. For that comparison we started to search all the available literature for late-Pleistocene sites from America and earlier sites from the rest of the world, trying to find some similarities, since we obtained C-14 dates of 12,600 yr B.P. for that layer.

**RB** What material was dated?

**AC** Charcoal. That was in 1973. After discovering that, we went to several scientific meetings and congresses to exhibit the material we had found to some of our colleagues and to see if they had something like it in their collections. We made some comparisons, but I always obtained the same answers: they didn't have anything like it.

**RB** Was that in the U.S., South America, or Europe?

**AC** In South America and also in the U.S. I remember a Congress that took place in Orono, Maine, in the late '80s [the 1989 World Summit Conference at the University of Maine]. Then I got in touch with some Asian scientists, especially from Japan. I showed them some of the lithic instruments of the 11th level because I suspected the first Americans arrived through

Bering. After analyzing them, they told me that, in Eastern Asia, that lithic industry didn't exist, and that in the route I suspected they might have taken (from Southeast Asia, and then up to the Bering Land Bridge to cross to North America), no one had ever found any stone tools of that kind.

To carry on with my research I went to Australia to see the lithic material they had there. I went to Sydney University and their museum, where I met several researchers. They showed me their lithic artifact collections, where I found very interesting materials from Australia and Tasmania that belonged to the late Pleistocene, very similar in some aspects to what we found here in Patagonia. For example, both here and there were found a large number of scrapers, wide unifacial artifacts, and no presence of projectile points—you know that the first Australian points, the Kimberly points, are from the Holocene. I wanted to go see the sites for myself, but the aboriginal people now living there don't usually admit archaeologists to sites in their territories. Talking about these similarities, of course you might think, "Well, they are actually very simple artifacts, and maybe they just resemble one another for that reason." But there's no doubt there are also more elaborate instruments that have many similarities as well.

A characteristic feature of the stone tools that I find meaningful, and that attracted the attention of Dr. Estela Mansur, a specialist who also analyzed them, is that there are no handles on any instruments that I observed in Australia, just as there are none in tools from Los Toldos. They always used their bare hands to handle them.

Another interesting thing I noticed in that journey is the Australian cave paintings. You'll see that in Los Toldos, and



Entrance to Los Toldos Cave.

particularly in another site in Patagonia called Estancia La María. There are many paintings that happen to be almost identical to those I saw in Australia, like the hand negatives [silhouettes of an artist's hands, made by blowing or sputtering ash from the

mouth] and the spiral and circular drawings made with little spots. They're not naturalistic drawings, which makes those similarities even more suspicious because it seems to me drawings inspired by things in nature are more likely to be found repeated in different places. Maybe the hand patterns can be found here as well as in Australia, but it's harder to account for finding the rest in both places without a contact.

**RB** Where, in Australia, has that style been found?

**AC** All over Australia, and also in Tasmania. The hand negatives also appear in other countries, like France, dating 32,000 years ago. That style arrived in Australia quite a long time ago for sure. In America, most hand negatives have been found in Patagonia. We didn't find them anywhere else in South America, and I think in North America there are only a couple of them, in Texas.

I also saw some engravings in Australia, like deep lines traced on the cave walls, which also can be seen here.

**RB** Was the engraved art associated with the hands?

**AC** They were in the same sites, but not necessarily next to each other.

What we have to acknowledge is that Australia must have an older artistic and lithic tradition than ours because we found things there that don't exist here at all.

Summarizing, if we start from those two characteristics, the lithic industry and the cave paintings, I believe contact between these peoples is very likely to be suspected, and that we



Artifacts at La Plata conference exhibit from earliest levels of Los Toldos cave.

have the basis for carrying out more profound research.

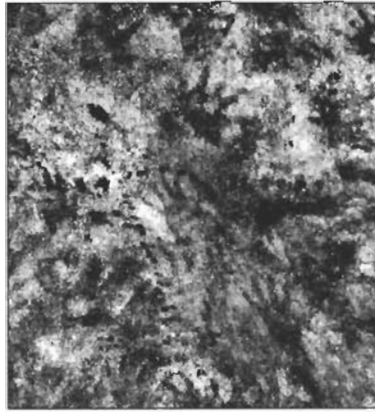
**RB** So there's a complex of artistic elements—hand negatives, stone tools, spiral and circular drawings, etc.?

**AC** Yes; and to me the important thing to emphasize here for a better understanding of the importance of the art and tools in linking both cultures is the fact that the art is not naturalistic, that even the more abstract drawings are similar.

**RB** Did the Australians take any hallucinatory drugs?

**AC** I'm not completely sure, but it's very likely to me because they had a very intense ritual life. There's an interesting book about that subject by an Australian author called Timothy Flannery. He says the men that arrived in Australia in the early moments of its history devoted themselves very deeply to their ritual life in a way that even diminished possible advancement in other aspects of their lives, such as technological development, for example.

Besides that, there's another negative factor that plays an important role in the lack of development, and that's the climate. Australia is especially affected by the El Niño current, since a great portion of the country is subject to its cyclical flowing and the consequences, a marked fluctuation between very dry and very



Cave paintings at Los Toldos, remarkably similar to those found in Australia

humid periods. The climatic factor also influenced the demography, and that's why the population was so low—only 500,000 inhabitants—when the first Europeans arrived. All this gave some Australian scientists good reason to think it very unlikely that the primi-

tive Australians would have felt the need to travel so far—to South America—under such contrary conditions, being such a small population in such a huge country. That presented a contradiction to them.

One of the first scientists who seriously put forward a possible migration from Australia to South America during the last Ice Age was Dr. Mendes Correa, a Portuguese. His theory states that a small group of people would have reached South America by coming from Australia, through Tasmania and some Pacific island that had emerged until they got to Antarctica, from where they crossed to Tierra del Fuego in the south of our continent.

**RB** Is there any evidence of occupation in Antarctica?

**AC** No, nothing has been found yet.

**RB** We're talking about what period—10,000, 12,000 years ago?

**AC** In the warmer periods of the last Ice Age. They arrived by sea, making their way through some of the South Pacific islands.

**RB** They took boats. Is there any idea what kind of boats?

**AC** No, we don't know for sure, but it's what has always been thought the most likely way.

I've read some works of geologists that say, just as the ice of the North Pole descended until it reached 40° North latitude 17,000 years ago, in the same way ice in Antarctica advanced north to 55° South latitude.

**RB** Basically, an ice shelf developed around Antarctica.

**AC** Right. We know now that a lot of sea fauna usually lived on the edge of the ice shelves. The shelf that reached 55° South latitude almost touched the coast of Tierra del Fuego, so we think the fauna came from Tasmania, which is more or less at 45° South latitude and at that time was still attached to Australia. Then they followed the Pacific island ring, always remaining close to the edge of the ice, in some kind of boats or small vessels.

**RB** What's the distance from Tasmania to the Antarctic ice shelf?

**AC** Oh, there's very little distance.

**RB** So, I'm wondering if there are any islands between Tasmania and the ice shelf.

**AC** Yes; and they're actually very close to each other. They probably used some kind of small vessel to sail through them, following the coastline of the ice shelf.

I think it's something similar to what Stanford said for North America, that the first people that got there traveled from Iberia to North America following the Arctic ice shelf. He thinks three weeks was enough. Here it might have taken a bit longer . . . let's say some four weeks. Of course, that's just a hypothesis. I'm not saying that all must have happened this way; we need to study some more, to do some more research in the areas entangled in what could have been their journey. But in all it's a good explanation, one that allows us to relate the artifacts discovered at the 11th level of Los Toldos and the cave paintings of Patagonia to similar discoveries made in Oceania.

Man has been sailing for a long time, you know. There's work being carried on in Indonesia. Australian and Indonesian scientists found an island called Island of Flores, where they discovered that its ancient inhabitants have been sailing the 24 km separating the island from the continent for the last 800,000 years!

Another good example is the way the first Australians arrived in their country. We know they arrived by sea, so they were already using boats and sailing 60,000 years ago. All this evidence makes me think it isn't crazy at all to think they might have sailed from Australia to South America.

Well, that's our hypothesis. It would be very important if we could find human remains in Patagonia belonging to that period—late Pleistocene or early Holocene—since there are many human remains in Australia dating to 20,000 or 30,000 years ago. It would be a wonderful opportunity to do morphological comparisons.


**RB** What do you think about Walter Neves's argument that the early skeletons had similarities to the Australians?

**AC** Well, maybe the remains Neves studied and the first Australian immigrants to America are actually the same people, or descendants of the small group that first entered South America from Australia, whose population grew and spread throughout the continent. I think they might have reached the south of our continent some 14,000 or 15,000 years ago.

**RB** The date I reported, of a very rapid sea level rise, was that between 14,600 and 14,100 years ago?

**AC** Yes, and around that time they were experiencing a period of very dry weather in Australia that had started some 3,000 years before. That might have been another factor that pushed them towards the ocean.

**Ruth Gruhn** We have evidence now that early people did have boats in places like Solomon Islands and Okinawa about 30,000 years ago. However, it concerns me that the Southern Pacific now, to the east of Tasmania, is very stormy.

**AC** Well, at the present time that's true. But I read a paper that stated that during the Pleistocene things were the other way round, that the waters of the Southern Pacific were much calmer than the waters in the north. Also the sea temperature was different, much warmer in the Southern Pacific indeed. 



## Smith Symposium II

The Hiscock Site:  
Late Pleistocene and Holocene  
Paleoecology and Archaeology  
of Western New York State

October 14–15, 2001  
Buffalo Museum of Science

The Hiscock Site has been excavated and studied continuously since 1983. Through those years it has yielded a remarkably rich record of environmental, biological, and cultural changes in the Northeast over the past 13,000 years. Hiscock was introduced officially to the scientific community through the "Smith Symposium" 15 years ago, relatively soon after its discovery. Since then, a very large body of data has accumulated, and will be presented and discussed in a second symposium to be held in Buffalo in October of this year.

Approximately two dozen papers on paleozoology, paleobotany, archaeology, geomorphology, sedimentology, taphonomy, and paleoclimatology will be presented and discussed by more than 40 scientists at this event. Question sessions and a reception will provide attendees the opportunity to interact personally with the presenters. The proceedings of the symposium will be published as a volume by the Buffalo Museum of Science.

Information flyers will be mailed out in March, providing a detailed description of the symposium, as well as registration materials. For updates watch future issues of *Mammoth Trumpet*. Information can also be obtained by contacting Michelle Rudnicki, (716) 896-5200, ext. 312; e-mail [rudnicki@sciencebuff.org](mailto:rudnicki@sciencebuff.org)

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Buffalo, New York 14211

## COMING CONFERENCES

March 28–31 2001, 70th Annual Meeting, American Association of Physical Anthropologists, Westin Crown Center, Kansas City, MO.

Contact: David Frayer or Sandra Gray, Dept. of Anthropology, 622 Fraser Hall, University of Kansas, Lawrence, KS 66045-2110; [Frayer@ukans.edu](mailto:Frayer@ukans.edu) or [sgray@kuhub.cc.ukans.edu](mailto:sgray@kuhub.cc.ukans.edu)

March 28–31 2001, Northwest Anthropology Conference, Best Western University Inn, Moscow, ID.

