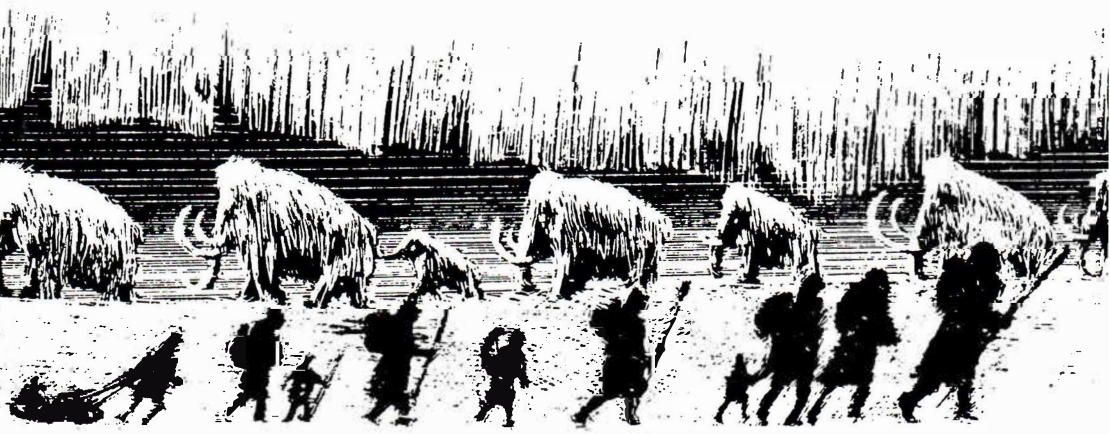
CURRENT RESEARCH IN THE PLEISTOCENE

Volume 5 1988



A Peopling of the Americas Publication

CURRENT RESEARCH IN THE PLEISTOCENE

Volume 5 1988

Editor
Jim I. Mead

Quaternary Studies Program
and
Department of Geology
Northern Arizona University
and the
Museum of Northern Arizona
Flagstaff

A Peopling of the Americas Publication
Center for the Study of Early Man
University of Maine
Orono, Maine

CURRENT RESEARCH IN THE PLEISTOCENE
Volume 5 **1988**

Current Research in the Pleistocene is published annually by the Center for the Study of Early Man. ISSN 8755-898X.

Contents

From the Editor vii
Regional Map xv

Archaeology

Archaeological Investigations at the Brockway Site in Central Maine
R.N. Bartone, D.E. Putnam, and J.B. Petersen 1

The Upper Paleolithic of Northeast Asia and its Relevance to the First Americans: A Personal View
G.A. Clark 3

Early Paleoindian Site Reconnaissance in the Lower Yellowstone Badlands Area, Southern Montana
L.B. Davis, and S.A. Aaberg 7

Paleoindians in Transmontane Southwestern Montana: The Barton Gulch Occupations, Ruby River Drainage
L.B. Davis, S.A. Aaberg, and S.T. Greiser 9

Stewart's Cattle Guard: A Folsom Site in Southcentral Colorado
M.A. Jodry and D.J. Stanford 11

Recent Advances in Pleistocene Archaeology in Northern Japan
C.T. Keally 13

A Possible 18,000 Year Old Hunting and Fishing Camp on the Texas Coastal Plain
C.R. Lewis 15

The Yellow Hawk Site: A Clovis Quarry Workshop in North-Central Texas
R.J. Mallouf 17

A Stratigraphic Sequence at Sharrow Site in Central Maine
J.B. Petersen, T.R. Baker, and M.J. Heckenberger 19

The Drake Clovis Cache
D.J. Stanford and M.A. Jodry 21

Recent Excavations at the Udora Site: A Gainey/Clovis Occupation Site in Southern Ontario
P.L. Storck 23