Contact: Donald E. Tyler, Professor & Chair, Dept. of Anth/Soc/Justice Studies, 101 Phinney Hall, University of Idaho, Moscow, ID 83844-1110; 208-885-6752; fax 208-885-2034; [dtyler@novell.uidaho.edu](mailto:dtyler@novell.uidaho.edu)

April 18–22 2001, 66th Annual Meeting, Society for American Archaeology, New Orleans Marriott, New Orleans, LA.

Information: <http://www.saa.org/Meetings/index.html>  
Slawkowska 17, 31-016, Krakow, Poland,  
[bochenski@isez.pan.krakow.pl](mailto:bochenski@isez.pan.krakow.pl); <http://www.isez.pan.krakow.pl>

Send conference notices to *Mammoth Trumpet*, CSFA, 355 Weniger Hall, Oregon State University, Corvallis, OR 97331 

# Carbon, and Radiocarbon Dating: A Primer



**A**LTHOUGH IT ACCOUNTS for only a tiny fraction of our planet's crust—less than 0.02 percent—carbon exerts an influence on Earth processes all out of proportion to its modest bulk.

## Carbon, a versatile element

In its pure form carbon can appear as graphite, the stuff of pencil lead; because it has a high melting point and is an excellent conductor of electricity, graphite is also the stuff of electrodes for electric motors, arc lamps, and furnaces. If its atoms are fused under intense heat and pressure deep in the Earth—or in the laboratory—pure carbon is diamond, the hardest substance known and an electrical insulator. Carbon also has the remarkable ability to alter the properties of other materials. Combined with ordinary metals like aluminum and boron, it makes extremely tough tools for cutting and grinding. Steel heat-treated with carbon ("case hardened") is highly resistant to wear and impervious to almost any object—except tools made from carbon.

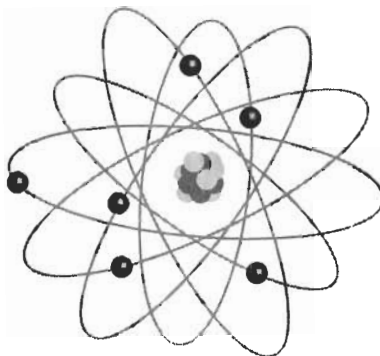
The many roles of carbon aren't confined to the inorganic realm. Carbon when heated combines readily with oxygen to form carbon dioxide,  $\text{CO}_2$ , the fizz of soda pop. Ingested by plants, atmospheric  $\text{CO}_2$  is converted by photosynthesis to carbohydrates, the food of life. The basis of all sugars, starches, and proteins, organic carbon is bound up in every living cell, plant and animal.

## Different kinds of carbon

Six protons in the nucleus of the carbon atom identify it as carbon, atomic number 6. Recall from your high school chemistry class that six protons (positive charge) require six orbiting electrons (negative charge) to make the atom electrically neutral. Most carbon atoms occurring naturally (about 98.9 percent) have six neutrons, each about equal in weight to a

proton but carrying no charge. This most prevalent form of carbon is known as  $^{12}\text{C}$ , 12 identifying the total number of nucleons (protons and neutrons). About 1.1 percent of carbon atoms in nature have seven neutrons; these are  $^{13}\text{C}$ . Both these isotopes (atoms of the same element differing in the number of neutrons) of carbon are stable.

$^{12}\text{C}$  and  $^{13}\text{C}$  form the basis of the Carbon Cycle that is life on Earth: they combine with oxygen to form  $\text{CO}_2$ , which is converted by plants into nutrients; the nutrients fuel cell growth and activity in animals that graze on the plants and in the carnivores that prey on them; after death, all organisms decompose and return their carbon to the vast reservoirs in the soil, seas, and atmosphere, to begin the Cycle anew.



## Radiocarbon, the unstable isotope

A third kind of carbon,  $^{14}\text{C}$ , is continuously being created in the upper reaches of the atmosphere, where cosmic rays from stellar sources bombard air molecules, creating random chunks of atomic matter and liberating neutrons. Most important for us is the result when a neutron collides with a nitrogen atom. Nitrogen, carbon's close relative in the family of elements, is atomic number 7, with 7 protons, neutrons, and electrons, hence  $^{14}\text{N}$ . When a neutron strikes a nitrogen

atom, it is captured and a proton is released. The remaining atom is no longer nitrogen. With 6 protons, it has become carbon with 14 nucleons. This is  $^{14}\text{C}$ , an unstable isotope of carbon—in other words, radioactive carbon, or just radiocarbon. Being radioactive,  $^{14}\text{C}$  decays. The radiocarbon atom emits a weak beta particle ( $\beta^-$ ) as it decays back to  $^{14}\text{N}$ , the nitrogen atom it was made from.

Every second, cosmic radiation impacting the atmosphere produces 2.4 atoms of  $^{14}\text{C}$  for every square cm of the Earth's surface. The concentration of  $^{14}\text{C}$  in the carbon reservoirs is minute, just one radiocarbon atom for every  $10^{12}$  atoms of stable carbon isotopes.  $^{14}\text{C}$  behaves just like carbon isotopes  $^{12}\text{C}$  and  $^{13}\text{C}$ : it binds with oxygen, and  $^{14}\text{CO}_2$  enters the Carbon Cycle and is continuously taken up by every living cell. When the host organism dies, no more carbon or radiocarbon is ingested and accumulated  $^{14}\text{C}$  begins to decay.

## Radiocarbon dating, a boon for scientists!

The existence of radiocarbon was known for years before Willard Libby at the University of Chicago discovered that it decays at a constant rate. After 5568 years, half the  $^{14}\text{C}$  in the organism decays back to  $^{14}\text{N}$ ; after another 5568 years, half the remaining  $^{14}\text{C}$  decays, and so on. This half-life of 5568 years, Libby reasoned, makes it possible to date organic remains: by measuring the rate of  $\beta^-$  emissions, we can calculate the concentration of  $^{14}\text{C}$ —how much it differs from the radiocarbon content of living matter—and thereby determine the number of years that have elapsed since the death of the organism. (Subsequent research determined that the actual half-life of  $^{14}\text{C}$  is 5,730 years, but 5,568 years remains the conventionally accepted half-life; the difference, about 3 percent, poses a minor problem for uncorrected samples.)

Libby and his colleagues developed a practical method for performing radiocarbon dating, and they ran exhaustive tests to check its accuracy. Organic materials associated with artifacts from Egyptian dynasties dating back as far as 5000 yr B.P. were radiocarbon dated and the results compared with written records. All the radiocarbon dates fell within acceptable limits of error of the true historic



dates. Reaching further back in time, Libby tested specimens of wood, peat, and mud from North America and northern Europe buried under glacial debris from the last ice sheet. All results were consistent, demonstrating that the last glaciation occurred about 11,000 yr B.P. in North America and Europe. For his method of using radiocarbon to determine age in Earth sciences, Libby received the 1960 Nobel Prize in Chemistry.

### A valuable tool, but flawed

Radiocarbon dating has to be used with care. Sources of error, some obvious, some insidious, can skew the results.

For a start, the concentration of  $^{14}\text{C}$  in the carbon reservoirs has not remained constant over the ages. With the Industrial Revolution came the burning of vast quantities of fossil fuel and the discharge of huge volumes of  $^{12}\text{CO}_2$  and  $^{13}\text{CO}_2$  into the atmosphere; therefore the concentration of radiocarbon in living matter today is not the same as in living matter before, say, 150 years ago.

In the first 20 years after Libby's invention was unveiled, scientists radiocarbon dated wood of known age and found that the  $^{14}\text{C}$  content varies by as much as 5 percent over the last 1500 years from various causes, some understood and some unknown. Researchers, by painstakingly counting the annual rings of trees (a process called dendochronology), have since constructed a calibration curve that corrects radiocarbon dates for samples dating back more than 10,000 years.

The environment from which a specimen is taken can affect radiocarbon dating. A marine specimen, for example, typically yields an age about 400 radiocarbon years older than a terrestrial specimen of the same age (Stuiver and Braziunas, 1993: Higham Website) because the oceans are a vast reservoir of dissolved carbon dioxide whose radiocarbon content lags behind the atmospheric content. A correction factor must therefore be applied to the radiocarbon age of marine organisms and to animals (including humans) that feed on them.

For an excellent description of radiocarbon dating, its history and considerations in its application, visit the Website of Tom Higham of the Radiocarbon Dating Laboratory of the University of

Waikato in Hamilton, New Zealand, [www.c14dating.com/corr.html](http://www.c14dating.com/corr.html)

### Some troubling results

Radiocarbon dates for Pleistocene remains in northeastern North America, according to scientists Richard Firestone and William Topping, are younger—as much as 10,000 years younger—than for those in the western part of the country. Dating by other methods like thermoluminescence (TL), geochronology, and sedimentation suggests that many radiocarbon dates are grossly in error. For example, materials from the Gainey Paleoindian site in Michigan, radiocarbon dated at 2880 yr B.P., give an age by TL dating of 12,400 yr B.P. Archaeologists Robson Bonnicksen and Richard Will report in *Ice Age Peoples* (1999) that, of 13 Paleoindian sites in northeastern North America, more than half yielded radiocarbon dates of Holocene age, dates regarded as too young by site investigators.

Many anomalies reported in the upper U.S. and in Canada cannot be explained by ancient aberrations in the atmosphere or other radiocarbon reservoirs, nor by contamination of data samples (a common source of error in radiocarbon dating).

Assuming correct methods of radiocarbon dating are used, ***organic remains associated with an artifact will give a radiocarbon age younger than they actually are only if they contain an artificially high radiocarbon level.***

A clue to the possible source of artificially elevated  $^{14}\text{C}$  content of Pleistocene remains may be found in the well-documented "atom bomb effect." By the mid-1960s, thermonuclear tests, with their enormous flux of thermal neutrons, had nearly doubled the volume of  $^{14}\text{C}$  in the atmosphere and—more important—***nearly doubled the  $^{14}\text{C}$  activity of buried carbon-bearing materials*** (Taylor, 1987: Higham Website). In other words, the rate of  $\beta^-$  emissions was artificially accelerated. The flux of thermal neutrons had reset the radioactive clock, making materials appear younger by radiocarbon dating than they actually were.

This is the effect of man-made neutron bombardment, and we are at best feeble imitators who can only glimpse the awesome power of Nature.

### A natural nuclear catastrophe?

Firestone and Topping have collected evidence from a broad range of sources: abnormal ratios of uranium isotopes and elevated levels of plutonium; Pleistocene cherts scarred by high-speed particles; a series of geomagnetic excursions coincident with stepwise increases in  $^{14}\text{C}$  in marine sediments. The totality of the evidence leads them to the inescapable conclusion:

**a cosmic ray catastrophe, probably caused by a supernova, occurred in northeastern North America in the late Pleistocene. Massive thermal neutron irradiation radically altered the radioactivity of terrestrial materials, probably figured in the mass extinction of Ice Age fauna, and may account for plant mutations.**

### A first for Mammoth Trumpet

The accompanying article by Dr. Firestone and Dr. Topping, "Terrestrial Evidence of a Nuclear Catastrophe in Paleolithic Times," differs from reports our readers are used to seeing in several important respects:

- **It is a controversial theory.** For nearly half a century radiocarbon dating has been an indispensable tool of archaeologists, anthropologists, paleontologists, geologists. Chronologies of human migration, fauna extinctions, even glacial movements have been based with absolute confidence on the dating of evidentiary carboniferous materials. Firestone and Topping contend that radiocarbon dates for sites in North America are suspect, the result of a late-Pleistocene cosmic ray bombardment that created vast amounts of radiocarbon and thereby reset the clock by which radiocarbon dating measures the passage of time. The closer the site to the Great Lakes, the center of the purported nuclear catastrophe, the greater the probability of error—amounting in some cases to many thousands of years. Firestone and Topping's theory challenges the chronology that underpins many theories. Consequently, it casts doubt on many theories themselves.


- **Their theory is based on nuclear physics.** Although Firestone and Topping find supporting evidence in such diverse sources as marine sediments and Greenland ice cores, they base their theory principally on analysis of radioactive iso-

topes of uranium, plutonium, and beryllium in samples drawn from across North America. (Isotope analysis is the stock in trade at Lawrence Berkeley National Laboratory, Firestone's home base.) They find abnormal depletion of  $^{235}\text{U}$  and elevated levels of  $^{239}\text{Pu}$ , both conditions especially pronounced at sites near the Great Lakes. **The only phenomenon capable of creating such imbalances, they argue, is massive neutron bombardment, probably from a supernova.** It is inescapable, they contend, that the catas-

trophe, which left its signature in abnormal isotopic ratios, must also have radiocally increased the radiocarbon content of materials, even of subterranean deposits. They conclude that radiocarbon dates for these altered materials inevitably make the materials appear younger than they actually are.

In *Mammoth Trumpet* we usually report on happenings in archaeology. In this issue we focus on an invaluable tool of archaeologists, radiocarbon dating, reported by the branch of science best

equipped to evaluate the tool, nuclear physics.

■ **We've published their report in its entirety.** That includes references, so that knowledgeable readers can check the authors' work, and the names of an impressive group of scientists to whom the authors are indebted for their help. Footnotes are included to explain terms and concepts to readers who don't happen to work with nuclear physics every day. 

-JMC

**T**HE PALEOINDIAN OCCUPATION of North America, theoretically the point of entry of the first people to the Americas, is traditionally assumed to have occurred within a short time span beginning at about 12,000 yr B.P. This is inconsistent with much older South American dates of around 32,000 yr B.P.<sup>1</sup> and the similarity of the Paleoindian toolkit to Mousterian traditions that disappeared about 30,000 years ago.<sup>2</sup> A pattern of unusually young radiocarbon dates in the Northeast has been noted by Bonnichsen and Will.<sup>3,4</sup>

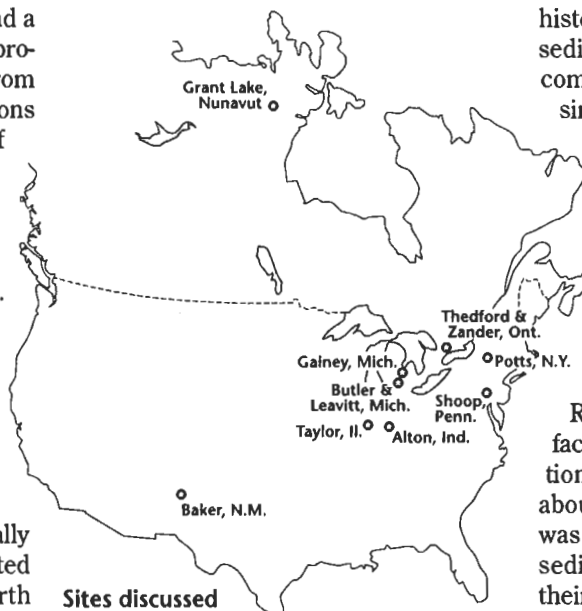
Our research indicates that the entire Great Lakes region (and beyond) was subjected to particle bombardment and a catastrophic nuclear irradiation that produced secondary thermal neutrons from cosmic ray interactions. The neutrons produced unusually large quantities of  $^{239}\text{Pu}$  and substantially altered the natural uranium abundance ratios ( $^{235}\text{U}/^{238}\text{U}$ ) in artifacts and in other exposed materials including cherts, sediments, and the entire landscape. These neutrons necessarily transmuted residual nitrogen ( $^{14}\text{N}$ ) in the dated charcoals to radiocarbon, thus explaining anomalous dates.

### The evidence from dated materials

We investigated a cluster of especially young radiocarbon dates concentrated in the north-central area of North America. For example, at the Gainey

## Terrestrial Evidence of a Nuclear Catastrophe in Paleoindian Times

by Richard B. Firestone, Lawrence Berkeley National Laboratory, and William Topping, Consultant, Baldwin, Michigan



Sites discussed in this article

site in Michigan a 2880 yr B.P. radiocarbon date was reported, while the thermoluminescence date for that site is 12,400 yr B.P.<sup>5</sup> Other anomalous dates

found at Leavitt in Michigan,<sup>6</sup> Zander and Thedford in Ontario,<sup>7</sup> Potts in New York,<sup>8</sup> Alton in Indiana,<sup>9</sup> and Grant Lake in Nunavut<sup>10</sup> are summarized in Table 1. The Grant Lake Paleoindian site is most remarkable because its 160 [rc] yr B.P. age is nearly contemporary, while adjacent and

deeper samples give ages of 1480–3620 [rc] yr B.P.

Stratigraphic associations place Paleoindian occupations at depth on the prehistoric North American landscape on sediments that form the old C horizon composed of parent material, Wisconsinan deposits that predate Holocene sediment buildup.<sup>11,12,13</sup> The young Paleoindian dates cannot be correct, particularly since there are no patterned anomalies noted in later-period prehistoric assemblages relating to higher stratigraphic positions. In a pioneering study of the Paleoindian site at Barnes, Michigan, Wright and Roosa observed that Paleoindian artifacts were deposited before the formation of spodosols ceased in this area about 10,000 yr B.P.<sup>14</sup> This conclusion was based on observing that cemented sediments on artifacts, found outside their original context, defines their original stratigraphic position.

Table 1. Site and particle impact data for Paleoindian artifacts, charcoals, and cherts.

Site	Coordinates	Particle/track/pit			<sup>14</sup> C date (yr B.P.)	Comments
		Density /mm <sup>2</sup>	Depth (μm)	Angle (approx.)		
Baker, N.M.	34.5° N, 106.4° W	130 ± 60	10	90°		pits; artifact
Alton, Ind.	38.7° N, 86.2° W	700 ± 300	60	90°	1860	particles; chondrules; unaltered flake with embedded particles
Taylor, Ill.	39.1° N, 88.2° W	c. 400	60	90°		particles; chondrules; outer flake
Shoop, Pa.	40.4° N, 76.5° W	130 ± 60	5	5°		tracks; flake
Butler, Mich.	42.4° N, 84.3° W					particles; flake
Leavitt, Mich.	42.4° N, 84.3° W	400 ± 90	120	90°	2830 ± 115	particles; tracks; no chondrules; flake
Gainey, Mich.	42.6° N, 83.4° W	460 ± 70	120	90°	2880 ± 175 <sup>▼</sup>	pits; particles; tracks; no chondrules; flake
Theford, Ont.	43.1° N, 81.5° W				2130 ± 230	
Potts, N.Y.	43.2° N, 76.2° W				3810	
Zander, Ont.	43.4° N, 79.2° W	200 ± 140	60	85°	3380 ± 420	particles; no chondrules; flake
Grant Lake, Nun.	63.4° N, 100.3° W				160 ± 65	

<sup>▼</sup>12,360 ± 1240 yr B.P. date determined by thermoluminescence

### The evidence from particle bombardment

Sediment profiles were taken at Paleoindian sites and at numerous widely separated control locations in Michigan. The C sediment horizon is clearly recognized by its transitional color and confirmed by elevated concentrations of potassium and other isotopes. Color and chemistry are key indicators of this very old soil<sup>11,12,13</sup> derived from parent materials and associated postglacial runoff.<sup>15</sup> At Gainey, large quantities of micrometeorite-like particles appear to be concentrated near the boundary between the B and C sediment horizons. They can be separated with a magnet and are identified by the presence of chondrules and by visual evidence of sintering and partial melting. These particles, dissimilar to common magnetites, are found in association with a high frequency of "spherules." The depth profiles for potassium and particles at the Gainey site are compared in Fig. 1. Minor vertical sorting of particles is apparent, with a shallow spike of particles near the surface probably resulting from modern agricultural or industrial activity. Total gamma-ray counting of sediment profiles in the various locations invariably showed increased radioactivity at the B-C boundary consistent with enhanced potassium (<sup>40</sup>K) and possibly other activities.

Microscopic examination of chert artifacts from several widely separated Paleoindian locations in North America revealed a high density of entrance wounds and particles at depths that are evidence of high-velocity particle bombardment. Chondrules were identified visually; their presence necessarily indicates heating during high-speed entry into the atmosphere. The depth of penetration into the artifacts implies that the particles entered with substantial energy.<sup>16</sup> Field simulations with control cherts for large particles (100–200 microns) suggest an entrance velocity greater than 0.4 km/s, and experiments at the National Superconducting Cyclotron Laboratory indicate that the smaller particles left tracks comparable to about 526 MeV iron ions (<sup>56</sup>Fe) in Gainey artifacts. Similar features are not observed in later-period prehistoric artifacts or in bedrock chert sources. Track angles were estimated visually; track densities were measured with a stage micrometer; track depths were found by adjusting the microscope focus through the track. These data are summarized in Table 1.

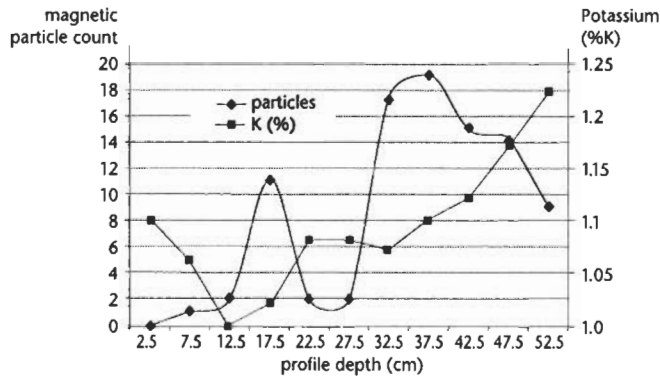
Track and particle data in Table 1 suggest that the total track volume (density times depth) is highest at the Michigan, Illinois, and Indiana sites and decreases in all directions from this region, consistent with a widespread catastrophe concentrated over the Great Lakes region. The nearly vertical direction of the tracks left by particle impacts at most sites suggests they came from a distant source.

### The evidence from uranium and plutonium

Natural uranium, which is ubiquitous in cherts, has a <sup>235</sup>U/<sup>238</sup>U isotopic ratio of 0.72 percent, which varies by less than 0.1 percent in natural sources.<sup>17</sup> Significant variations in the isotopic ratio do not occur because of chemical processes; however, a thermal neutron bombardment depletes <sup>235</sup>U and thus alters the ratio. Solar or galactic cosmic rays interacting with matter produce fast secondary neutrons that become thermalized by scattering from surrounding materials. Thermal neutrons see a target of large cross section (681 barns)<sup>A</sup> for destroying <sup>235</sup>U, compared with a target of only 2.68 barns for neutron capture on <sup>238</sup>U. Therefore, despite the low abundance of <sup>235</sup>U, about 1.8 times as many <sup>235</sup>U atoms are destroyed as <sup>238</sup>U atoms by thermal neutrons.