Lithic Studies

Paleoindian Tradition Fluted Points in Montana
L.B. Davis 25

Paleoindian Obsidian Artifacts from Texas: A Review
T.R. Hester 27

Burins from the Cummins Paleoindian Site, Thunder Bay, Ontario
P.J. Julig 29

The Raw Material Used by the Paleoindians of the Cueva Del Medio, Ultima Esperanza, Chile
H.G. Nami and A.M. Casé 31

Formalized Point Resharpening: A Paleoindian Example from Southern Utah
R.M. Ryan and D.R. Keller 32

The Exploitation Frontier of Hixton Quartzite
K.B. Tankersley 34

Engineering Use-Wear Studies of Early Paleoindian Tools
J. Tomenchuk 35

Secondary Use of a Folsom Point at the Foley Site in Wyoming
A.M. Tratebas 37

Methods

Archaeological Taphomomy
R. Bonnichsen 39

Accelerator 14C Dating of Late Pleistocene Megafauna
T.W. Stafford, Jr. 41

Paleoenvironments: Plants

Preliminary Opal Phytolith Analysis of Modern Analogs from Parklands, Mixed Forests, and Selected
Conifer Stands in Prince Albert National Park, Saskatchewan
S.R. Bozarth 45

Late Wisconsin Macroscopic Remains of Pinyon Pine on the Southern Colorado Plateau, Arizona
S.K. Cinnamon and R.H. Hevly 47

Use of Green Algae Abundances for Augmenting Palynological Interpretation
J.K. Huber 48

Thaw Lake Development and Its Effect on Plant Macrofossil Deposition
J.G. Kidd 50

Use of Algae for Inferring Paleolimnologic Water Quality
B.W. Liukkonen and J.K. Huber 52

Palynological Studies in the Venezuelan Guayana Shield: Preliminary
V. Rull, C. Schubert, and R. Aravena 54

Paleoenvironments: Invertebrates

Pilot Study of Fossil Beetles at the Lubbock Lake Landmark
S. Elias and E. Johnson 57

Mollusks Associated with Articulated Vertebrate Remains from Rancho La Brea
R.V. Lamb and G.T Jefferson 59

Biostratigraphy and Paleoecology of Ostracodes from Pleistocene Lake Manix, Central Mojave Desert California
J.J. Steinmetz and G.T Jefferson 61

Paleoenvironments: Vertebrates

Guanaco Indexes: Their Implications for the Study of Other Ungulates
L.A. Borrero 63

Illinoian Age Fossil Birds of Eastern Nebraska
R.M. Chandler and L.D. Martin 64

The First Individual Skeleton of *Smilodon* from Rancho La Brea
S.M. Cox and G.T. Jefferson 66

Dental Metrics of *Mammuthus* in the Non-Glacial Regions of North America
J.P. Dudley 68

Bone Litter from an Alaskan Pleistocene Carnivore Den
R.D. Guthrie 69

Bears and Man at Porcupine Cave, Western Uinta Mountains, Utah
T.H. Heaton 71

Ontario Fossil Cervids: Neglected Data and Dating
L.J. Jackson and H. McKillop 73

The Distribution of *Mammut Americanum* (Mastodon) and *Mammuthus*
W.C. Johnson and E.J. Kost 75

A New Cavity Biota from Northeastern Utah
M.E. Nelson 77

Late Irvingtonian *Ondatra* in Nebraska: the Identity of the Hay Springs Muskrat
M.R. Voorhies and R.G. Corner 78

Paleoenvironments: Geosciences

Discrepancy in Termination of Pinedale Glaciation, Wind River, Mountains, Colorado
D.E. Dahms 81

Late Glacial Loess Stratigraphy and Archaeology in the Nenana Valley,Central Alaska
J.F. Hoffecker, C.F. Waythomas, and W.R. Powers 83

Dating the Lower Member of the Domebo Formation in Western Oklahoma
J.L. Hofman 86

A Rhythmite Sequence from Glacial Lake Upham, Northeast Minnesota
J.K. Huber, J. Ballantyne, and D. Dorland 88