If a large cosmic-ray bombardment impacted the earth and irradiated the prehistoric landscape with thermal neutrons, the <sup>235</sup>U/<sup>238</sup>U ratio would be changed; <sup>239</sup>Pu would be produced from neutron capture on <sup>238</sup>U, followed by the decay of <sup>239</sup>U. Neutrons colliding with nitrogen (1.83 barns) would create <sup>14</sup>C in exactly the same way <sup>14</sup>C is normally produced in the upper atmosphere, necessarily resetting the radiocarbon dates of any organic materials lying near the surface on the North American prehistoric landscape—including charcoals at Paleoindian sites—to younger values. <sup>239</sup>Pu produced during the bombardment will also be partly destroyed by thermal neutrons with 1017 barn cross section. Assuming <sup>239</sup>Pu doesn't mobilize, it will

<sup>A</sup>A barn is a unit of area equal to 10<sup>-24</sup> cm<sup>2</sup>, used in nuclear physics. The fraction of isotopes that are transformed by a nuclear reaction is given by  $\sigma \times I$ , where  $\sigma$  is the cross section in cm<sup>2</sup> of the target presented by an atom, and  $I$  is the neutron flux per cm<sup>2</sup> impinging on the target. Most neutron-induced reactions involve the capture of a neutron to produce a heavier isotope of the same element. Exceptions include <sup>14</sup>N, which captures a neutron and emits a proton to produce <sup>14</sup>C; and <sup>235</sup>U, which mainly fissions into two lighter elements. The relative size of isotopes in chert is shown in figure "A neutron's view of chert."



**Figure 1. Sediment profile showing the number of magnetic particles and the potassium concentration at the Gainey site. The potassium concentration was determined by <sup>40</sup>K gamma-ray counting; the uncertainty is within the plotted points. Particle frequencies were counted under a microscope for 0.25-ml samples at each interval.**

decay back to <sup>235</sup>U (half-life 24,110 yr), partially restoring the normal abundance.

Paleoindian artifacts from Gainey, Leavitt, and Butler, and two later-period artifacts from the same geographic area of Michigan were analyzed for <sup>235</sup>U content by gamma-ray counting at the Phoenix Memorial Laboratory, University of Michigan. They were compared with identical chert types representative of the source materials for the artifacts. Control samples were extracted from the inner core of the purest chert known to be utilized by prehistoric people. The Paleoindian artifacts contained about 78 percent as much <sup>235</sup>U as the controls and later-period artifacts, suggesting substantial depletion. *Depletion of <sup>235</sup>U necessarily indicates that thermal neutrons impacted these artifacts and the surrounding prehistoric landscape.*

Various artifacts, cherts, sediments, and a control sample containing about 0.2 percent uranium obtained from uraninite were sent to the McMaster University Centre for Neutron

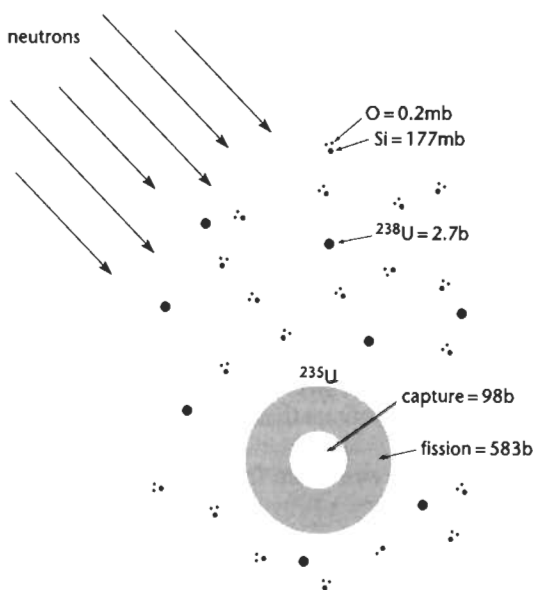
Activation Analysis to determine <sup>235</sup>U concentration by delayed neutron counting and <sup>238</sup>U concentration by activation analysis. These results are shown in Table 2. The <sup>235</sup>U/<sup>238</sup>U ratios for all samples except the control deviated substantially from the expected ratio. McMaster ran additional calibration standards and has considerable expertise analyzing low-level uranium. This analysis was sensitive to a few ppb for <sup>235</sup>U and 0.1–0.3 ppm for <sup>238</sup>U, more than sufficient to precisely analyze the uranium-rich chert samples (0.7–163.5 ppm). Most samples were depleted in <sup>235</sup>U, depletion increasing geographically from the southwest (Baker, Chuska chert, 17 percent) to the northeast (Upper Mercer, 77 percent), as shown in Table 2. This is consistent with cosmic rays focused towards northern latitudes by Earth's magnetic field. Only a very large thermal neutron flux, greater than 10<sup>20</sup> n/cm<sup>2</sup>, could have depleted <sup>235</sup>U at all locations.

Samples of unaltered flakes from Taylor and sediment originally adjacent to Gainey artifacts showed <sup>235</sup>U enriched by 30 percent. Both samples were closely associated with the particles described above. The position of these samples appears to be related to the enrichment, which cannot be explained by thermal neutrons from the bombardment. To test this, we bathed another Taylor flake in 48-percent HF at 60°F for ten minutes to remove the outer 70 percent of the sample and the attached particles. Analysis showed the “inner” flake depleted in <sup>235</sup>U by 20 percent, consistent with the other depleted cherts.

Samples of Gainey sediment and Taylor flakes were analyzed for plutonium by Nuclear Technology Services, Inc., of Roswell, Georgia, which specializes in radiochemistry using standard methodology. The plutonium, with an aliquot of NIST-traceable <sup>242</sup>Pu added, was chemically separated on an anion exchange resin column and counted on an alpha-particle spectrometer. The <sup>239</sup>Pu/<sup>238</sup>U ratios in both samples were approximately 10 ppb, vastly exceeding the expected ratio of 0.003 ppm.<sup>18</sup> The results of this analysis are shown in Table 2.

Chert is a glass-like material highly impervious to penetration by any nuclear fallout that might also contribute <sup>239</sup>Pu. We

**A neutron's view of chert**



Chert (SiO<sub>2</sub>, silicon dioxide or silica) is an interesting material. Because silicon and oxygen present small cross sections to neutrons, neutrons are only slowly absorbed in chert. Atoms of uranium, a natural impurity in chert, have much larger cross sections for neutron capture. <sup>235</sup>U has a cross section so large that, although it constitutes only 0.72 percent of all uranium, it presents a larger target and is therefore nearly twice as likely to be destroyed by neutrons as <sup>238</sup>U, which is 99.28 percent of all uranium. This is why <sup>235</sup>U becomes depleted in uranium when bombarded by neutrons. (The cross section for <sup>14</sup>N—to produce <sup>14</sup>C—is about the same as for <sup>238</sup>U to capture a neutron.) Since uranium is only a trace impurity in chert, most of the neutrons are captured by silicon atoms, but the neutron flux is attenuated slowly with sample depth. Half the neutrons will penetrate 150 cm of chert, compared with 100 cm for CaCO<sub>3</sub>, 60 cm for H<sub>2</sub>O, and 6 cm for FeO. Thus, in the event of a thermal neutron-producing event, buried artifacts would be irradiated uniformly and would not attenuate neutrons. Carbon in associated charcoals used for radiocarbon dating has a very small cross section for neutron capture (0.0035 barn), which is only 0.02 percent of the cross section for residual <sup>14</sup>N (1.83 barn). Thus, even small amounts of <sup>14</sup>N in charcoal will disproportionately absorb neutrons, producing <sup>14</sup>C and resetting their radiocarbon clocks.

**Table 2. Uranium and plutonium data for Paleoindian artifacts, cherts, sediments, and standards. Sites are ordered by increasing latitude.**

Site	Sample	Total uranium (ppm)	<sup>235</sup> U/ <sup>238</sup> U Ratio (%)	<sup>235</sup> U Depletion (%)	<sup>239</sup> Pu/ <sup>238</sup> U (ppb)
Control	uraninite	2269 ± 112	0.73 ± 0.04	< 5	
Baker	artifact	163.5 ± 7.6	0.59 ± 0.03	19 ± 4	
Baker	Chuska chert	129.0 ± 6.5	0.60 ± 0.03	17 ± 4	
Alton	flake	56.3 ± 2.7	0.60 ± 0.03	17 ± 4	
Alton	Wyandotte chert	7.7 ± 0.5	0.51 ± 0.06	30 ± 8	
Taylor	outer flake	note a	0.95 ± 0.03	note b	10 ± 1
Taylor	inner flake	8.2 ± 0.5	0.59 ± 0.06	19 ± 8	
Butler	flake	4.6 ± 0.5	0.37 ± 0.12	49 ± 17	
Leavitt	flake	0.6 ± 0.2	<0.5	>30	
Leavitt	Bayport chert	8.1 ± 0.5	0.42 ± 0.06	42 ± 8	
Gainey	sediment	1.39 ± 0.09	0.94 ± 0.09	note b	43 ± 4
Gainey	flake	0.7 ± 0.2	<0.4	>45	c. 90
Gainey	inner artifact <sup>■</sup>	1.6 ± 0.2	<0.15	>79	
Gainey	Upper Mercer chert	1.8 ± 0.3	0.17 ± 0.12	77 ± 17	
Zander	flake	1.0 ± 0.2	<0.25	>65	

<sup>a</sup> 3–13 ppm U, weighted average of six measurements.

<sup>b</sup> Enriched in <sup>235</sup>U.

<sup>■</sup> Acid-reduced flake core with micrometeorites removed.

analyzed a long-exposed piece of Bayport chert by gamma-ray counting at the LBNL low-background facility for the presence of cesium-137 (<sup>137</sup>Cs), a key indicator of fallout (from nuclear testing), and found none. The B-C interface typically lies sufficiently deep that contamination by fallout is improbable. It is important to note that *fallout cannot explain the depletion of <sup>235</sup>U.*

Since the depletion of <sup>235</sup>U must have resulted from bombardment by thermal neutrons, the presence of <sup>239</sup>Pu from irradiation of <sup>238</sup>U is expected. The total thermal neutron flux required to produce the observed <sup>239</sup>Pu concentration can be calculated from the relative concentrations of <sup>239</sup>Pu (corrected for the decay) and <sup>238</sup>U, and the thermal neutron-capture cross section for <sup>238</sup>U. This neutron flux can then be used to estimate the amount of additional <sup>14</sup>C that would have been produced in charcoal by neutrons colliding with <sup>14</sup>N (<sup>14</sup>N cross section = 1.83 barns). The corrected radiocarbon age can then be estimated by comparing the current amount of <sup>14</sup>C in the dated charcoals, determined from their measured radiocarbon age, with the amount of <sup>14</sup>C that would have been produced by the bombardment. For these calculations we assume that charcoal contains 0.05 percent residual nitrogen<sup>19</sup> and that initial <sup>14</sup>C concentrations were the same as today (one <sup>14</sup>C atom for 10<sup>12</sup> <sup>12</sup>C atoms).

We derive a thermal neutron flux of c. 10<sup>17</sup> n/cm<sup>2</sup> at Gainey, which corresponds

to an approximate date of 39,000 yr B.P. No radiocarbon date is available for the more southerly Taylor site, but for the conventional range of accepted Paleoindian dates the neutron flux would be c. 10<sup>16</sup> n/cm<sup>2</sup>, giving a date of about 40,000 yr B.P. These calculations necessarily neglect differences in the neutron flux experienced by the dated charcoal and the artifacts, the effects of residual <sup>239</sup>Pu from previous bombardments, and loss of <sup>239</sup>Pu due to leaching from chert over time.

The neutron flux calculated from the <sup>235</sup>U/<sup>238</sup>U ratio is more than 1000 times that implied by the level of <sup>239</sup>Pu. Since <sup>239</sup>Pu decays to <sup>235</sup>U, partly restoring the natural abundance, it appears that substantial quantities of <sup>239</sup>Pu have migrated out of the chert. This mobility is demonstrated at the Nevada Test Site, where plutonium, produced in nuclear tests conducted by the U.S. between 1956 and 1992, migrated 1.3 km.<sup>20</sup> It has also been shown that atoms produced by radioactive decay or nuclear reaction become weakly bound to the parent material and pass more readily into solution than isotopes not affected.<sup>21</sup> Both <sup>239</sup>Pu and <sup>235</sup>U are thus expected to be mobile, complicating any analysis. This is consistent with the enrichment of <sup>235</sup>U in the two external samples where migrating <sup>239</sup>Pu or <sup>235</sup>U may have been trapped, thus enriching the relatively uranium-poor outer regions. Alternatively, excess <sup>235</sup>U may have been carried in by the particles. Ra-

diocarbon produced in situ by irradiation should also be mobile. If <sup>14</sup>C is more mobile than <sup>239</sup>Pu, then the dates calculated above should be decreased accordingly.

### Redating North American sites

The 39,000 yr B.P. date proposed for the Gainey site is consistent with the prevailing opinion among many archaeologists about when the Americas were populated. It is also commensurate with dates for South American sites and with a Mousterian toolkit tradition that many see as the Paleoindian precursor. The proposed date for the Gainey site also falls closer in line with the radiocarbon date for a Lewisville, Texas, Paleoindian site of 26,610 ± 300 yr B.P.<sup>22,23</sup> and radiocarbon dates as early as c. 20,000 yr B.P. for Meadowcroft Rockshelter.<sup>24</sup> Since the Lewisville and Meadowcroft sites were likely exposed at the same time to thermal neutrons, we estimate that their dates should be reset to c. 55,000 yr B.P. and c. 45,000 yr B.P., respectively.

It is likely that Paleoindians occupied low latitudes during the full glacial and migrated to more northerly areas as the ice front retreated. Therefore the pattern of dates makes sense from the archaeologist's point of view. Dates for North American sites should generally be reset by up to 40,000 years, depending on latitude and overburden.

Geologists believe that before c. 15,000 yr B.P. the Wisconsinan glaciation covered the more northerly locations where Paleoindian sites have been found.<sup>25</sup> The ice sheet would have shielded the landscape and any artifacts from an irradiation. (The Gainey thermoluminescence date of 12,400 yr B.P. is probably a result of the heat generated by the nuclear bombardment at that time, which would have reset the TL index to zero.) The modified dates for Paleoindian settlements suggest that the timetable for glacial advance sequences, strongly driven by conventional radiocarbon dates, should be revisited in light of the evidence presented here of much older occupations than previously thought."

### The evidence from tree rings and marine sediments

A large nuclear bombardment should have left evidence elsewhere in the radio-

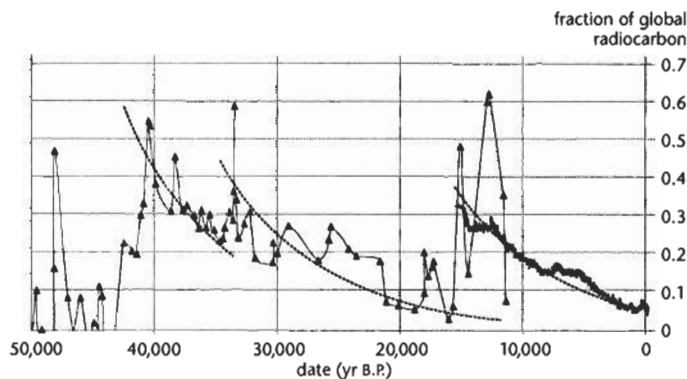
carbon record. It is well known that radiocarbon dates are increasingly too young as we go back in time. The global Carbon Cycle suggests that  $^{14}\text{C}$  produced by cosmic rays would be rapidly dispersed in the large carbon reservoirs in the atmosphere, land, and oceans.<sup>26</sup> We would expect to see a sudden increase in radiocarbon in the atmosphere that would be incorporated into plants and animals soon after the irradiation; after only a few years, most of the radiocarbon would move into the ocean reservoirs. The  $^{14}\text{C}$  level in the fossil record would reset to a higher value. The excess global radiocarbon would then decay with a half-life of 5730 years, which should be seen in the radiocarbon analysis of varved systems.

Fig. 2 plots  $^{14}\text{C}$  from the INTCAL98 radiocarbon age calibration data of Stuiver et al. for 15,000–0 yr B.P.<sup>27</sup> and Icelandic marine sediment  $^{14}\text{C}$  data measured by Voelker et al. for 50,000–11,000 yr B.P.<sup>28</sup> Excess  $^{14}\text{C}$  is indicated by the difference between the reported radiocarbon dates and actual dates. Sharp increases in  $^{14}\text{C}$  are apparent in the marine data at 40,000–43,000, 32,000–34,000 and c. 12,000 yr B.P. These increases are coincident with geomagnetic excursions<sup>B</sup> that occurred at about 12,000 (Gothenburg), 32,000 (Mono Lake), and 43,000 yr B.P. (Laschamp),<sup>29</sup> when the reduced magnetic field would have made Earth especially vulnerable to cosmic ray bombardment. The interstitial radiocarbon data following the three excursions were numerically fit, assuming exponential decay plus a constant cosmic ray–produced component. The fitted half-lives of 5750 yr (37,000–34,000 yr B.P.), 6020 yr (32,000–16,000 yr B.P.), and 6120 yr (12,000–0 yr B.P.) are in good agreement with the expected value.

We also determined that contemporary radiocarbon contains about 7 percent residual  $^{14}\text{C}$  left over from the catastrophe. The constant cosmic ray production rate was about 34 percent higher for the Icelandic sediment than the INTCAL98 samples, perhaps implying higher cosmic ray rates farther north. Disregarding fluctuations in the data from variations in ocean temperatures and currents, the results are clearly consistent with the decay of radiocarbon following the three geomagnetic excursions.

In Fig. 2, the sharp drop in  $^{14}\text{C}$  activity before 41,000 yr B.P. suggests that global radiocarbon increased by about 45 percent at that time and by about 20 percent at 33,000 and 12,000 yr B.P. The results are remarkably consistent with Vogel's comparison of  $^{14}\text{C}$  and U-Th dates of a stalagmite that indicates global radiocarbon increased about 75 percent from 30,000 to 40,000 yr B.P. and about 30 percent around 18,000 yr B.P.<sup>30</sup>

McHargue et al. found high levels of  $^{10}\text{Be}$  in Gulf of California marine sediments at 32,000 and 43,000 yr B.P.<sup>C</sup> that could not be explained by magnetic reversal alone and were attributed to cosmic rays, possibly from a supernova.<sup>29</sup> The geomagnetic excursion at 12,500 yr B.P. coincides with the thermoluminescence date from Gainey, and additional evidence for a cosmic ray bombardment at that time is found in the increases of  $^{10}\text{Be}$ ,<sup>31</sup>



**Figure 2.** INTCAL98 radiocarbon age calibration data from Stuiver et al. (jagged curve), and Icelandic marine  $^{14}\text{C}$  data (Voelker et al.<sup>31</sup>) for 50,000–11,000 yr B.P. (triangles) were independently fit assuming a constant galactic cosmic ray–induced  $^{14}\text{C}$  background plus residual radiocarbon decaying from nuclear events at 41,000, 33,000, and 12,500 yr B.P. The residual  $^{14}\text{C}$  is plotted as a fraction of total observed  $^{14}\text{C}$  (global radiocarbon), assuming equilibrium was rapidly achieved over the time scale of the measurements. Global carbon, primarily dissolved in the oceans, thoroughly mixes over a time scale of centuries. The smooth curves show the expected decay curves for the three events assuming  $^{14}\text{C}$  half-life = 5730 yr. The fit to the data gives 6120 yr (12,000–0 yr B.P.), 6020 yr (32,000–16,000 yr B.P.), and 5750 yr (37,000–34,000 yr B.P.). Fluctuations in the measurements from the decay curves may result from variations in ocean temperatures and currents. The sharp drop in  $^{14}\text{C}$  activity before 41,000 yr B.P. suggests that this series of events was initiated by an event that increased global  $^{14}\text{C}$  by about 45 percent, followed by two events each increasing  $^{14}\text{C}$  by about 20 percent. About 7 percent of modern radiocarbon is residue from these early events. The galactic cosmic ray  $^{14}\text{C}$  background component was about 34 percent larger for the Icelandic data, consistent with a higher expected cosmic ray flux at Northern latitudes.

Ca,<sup>32</sup> and Mg<sup>32</sup> in Greenland ice cores around 12,500 yr B.P. Similar increases are also seen in the data for  $\text{NO}_3^-$ ,  $\text{SO}_4^-$ ,  $\text{Mg}^+$ ,  $\text{Cl}^-$ ,  $\text{K}^+$ , and  $\text{Na}^+$  ions in Greenland ice cores.<sup>33</sup> This occurrence can be dated precisely to 12,500 ± 500 yr B.P., an average of the remarkably consistent concentration peak centroids in the Greenland ice core data. Significant increases at that time are not found in comparable data for the Antarctic, which indicates that the cosmic ray irradiation was centered in the Northern Hemisphere. Weak evidence of an occurrence at 12,500 yr B.P. is seen in the radiocarbon record for marine sediments near

<sup>C</sup> Beryllium occurs naturally as  $^9\text{Be}$ .  $^{10}\text{Be}$  is produced by cosmic rays, mostly protons, striking the atmosphere and breaking apart nitrogen and oxygen. It has a half-life of 1.5 million years. Unlike  $^{14}\text{C}$ , which is caught up in the global Carbon Cycle,  $^{10}\text{Be}$  is inert and falls as dust.  $^{10}\text{Be}$  is produced almost entirely by galactic cosmic rays, which are much higher in energy than solar cosmic rays. Thus any increase in  $^{10}\text{Be}$  would be cosmic in origin; and the cosmic ray rate could only change if there were a nearby supernova. During the last Ice Age the  $^{10}\text{Be}$  deposition rate in ice at both poles was much higher than today. Gulf of California marine sediments clearly show strong  $^{10}\text{Be}$  peaks at 32,000 and 43,000 yr B.P. McHargue argues that these peaks can only be explained by a supernova.