Dating Late Quaternary Deposits in the Alpine of Western Wyoming by Soil Stratigraphy
W.C. Mahaney 89

Late Quaternary Sedimentation in the Republican River Basin, South-Central Nebraska
C.W. Martin 92

The Seaman Reservior Mammoth Locality (5LR1098) North Fork Cache La Poudre River, Colorado
M. McFaul, C.J. Zier, and E. Anderson 94

A Long Pleistocene Glacial Sequence in Southwestern Montana
M.D. Turner, J.C. Turner, and R. Bonnichsen 96

Implications of the Alluvial Record of the Santa Cruz River to the Discovery of Paleoindian and Early Archaic Sites in the Tucson Basin
M.R. Waters 98

Preliminary Geoarchaeological Studies in Loess of the Lanzhou Area, Gansu Province, People's Republic of China
M.C. Wilson 100

Special Focus: Bone Modification

Aspects of Bone Modification Applied to Time Resolution in the Fossil Record—An Example from the Miocene of Western Nebraska
A.R. Fiorillo 103

Saw Marks on Pleistocene Megafaunal Remains from Alaska
R.D. Guthrie and A. Greenwalt 109

Author Index 113
Information for Contributors 115
General Index 119

From the Editor

The Pleistocene (Quaternary) spans approximately 2 million years of history, a time when climate, geology, plants, and animals (including humans) were changing drastically. A wide variety of research disciplines are used together to reconstruct a "complete" picture of the Quaternary. No single researcher can reasonably master all the necessary disciplines encompassing Quaternary studies, therefore, we all depend on our colleagues. No two researchers will agree 100% with reconstructed environments, timing of events, climatic scenarios, etc.; however, that is the excitement of working with Quaternary deposits. All this results in an elaborate system of collegial trust and independent verification. Often we have seen at national meetings two colleagues arguing until they are blue in the face about two versions of "truth." At best, both are working with but a glimpse of the fossil record.

It really is true that working with the Quaternary is like a detective story, with little bits of information, some even masked to appear otherwise. The best scenario/solution is one that combines lots of independent information. This is where *Current Research in the Pleistocene* enters. I would like *CRP* to be able to play a critical role for you in your grappling for various bits of information and building your reconstruction. There are many, many quarterly journals and books to examine each year. As you well know, this information is at best one year old, if not two. Where can you go to get more information than from a symposium abstract and yet still have it timely? Again, this is where I hope that *CRP* is valuable; the turnaround time is less than a year (due date: 1 February, publication date: hopefully June).

How does the Center produce note-length articles with a quick printing time? Through trust and verification. We all want two things in a publication: 1) fast conveyance of information, and 2) the knowledge that the information is true. I receive approximately 60 to 75 manuscripts each year for *CRP*. I read all of them as does the Center's editorial board. First I look for a Pleistocene theme. Then I look for the correct length (I just cannot accept long articles). Lastly I examine the data; just what is being presented. If I feel that a certain manuscript contains "uncertain" data, I will send it to a colleague or two for independent review. This review period takes time. For the most part, the manuscripts appear true—this is where trust comes in on my part. *CRP* is usually not the final publication of data; it is the first. Detailed explanations, verifications, and a peer review will come with a longer article in another journal at a later date.

Is our lack of peer reviewing 100% of the manuscripts allowing questionable science into the literature? We hope not. We are trying to bridge a gap so that you can obtain current data trends and "honest-to-goodness" science that you can use to formulate your own thoughts. Is this possible, or have we been mistaken? Following are two letters to the editor. Mark A. McConaughy (State Museum of Pennsylvania) is writing to me indicating that four manuscripts by Harry J. Tucci (*CRP* 2:29; *CRP* 3:24-25, 25-26; and *CRP* 4:39-41) contain data of uncertain quality and lack verification. To be fair, I contacted Mr. Tucci to respond to the questions of his character; the following is typed from his handwritten letter. As with all material published in *CRP*, the Center for the Study of Early Man is not taking a stand on the contents. These letters are being presented to you for your information.

Jim I. Mead

Dear Jim:

Harry Tucci (1985, 1986a, 1986b, 1987a) has published several articles in CRP concerning Durham Caves #1 and #2 and the Sycamore site, several possible Paleoindian sites from eastern Pennsylvania. The data presented by Tucci in these articles and in several other papers and manuscripts need to be reexamined and reevaluated in light of recent developments.

I attended the 1987 Middle Atlantic Archaeological Conference, April 3-5, in Lancaster, Pennsylvania. At that meeting, Harry Tucci (1987b) presented a paper based on his investigations of Durham Cave #2 (36Bu196). Tucci (1987b:8) claimed to have seven radiocarbon dates ranging from 34,895±200 yr B.P. to 36,180±225 yr B.P. run on charcoal from Durham Cave #2 by five separate laboratories. These dates were associated with several bone artifacts, Pleistocene fauna, and human burials. Tucci did not provide the names of the radiocarbon labs or laboratory numbers while presenting his paper (or in the distributed copy of his paper). However, while being questioned by the audience after the paper was presented, Tucci claimed Robert Stuckenrath from the Smithsonian, Beta Analytic, and Gary Haynes [sic] from the University of Arizona radiocarbon lab had run three of the dates for him. Tucci also stated that Russell Graham and James Oliver had examined the site and confirmed Tucci's interpretation of the rockshelter as a pre-Clovis occupation.

I was skeptical of Tucci's claims of early dates from Durham Cave #2 and of the classification of the artifacts presented as Paleoindian tools. However, his statement that Graham and Oliver had visited the site, etc., caused me to investigate Tucci's claims more fully. I had worked with Russell Graham and James Oliver while I was employed at the Illinois State Museum from 1980 to 1986 and they had not made any trips known by me to eastern Pennsylvania to view a Paleoindian site over this period. I contacted Graham and Oliver and they confirmed they had never visited Durham Cave and could not support or refute any interpretation about it. They were both upset that anyone should be using their names in an unauthorized manner.

I then tried to check on the 30,000+ yr B.P. radiocarbon dates. None of them were reported in *Radiocarbon*. Robert Stuckenrath and Beta Analytic were contacted to see if they would confirm dates of 30,000+ yr B.P. from Durham Cave. Stuckenrath denied running any dates from the site for Harry Tucci or for anyone else. Beta Analytic would not confirm or deny running a 30,000+ yr B.P. date from Durham Cave, but indicated Harry Tucci had not applied for any radiocarbon assays from their firm. I have enclosed copies of both of these letters. I have not yet contacted *C. Vance* Haynes to find out whether Tucci had the University of Arizona run a date for him.

I reported my findings to Tucci and asked him to provide laboratory numbers and exact information concerning his radiocarbon dates. Tucci then indicated Fred Grady of the Smithsonian had run some of the dates from Durham Cave #2 and that I should contact him. I contacted Grady (pers. comm.) and he denied running any radiocarbon dates from Durham Cave #2. Tucci has not, to date, supplied the requested laboratory numbers for his radiocarbon dates from Durham Cave #2.

While conducting these investigations, I came across several manuscripts about Durham Caves #1 and #2 in the Section of Archaeology, State Museum of Pennsylvania files which Harry Tucci had passed out to various members of the Society for Pennsylvania Archaeology. These manuscripts variously listed James Oliver, Robson Bonnichsen, and Jim I. Mead. as co-authors. One manuscript was a xerox of a published article lacking its published title page but with an additional typed title page as follows; "Cultural Modification of Bone by Harry Tucci, Mary Ann Arelli, Robson Bonnichsen and Jim I. Mead." This article was actually written and published by Bonnichsen and Will (1980). I sent copies of these manuscripts to Bonnichsen, Mead, and Oliver for their comments. All denied having written anything about Durham Caves #1 and #2 and they were not pleased by Tucci's use of their publications without permission or proper citation. Tucci was contacted and asked to retract these manuscripts and to apologize for misuse of Bonnichsen's, Mead's and Oliver's names and publications. He has sent apologies to all of these people (pers. comms. from Bonnichsen, Mead, and Oliver).