<sup>B</sup> The alignment of magnetic particles in sediment indicates that the Earth's magnetic poles have repeatedly reversed their polarity in the past. Complete magnetic excursions occurred about 10 times in 4.5 million years; the last reversal occurred about 700,000 years ago. Magnetic excursions occur every 10,000–20,000 years when the Earth's magnetic field becomes weak, and the poles may even reverse for a short time.

Venezuela,<sup>34</sup> confirming that the cosmic ray bombardment was most severe in northern latitudes.

Lunar cosmogenic data also show evidence of increased solar cosmic ray activity at or before 20,000 yr B.P.<sup>35,36</sup> although these data are not sensitive to earlier irradiation.

### The effect of a supernova on Earth

Sonett suggests that a single supernova would produce two or three shock waves, an initial forward shock and a pair of reverse shocks from the initial expansion and a reflected wave from the shell boundary of a more ancient supernova.<sup>39,40</sup> Fig. 2 shows that each episode in a series produced a similar amount of atmospheric radiocarbon. The sun lies almost exactly in the center<sup>41</sup> of the Local Bubble, believed to be the result of a past nearby supernova event. A candidate for the reverse shock wave is the supernova remnant North Polar Spur, with an estimated age of 75,000 years and a distance of  $130 \pm 75$  parsecs (424 light years),<sup>42</sup> conveniently located in the north sky from where it would have preferentially irradiated the Northern Hemisphere. Assuming the Taylor flux is average and 1,000 neutrons are produced per erg of gamma-ray energy,<sup>43</sup> the catastrophe would have released about  $10^{16}$  erg/cm<sup>2</sup> ( $2 \times 10^8$  cal/cm<sup>2</sup>), corresponding to a solar flare of  $10^{43}$  ergs or a gamma-flash of  $10^{54}$  ergs from a supernova about 1 parsec away.

The geographical distribution of particle tracks, <sup>235</sup>U depletion, and <sup>239</sup>Pu concentration shown in Fig. 3 are quite consistent, although the particle tracks seem to be confined to a smaller geographic area. They indicate energy released over the northeastern sector of the U.S., with maximum energy at about 43° N, 85° W, the Michigan area of the Great Lakes region.

### A history of suspected cosmic cataclysms over the ages

Wdowczyk and Wolfendale<sup>44</sup> and Zook<sup>36</sup> propose, based on the existing record of solar flare intensities, that solar flares as large as  $3 \times 10^{38}$  ergs should be expected every 100,000 years. Clark et al. estimate that supernovas release  $10^{47}$ – $10^{50}$  ergs within 10 parsecs of Earth every 100 million years.<sup>45</sup> Brackenridge suggests that a supernova impacted the earth in Paleoindian times.<sup>46</sup> Damon et al. report evidence from the <sup>14</sup>C tree ring record that SN1006, which occurred at a distance of 1300 parsecs, produced a neutron shower of  $2 \times 10^8$  n/cm<sup>2</sup>.<sup>47</sup> Castagnoli et al. report evidence of the past six nearby supernovae from the thermoluminescence record of Tyrrhenian sea sediments.<sup>48</sup> Dar et al. suggest that a cosmic ray jet within 1000 parsec would produce  $10^{12}$  muons/cm<sup>2</sup> (greater than  $3 \times 10^9$  eV) and  $10^{10}$  protons and neutrons/cm<sup>2</sup> (greater than  $10^6$  eV) and deposit

over  $10^{12}$  erg/cm<sup>2</sup> in the atmosphere every 100 million years.<sup>49</sup> A cosmic ray jet is also predicted to produce heavy elements via the r-process and could be a source of <sup>235</sup>U enriched up to 60 percent in uranium.

The Paleoindian catastrophe was large by standards of all suspected cosmic occurrences. Normal geomagnetic conditions would focus cosmic rays towards the magnetic poles, concentrating their severity in those regions. However, low magnetic field intensity during a geomagnetic excursion may have allowed excessive cosmic rays to strike northeastern North America. (Whether the geomagnetic excursion admitted cosmic radiation, or the radiation caused the excursion, is uncertain. Given our present state of knowledge, cause and effect in this instance are unclear.) The presence of a nearby small and dense interstellar cloud may explain the origin of the particle bombardment.<sup>50</sup> The size of the initial catastrophe may be too large for a solar flare, but a sufficiently powerful nearby supernova or cosmic ray jet could account for it. It appears that the catastrophe initiated a sequence of events that may have included solar flares, impacts, and secondary cosmic ray bombardments.

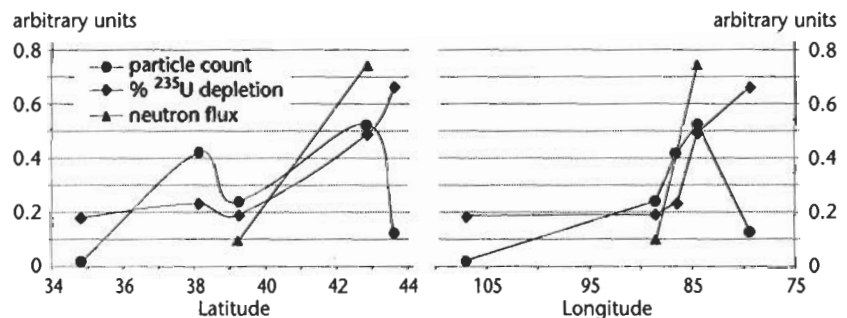
### A devastating effect on Earth

The enormous energy released by the catastrophe at 12,500 yr B.P. could have heated the atmosphere to over 1000°C over Michigan, and the neutron flux at more northern locations would have melted considerable glacial ice. Radiation effects on plants and animals exposed to the cosmic rays would have been lethal, comparable to being irradiated in a 5-megawatt reactor more than 100 seconds.

The overall pattern of the catastrophe matches the pattern of mass extinction before Holocene times. The Western Hemisphere was more affected than the Eastern, North America more than South America, and eastern North America more than western North America.<sup>51,52,53</sup> Extinction in the Great Lakes area was more rapid and pronounced than elsewhere. Larger animals were more affected than smaller ones, a pattern that conforms to the expectation that radiation exposure affects large bodies more than smaller ones.<sup>54,55</sup> Sharp fluctuations of <sup>14</sup>C in the Icelandic marine sediments at each geomagnetic excursion are interesting; because global carbon deposits in the ocean sediments at a rate of only about 0.0005 percent a year, a sudden increase in sediment <sup>14</sup>C may reflect the rapid die-off of organisms that incorporated radiocarbon shortly after bombardment.

Massive radiation would be expected to cause major mutations in plant life. Maize probably evolved by macro-mutation at

**Figure 3. Comparison of relative particle volume, depletion of <sup>235</sup>U, and neutron flux as a function of latitude and longitude. The neutron flux is calculated from the measured <sup>239</sup>Pu activity and <sup>238</sup>U concentration in the chert. The data have been renormalized to a common scale for comparison.**





A shock wave of the magnitude that would be expected from a supernova may have gouged out the Carolina bays, 500,000 depressions spread over an area of 100,000 square miles on the Atlantic coast from North Carolina to Florida. First noted in aerial photographs in the 1930s, they date to Paleoindian or late glacial times.<sup>37,38</sup> At least 16 hypotheses involving terrestrial and extra-terrestrial causes have been postulated to explain their origin. In this mosaic of 1930s aerial photos shot in the vicinity of Myrtle Beach, S.C., the large depression at extreme left measures about a mile along its major axis. It is noteworthy that the elliptical depressions are all oriented with their major axes pointing towards the Great Lakes region.

FROM THE ORIGIN OF THE CAROLINA BAYS, BY DOUGLAS JOHNSON.  
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that time,<sup>55,56</sup> and plant domestication of possibly mutated forms appears worldwide after the Late Glacial period. For example, there was a rapid transition from wild to domesticated grains in the Near East after the catastrophe.<sup>57</sup>

### Implications for future study

Much of what we assume about the Paleoindian period and the peopling of the Americas has been inferred from conventional radiocarbon chronology, which often conflicts with archaeological evidence. This work mandates that conventional radiocarbon dates be reinterpreted in light of hard terrestrial evidence of exposure of the radiocarbon samples to a cosmological catastrophe that affected vast areas of North America and beyond. A nuclear catastrophe can reset a group of unrelated artifacts to a common younger date, creating gaps and false episodes in the fossil record. Geographical variation and complicated overburdens may further confuse the interpretation. Scrutiny of Paleoindian artifacts and the North American paleolandscape, associated stratigraphic sediments, coupled with continued radiological investigations, may provide more evidence for the cosmic catastrophe and new clues to the origin of Paleoindians.

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### Acknowledgments

This paper results from dissertation research that began in 1990, most

recently funded by a National Science Foundation Physics Division, by William Topping. Support of Richard Firestone by the Director, Office of Energy Research, Division of Nuclear Physics, of the Office of High Energy and Nuclear Physics of the U.S. Department of Energy is greatly appreciated. The contributions of particular individuals over the years have been invaluable. Tony Baker, Kurt Carr, Chris Ellis, Mima Kapches, Ronald Leshner, Donald B. Simons, James Taylor, Curtis Tomak, John Tomenchuk, and Henry Wright in particular should be thanked for their contributions of artifacts which provided essential information. Alan Smith contributed important experimental data for this paper. We particularly acknowledge the participation of the Royal Ontario Museum and the Smithsonian Institution. In addition, there have been many invaluable contributions of time, analysis, and commentary by physicists, archaeologists, and geologists from the National Superconducting Cyclotron Laboratory at Michigan State University, Phoenix Memorial Laboratory and the Department of Physics at the University of Michigan, Departments of Anthropology and Geology at Wayne State University, Department of Physics at Washington University in St. Louis, Museum of Anthropology at the University of Michigan, Department of Physics at the University of Arizona, Harvard Cyclotron at Harvard University, Oak Ridge National Laboratory, Los Alamos National Laboratory, Johnson Space Center, the State University of Pennsylvania, Lawrence Livermore National Laboratory, and the Lawrence Berkeley National Laboratory.

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## Anzick Site Skeletons Threatened

*continued from page 3*

have been preserved while scientific techniques for studying them are being improved. Owsley, Lahren, and Hunt conclude the research paper reporting their results with this statement:

As our ability to read these ancient bones increases through advances in osteology, and appreciation of what other areas of science can contribute to multidisciplinary studies of the First Americans, we can only marvel at what else will be learned from the Anzick children in the decades to come.

Rep. Gail Gutsche and other members of the Montana State legislature do not share this optimism about what future studies might tell us about these ancient Montanans; neither do they seem to share an appreciation of the contribution science can make to our understanding of the human past. If Gutsche has her way, the bones of the Anzick children and the entire collection of magnificent stone tools will be given to modern Native Americans for reburial.

Rep. Gutsche and her colleagues have drafted a bill (House Bill 165) that would allow Native Americans to claim human skeletal remains and funerary objects taken from burial sites on state or private land. Gutsche insists the new law is needed in order "to protect the sanctity of graves." She and her supporters want to ensure that human remains "won't be treated like a science project."