Tucci was interviewed and an article titled "Students unearth significant finds in digs at a cave" was published in the Sunday, July 20, 1986, issue of *the Philadelphia Inquirer.* In this article James B. Richardson from Carnegie Museum of Natural History is quoted as saying "The site Durham Cave #2 may hold the answer to the antiquity of man in the eastern portion of the United States." I sent a copy of this article to Richardson. Richardson (pers. comm.) replied that "the article in *the Philadelphia Inquirer* where I am quoted as saying that Tucci's discovery is highly significant is absolutely false. I was never contacted by the newspaper reporter or ever made this statement to Mr. Tucci."

Tucci (1987a:40) recently wrote "Mr. Fred Grady of the Smithsonian Institution conducted investigations at Durham Cave complex recovering 500 bones which represent 60+ species including *many which are now extinct* or at least no longer extant in eastern Pennsylvania" (italics mine). I asked Fred Grady about the materials he recovered during his investigations at Durham Cave #2. Grady (pers. comm.) replied that he had found fragmentary human remains and several worked pieces of bone at Durham Cave #2. However, none of the faunal remains Grady recovered were identified as from extinct Pleistocene animals.

I have been able to confirm the following information concerning Durham Cave #1. Bones from an extinct species, now identified as *Symbos cavifrons,* were recovered from Durham Cave #1 in the late 19th century (Ray 1966; Kurtén and Anderson 1980:76). Extinct peccary was apparently recovered from Durham Cave#1 by Mercer during the late 19th century (Barnsley 1932:40; Grady, pers. comm.). Caribou was also recovered from Durham Cave #1 (Academy of Natural Sciences of Philadelphia collections #ANS-539) and this species no longer is a Pennsylvania resident.

Joseph Leidy, who in 1880 described other bones recovered from Durham Cave #1,also stated that "the Durham cave appears to have since been obliterated in the quarrying of limestone (cited in Ray 1966:1)." Tucci (1986b:25) states that "most of what had been Durham Cave #1 had been quarried away, and the area to the south of Durham Cave #2 had seen a whole mountain, and perhaps part of the cave itself, removed by quarry operations." Tucci (1986b:25-26) then suggests human remains recovered from Durham Cave #2 were somehow associated with the extinct animals from Durham Cave #1 without providing any data to support this assertion. However, based on Tucci's and Leidy's statements, mining has apparently destroyed the Pleistocene fossil bearing strata of Durham Cave #1. There is no direct or demonstrable association between the extinct animals from Durham Cave #1 and any human remains or artifacts discovered at Durham Cave #2. Thus, it is only

Tucci's *belief* that the human remains from Durham Cave #2 are related to the extinct animals recovered from Durham Cave #1 during the 19th century.

Tucci (1986b:25) indicates that Terry Burlingame conducted the "uncontrolled test excavations" at Durham Cave #2 which provided his data. Thomas Waters is also mentioned as one of the Burlingame's crew (Tucci 1986b:25). Burlingame apparently did not keep any notes or other records of his excavations (Tucci 1986b:25). Thus, Burlingame's materials cannot be confidently sorted into items recovered in association with each other let alone attempt to associate them with anything else. Burlingame has moved out of Pennsylvania (Waters, pers. comm.) and I have not been able to contact him concerning his excavations at Durham Cave #2.

Tucci (1987b:8) now indicates that Pleistocene animal remains have been recovered from Durham Cave #2. He reports discovering an "intact living floor at a depth of 3 m below surface of Durham Cave #2 . This living floor was scattered with many faunal remains from extinct Pleistocene mammals, the bone tools discussed above, and well over 200 human bones from a minimum of 10 individuals." He provides a list of 18 extinct and one species, caribou, no longer living in Pennsylvania as coming from Durham Cave (Tucci 1987b:appendix). He does not specify which ones came from Durham Cave #2 (although it is presumed they all did) or Durham Cave #1. Any Pleistocene remains recovered from Durham Cave #2 were identified as such by Tucci (1987b:3) and he should produce them for confirmation of his identifications by trained specialists. Tucci is not a trained vertebrate paleontologist.