The effort to legislate "sanctity" and demean the scientific search for knowledge is becoming frighteningly familiar in this postmodern age. The Native American Graves Protection and Repatriation Act (NAGPRA) is the federal law that inspired the proposed "Montana Repatriation Act," but the Montana law would go further than NAGPRA. The federal law applies only to human remains and funerary objects found on federal or tribal lands or held by institutions receiving federal money. The Montana Repatriation Act will require institutions receiving state funds to surrender human remains and funerary objects to persons or groups able to demonstrate a "cultural affiliation" with those remains. "Cultural affiliation" is defined, for the purposes of this act, as "the existence of a shared group identity

that can be reasonably traced historically or anthropologically or by pre-European contact between a federally recognized or state-recognized Indian tribe, tribally recognized Indian group, or other individual or group and an identifiable earlier tribe, group or individual lineal descendant." This definition is confusingly worded; and unlike NAGPRA, no specific criteria for determining cultural affiliation are defined. Moreover, as we have already seen with NAGPRA, such vague definitions are subject to alternative interpretations. Former Secretary of the Interior Bruce Babbitt declared the 9,000-year-old Kennewick Man skeleton "culturally affiliated" with modern Indian tribes in the Washington State area on the basis of evidence (consisting largely of vague and sometimes inconsistent origin stories) the Society for American Archaeology (SAA) regarded as wholly insufficient. Indeed, the SAA said the claim of cultural affiliation was "inconsistent with the evidence."

One of most profound and disturbing differences between the Montana law and NAGPRA is that Montana's proposed Repatriation Act extends to human remains and funerary objects found on private land or owned by private individuals. The ancient human remains from the Anzick site and the accompanying artifacts are the property of private individuals; the spectacular artifacts are currently on loan to the Montana Historical Society Museum in Helena. If the Montana Repatriation Act becomes law, Native Americans could claim cultural affiliation with those remains and, if the claim were upheld by the state, dispose of them as they saw fit—without compensating the current owners.

Given the antiquity of the Anzick remains and the wealth of information we might someday be able to glean from the bones and tools as new scientific techniques are developed, it would be a tragic loss to make them forever inaccessible to scholars. The Anzick tools are among the crown jewels of the Clovis culture. It would be a criminal disservice to the general public to close this window onto the world of America's first people. Reburying these remains would be like burning both a library and an art museum filled with priceless masterpieces. If the Montana State legislature passes this law, the freedom of scientists to unravel the mysteries of our past will be diminished and the people of Montana—and of the world—may forfeit an irreplaceable part of their heritage. 🐾

## La Plata Conference

*continued from page 1*

ignored by other authorities, was the first theory that took into account archaeological information from South America. Now his ideas, bolstered by new data coming from South America in recent years, truly challenge the Clovis-First model.

Speaking for himself and absent coauthor Gentry Steele, Dr. Bonnichsen discussed alternative routes and means that may have been used by people. "Using small boats along the Pacific Rim of Asia," he argues, the first people could have come to the Americas at the end of the last Ice Age.

### Evidence on thriving cultures in South America in Clovis times

Dr. Gruhn reviewed the peopling of South America, taking into account that by Clovis times (11,000 years ago in North America), major environmental zones in South America were already occupied by people of varied, distinct cultures. It was, after all, the discovery that people displaying regional diversity and a wide array of skills and technologies existed in the Southern Cone at Clovis times that was responsible for the collapse of the Clovis-First model.

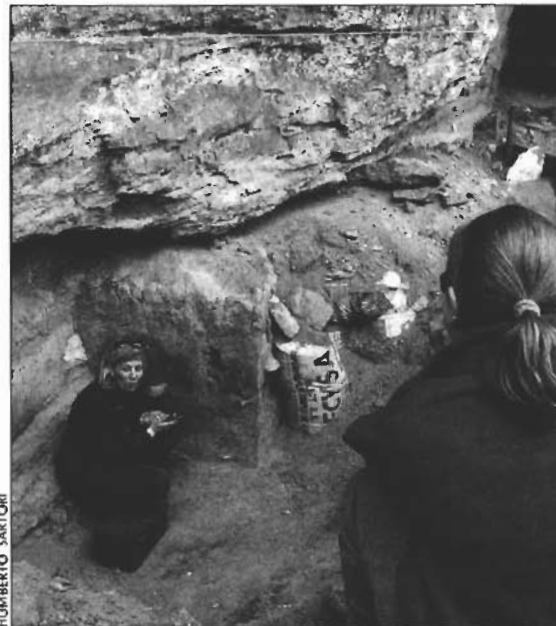
This hypothesis was supported by Cristobal Gnecco and Tom Dillehay. Dr. Gnecco, from Cauca University in Colombia, analyzed agrilocalities in northern South America during the Pleistocene-Holocene transition. Archaeologist Dr. Dillehay of the University of Kentucky, who stunned the academic community during the '80s with the discovery of Monte Verde in Chile, presented solid evidence on social and economic organization types ("proto-households") on the coast of northern Peru.

Gnecco's proposal, supported by Carlos Lopez of Popayan University of Colombia, created a regional model of northern South America, an area previously thought to be a wide savanna that served to filter migrations from north to south. It was, in fact, a rain forest in the late Pleistocene.

From the anthropologist's point of view, Neves, of the University of São Paulo in Brazil, and Pucciarelli, of the

University of La Plata, postulate that the peopling of the whole continent—a complex process that spans more than 10,000 years—can be explained not only by migration, but also by microevolution and adaptation. They conclude that a final migration by Paleoamericans completed the process. The authors are presently analyzing the position in a multi-varied space of ancient populations from Lagoa Santa and Arroyo Seco, whose members clearly deviate from Mongoloid ancestry.

Regional models for other areas of South America were proposed by Nora Flegenheimer of Mar del Plata University, CONICET, Argentina, together with



coauthors Jose Lopez Mazz ("Long-distance Tool Stone Transportation") and Adriana Schmidt and Andre Jacobus ("An Approach about the First Human Occupations along the Atlantic Shoreline in Uruguay").

Laura Miotti of La Plata University, Argentina, presented "South America: A Paradox for Building Images of the Colonization of the New World," based on site functionality in regional mobility systems, differences in the circulation of lithic raw materials, and different taphonomical histories and paleolandscapes during the colonization of the Southern Cone.

Described in oral presentations and in archaeological materials displayed in the exhibition were new sites, including Baño Nuevo and Quereo II (central

Chile); Arroyo Malo (Mendoza); Cerro Tres Tetras, La Maria, and Cueva del Minero (Santa Cruz, Argentina); Paypaso locality; and upper Río Negro and Cabo Polonio (Uruguay). Information about such well-known sites as Los Toldos, Gruta del Indio, Lauricocha, Tres Arroyos, and Quereo was reorganized and updated in the light of new evidence.

Studies of archaeofaunas from Arroyo Seco 2 led Mónica Salemme of Centro Austral de Investigaciones Científicas de CONICET, Ushuaia, Argentina, to change some previous ideas about the relationship between early Pampean peoples and Pleistocene megamammals. Her hypotheses

reinforce the premise that the ancient humans practiced foraging strategies. The First Americans, she contends, were not great killers of megaherbivores, merely successful colonizers.

The presentations drew upon many disciplines—geoarchaeology, paleoclimatology, paleobotany, palynology, vertebrate paleontology, taphonomy, bone modification, lithic technology

**Laura Miotti describes the excavation at Piedra Museo, a rockshelter locality that was occupied in the Pleistocene.**

and functional analysis, rock art, anthropobiological analyses, genetic studies, and chronology—in exploring migrations, routes, and the economic, social, and symbolic use of space and landscape transformations during colonization.

### No total agreement about the peopling of the Americas

Bob Kelly of the University of Wyoming, president of the American Archaeological Society, was the sole defender of the hypothesis of the late entry of humans into the New World. He defended radiocarbon dates that favor the Clovis model, and he rejected theories of the '70s that promoted pre-Clovis peopling of North America. The atmosphere in the audience warmed a bit when Kelly questioned South American radiocarbon dates; Dillehay inquired of Kelly, Why weren't the

wrong dates the North American ones of Clovis age?

After the discussion and subsequent visits to Pleistocene sites in Patagonia, Kelly said he was already rethinking the Clovis phenomenon and its impact on the colonization of South America.

### A look at the South American evidence

Conference participants were treated to a display of archaeological remains from important South American sites dating to the Pleistocene-Holocene transition. It was the first opportunity many colleagues had to view the materials firsthand. It was also an important event for the La Plata Museum, since the exhibition will be open to the general public until April 2001. The museum, which is proud of its ties with Ameghino's ideas and its academic tradition of Quaternary paleontology, had never before hosted an exhibit showing evidence of the first Americans in the farther South Cone.

A 4-day excursion in Patagonia gave scientists and students a look at early archaeological localities in the Santa Cruz province of Patagonia. At Los Tol-

**Archaeologists enjoying the opportunity to inspect rock art up close in Cave 2 at Los Toldos.**

dos, the visitors learned about the occupations found in different caves from one of its researchers, Rafael Paunero.

At Piedra Museo locality, Mónica Salemme and Laura Miotti gave visitors a tour of the rockshelters, including petroglyphs, wall paintings, and a sector of the ongoing excavation. The participants learned details of the stratigraphic profile and heard a detailed history of the landscape from Quaternary geologist Jorge Rabassa.

Rafael Paunero, leading visitors through the caves at La María locality, showed them the spectacular landscape and rock art and discussed the findings from one of the caves. It was formerly thought that La María was first occupied during the early Holocene, but recent excavations in one of the caves have yielded an association of artifacts with extant and extinct vertebrate fauna.

On the last day the assemblage visited Cueva del Minero, now under excavation,

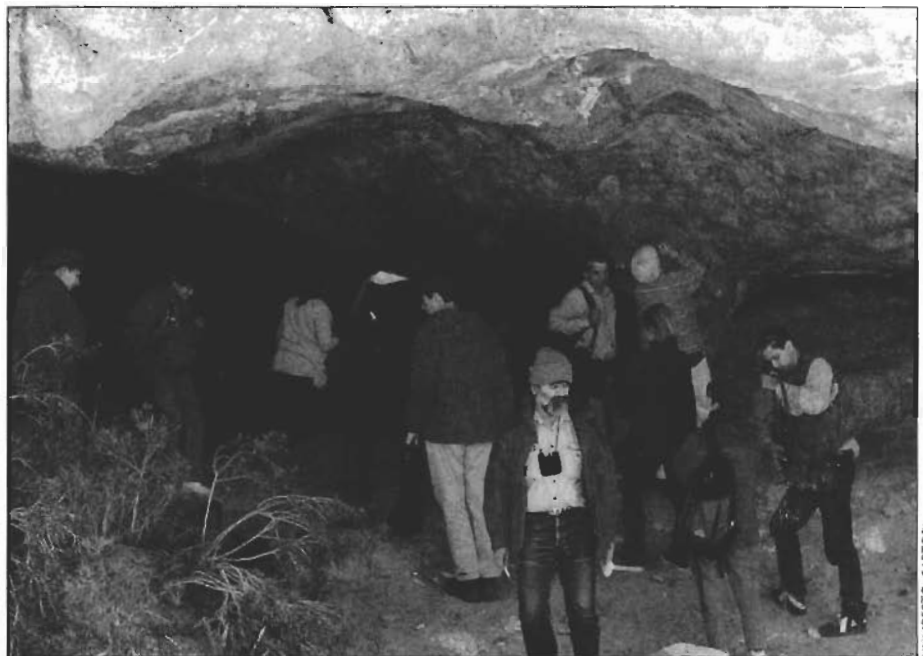
where a short but interesting profile shows an occupation estimated at 11,000 yr B.P. or earlier. Some of the findings from this cave were exhibited at the display during the conference. According to Rafael Paunero, radiocarbon samples are being processed.

### Thanks from the hosts

A remarkably kind and friendly environment characterized the entire meeting. Everybody was enthusiastic and pleased to share evidence from sites and their ideas. Those who brought thought-pro-

leagues are a challenge for the near future.

Thus this international workshop, built with an eye to a multidisciplinary viewpoint, has contributed to a better understanding of the cultural aspects, timing, and environmental conditions surrounding the peopling in South America in the late Pleistocene and early Holocene. A model of the evolution of the anthropological landscape is under construction; the presentations and discussions during the sessions and in the field were very rewarding. They will be useful



HUMBERTO SARTORI

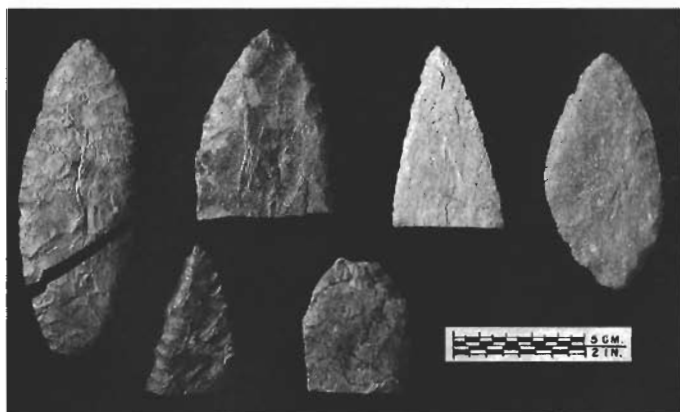
voicing materials to the conference and shared them were of immeasurable help in formulating continental models for the peopling of the Americas, especially for the South American archaeologists.

We detect a happy shift in emphasis in First American studies. The past 50 years have seen a disarray of information and scant communication among groups of South American archaeologists that favored the consolidation of North American models. The dominant paradigm said that the First Americans entered North America through Beringia and, only after traversing the breadth of the Great Plains, passed into South America. Today more and more groups of archaeologists working in South America are demonstrating that the Clovis-First model does not seem to be the only way to explain the peopling of the Americas. Regional models presented by South American col-

leagues in the continuing scientific research, education, and public policy in archaeology, geoarchaeology, paleobotany and palynology, DNA analysis, biological anthropology, and linguistics.

The members of the Organizing Committee of this event are deeply indebted to the following Institutions, which collaborated in different ways to develop this event: INQUA; the faculty of Natural Sciences and La Plata Museum; Wenner Gren Foundation; Universidad Nacional del Comahue; Agencia Nacional de Promoción Científica y Tecnológica; and Pico Truncado and San Julián Counties. Co-organizers Laura Miotti and Mónica Salemme are pleased with the level of the discussions during the meeting and very grateful to all their colleagues who made this a very productive and enjoyable conference. 🍷

—Laura Miotti & Mónica Salemme



Second in a series of articles on Pegi Jodry's research into the Paleoenvironment of the High Plains and Rocky Mountains.

Folsom ultrathin bifaces, knives Jodry believes were designed to thin-cut large quantities of meat for drying. Knife at upper right is from the Lindenmeier site, Colo.; lower right, La Manga site, N.M.; the others, Stewart's Cattle Guard site. Like Folsom points and endscrapers, ultrathins are reduced in size through repeated resharpenings.

marrow processing, and hide tanning." Folsom-age bison cows were about the size of modern adult bison bulls. Meat and hide processing were tasks, she argues, "not to be undertaken by the poorly equipped, either technologically or socially speaking."

**Assembly-line meat processing**

She sees what some call a mass-production atmosphere that placed a premium on efficiency to preserve the meat before it spoiled. At the Cattle Guard site, Folsom people killed 49 bison in the fall. Family groups camped nearby to process meat and hides. That processing almost surely meant drying a huge quantity of meat, which reduces its weight by about 80 percent. Jodry is confident that the need to thin-cut large quantities of meat for drying—quickly—partially explains the design of the delicate ultrathin stone knives. To better understand the process, Jodry's team used replicated ultrathins to cut meat in thin sheets suitable for drying. "The knife's biconcave cross section minimizes drag between the face of the tool

# A Very Delicate Tool for A Very Special Purpose

**T**HE FOLSOM TRADITION is best known by its hallmark projectile points, uniquely designed and beautifully knapped from high-quality, fine-grained lithic materials. Archaeologist Margaret A. Jodry of the Smithsonian Institution Department of Anthropology Paleoindian/Paleoecology program, however, has made extensive analyses of other Folsom tools, notably the ultrathin biface.

**The pinnacle of the knapper's art**

This remarkable knife may be more than 100 mm long, yet measures only 4 to 5 mm at its thickest point. Ultrathins occur in low numbers at Folsom sites, and usually only fragments are recovered. Stewart's Cattle Guard site, for example, yielded 14 fragments representing only 5 ultrathin bifaces. "Fracture is almost unavoidable for thin, brittle stone implements subjected to twisting or flex," Dr. Jodry says.

It takes a highly experienced flintknapper to make a knife 15 times thinner than wide. The question is, Why did Folsom knappers go to so much effort to craft fine knives so thin they could easily break? Their thinness notwithstanding, the knives are apparently designed as long-lived tools capable of repeated resharpening; because of the obvious cost—both in time and skill—of manufacture, Jodry is confident they were important to Folsom communities. Use-wear data, she reports, suggest that ultrathins were hand-held knives used for light butchering and meat cutting. Having a well-designed tool for a labor-intensive task probably made them worth the effort. "This task," she explains, "may have been the thin cutting of meat in preparation for drying."

Jodry reminds us that bison of the terminal Pleistocene, formidable beasts on the hoof, "were probably equally daunting after the kill, lying dead on the grass in numbers upwards of 50 awaiting gutting, dismembering, transport, filleting, drying,

understand the process, Jodry's team used replicated ultrathins to cut meat in thin sheets suitable for drying. "The knife's biconcave cross section minimizes drag between the face of the tool

## Bison aren't what they used to be

The American buffalo, *Bison bison*, is an impressive beast. A bull may stand 6 ft high at the shoulder and weigh upwards of a ton.

It pales beside its giant ancestors, though. Folsom hunters had to contend with *Bison antiquus*. Extrapolating from skeletal remains, Larry Todd at Colorado State University estimates that a large bull stood 7½ ft tall and weighed 2,400 pounds! Its horns were equally daunting, 4½ ft from tip to tip. (The long-horned bison, a rarer species, had a span of 6 ft.)

*B. antiquus* is a hypermorph, the term paleontologists use to identify megafauna that flourished in the Pleistocene—giant beaver, Irish elk with 11-foot antlers, ox-size ground sloths. Why they grew so huge is still debated. Perhaps it was a result of the super-fertile periglacial environment, or a response to the increasing size of predators—saber-tooth cats, dire wolves, and the giant carnivorous bear *Arctodus*.

Folsom peoples surely deserve respect: they killed and butchered *B. antiquus* using only flintknapped tools.



***Bison antiquus*, formidable prey for Folsom hunters**

DRAWING COURTESY OF HISTORIC RESOURCES BRANCH OF MANITOBA CULTURE HERITAGE AND TOURISM.

and the meat," she reports, "and focuses the primary contact at the cutting edge." She adds that the blade "facilitates long, even slicing by means of wrist rather than arm movements." Ultrathin blades are less likely to cut holes in thin sheets of meat than simple unmodified flake knives, which Jodry's team also tested.

A very large bison kill like Cattle Guard undoubtedly encouraged efficient processing, for the amount of meat is staggering. Using data from today's smaller bison, Jodry estimates that if only five adult cows of the Cattle Guard kill were processed for jerky, there would have been 2,750 pounds of fresh meat to dry. The kill apparently was from a cow-calf herd with at least one bull. Most of the bones were disarticulated and cracked, indicating that meat had been stripped from most of the animals and the marrow extracted. Ethnographic and archaeological studies suggest that dried bison meat required a dietary supplement of fat, often processed as pemmican. Jodry argues, however, that Folsom people don't necessarily fit the model of later people who found it necessary to boil bones to extract grease, which they pounded together with dried meat and possibly fruits to make pemmican. The lush forage of the Younger Dryas period likely meant that Folsom-era bison yielded greater amounts of fat in their internal organs than later animals; moreover, their greater skeletal size made larger amounts of marrow available in their limb bones.

### Efficient division of labor

Jodry says cracking bones to recover marrow began at the kill area and continued at every butchering location at Cattle Guard camp. Meaty portions of the front and hind quarters, rib slabs, and the hump were evidently cut away at the kill site and removed to nearby areas for further processing in the camp. Use-wear analysis of associated stone artifacts indicates their use on a variety of materials including hide, bone, wood and other plants. Broken, discarded, and lost tools provide the basis for estimating group composition—probably including no fewer than five households, with multiple generations and both sexes.

Depending on the temperature, bison carcasses would have begun to spoil in a few days, attracting predators and scavengers. Jodry believes the camp was only occupied long enough for the people to feast and socialize, dry some meat, process the hides into rawhide, and repair broken weaponry—perhaps a week or so.

The ultrathin blade, says Jodry, may well have been a "woman's knife," akin to the *ulu* in the North. Although Jodry believes that most members of Folsom societies were able to make many of their own tools and probably maintained and repaired most of them, she allows that some complementary division of labor along age and gender lines might be expected. For instance, cross-cultural studies indicate that adult male hunters, usually responsible for dispatching large and dangerous animals, tended to travel farther afield than others of the group. Jodry expects that Folsom points were items of male hunting gear. Highly skilled clothing manufacture, hide tanning, and mass production of dried meat following large kills, she suggests, may have been overseen by women who also required specialized tools.

From evidence at this hunting camp, Jodry postulates a model for division of labor in which young females and males overlapped in practicing and developing many skills. Repetition in tasks breeds proficiency, and some tasks were likely gendered. She proposes that females may have developed greater economic skills and know-how about processing hides and making clothing as well as assembly-line processing of dried meat; males may have developed


greater skills in hunting large game and making the weapons to do it.

She sees the basic economic unit as an adult female and an adult male "who together produced the social and ritual relations, materials items, subsistence resources, and children that ensured group survival." Further, "the complementary division of socioeconomic responsibilities along the lines of gender and age is believed to have bound female and male roles together in ways that were pervasive and enduring."

Although Stewart's Cattle Guard site yielded relatively few delicate ultrathin bifaces, artifacts classified as endscrapers were recovered, 69 in all. Use-wear analysis indicates that many of these were used to make rawhide; evidence points to a hunt in late summer or early fall, when



Crew member Pete Arena excavates bison bones in activity area at Stewart's Cattle Guard site.

bison hides would have been ideally suited for preparing leather to make containers, tents, ropes, moccasins, and the like. Jodry suspects that people made clothing from the hides of smaller animals like mountain sheep, deer, and elk. Endscrapers recovered from hide-processing locations were much worn and repaired. Though the use of these hides for shelters is conjectural, Jodry believes it likely, especially during cold seasons. She notes that before horses were available to Plains peoples, bison hunters used dogs to transport hide shelters. 

—Don Alan Hall