Tucci has several bone tools from the site including a fragment of a probable turtle shell rattle and some bone awls. These were recovered by Grady (pers. comm.) and Burlingame (Waters, pers. comm.; Tucci 1987a:40). None of the bone tools or faunal remains Tucci has provided for examination are heavily patinated or otherwise display evidence of great age or antiquity. The bone tools from Durham Cave #2 are all forms recovered from Archaic and Woodland Period sites and are better interpreted as Archaic or Woodland tools, not Paleoindian.

The controversy concerning Tucci's Durham Cave data necessitated a personal visit to examine the condition of the caves. Michael Stewart, from Lewis Berger Associates, and Steve Warfel, Paul Raber, Kurt Carr, and I, from the State Museum of Pennsylvania, visited Durham Caves #1 and #2 on February 19, 1988. Durham Cave #1 currently is an impressive rock shelter (about 160 ft. deep, 55 ft. wide, and 30 ft. high; Reich 1974:13). Unfortunately, it was not open in this fashion in antiquity. The existing "rock shelter" is the rear portion of the third room of a large three-room cave (Barnsley 1932:40; Reich 1974:13). The original cave had a six-foot wide entrance and the rear section of the existing room was under water (Barnsley:1932:40). Mining during the 19th century created Durham Cave #1's current configuration.

Durham Cave #2 has a trap-type entrance, entered from on top of the ridge above and behind (slightly southwest of) Durham Cave #1. Any bone deposits discovered by Tucci near the trap entrance probably were the result of animals falling into the cave, where they died. According to Tom Waters, the fragmentary human remains recovered by Burlingame were found on a shelf "to the left of the trap opening" and were not from any of the main rooms of Durham Cave #2. Leonard Greenfield and Anthony Ranere of Temple University identified the remains of at least three fragmentary skeletons, two adult females and one child circa 3 years old. Ranere (pers. comm.) suggested the partial human skeletons recovered may have eroded into the trap entrance from a prehistoric cemetery located along the ridge top. This certainly is a plausable hypothesis and one that remains to be tested.

There is a side entrance half way up the cliff into Durham Cave #2. However, the modern cliff entrance probably is the result of 19th century mining truncating other rooms, producing the cliff face and forming an entrance. Thus, we cannot confirm if there ever was a prehistoric side entrance to Durham Cave #2.

It currently is difficult to stand up in Durham Cave #2 and there is a lot of rock fall on its floor. The remaining sections of Durham Cave #2 were not mined, but vibrations from blasting, etc. could have caused some of the observed roof fall. Nevertheless, Durham Cave #2 is not likely to have been a habitation site.

Tucci's (1987b:8) living floor at a depth of 3 m from the surface is somewhat of a mystery. We failed to find any evidence of 3 m deep deposits in Durham Cave #2. However, if he is referring to 3 m deep from the top of the trap entrance to the top of the ground in the cave where he found the remains, then his floor is located on an approximate 45 degree slope (see Reich 1974:15 map which coincides with our examination of the cave) down into the first room of Durham Cave #2. We did find red flagging and some nails scattered about this room suggesting Tucci or someone had conducted excavations in this area.

The passage to the existing cliffside entrance extends westward from the main room. It is known as the "bone passage" because the remains of an opossum and a raccoon were found there (Reich 1974:15). It was along this passageway that Grady (pers. comm.) recovered pieces of human bone and faunal remains, none of which were from extinct animals. It is possible that the fragmentary human remains recovered by Grady were washed down into the cave after the ridge was truncated by mining. The ridge top needs to be examined for evidence of a human burial ground. Our examination of the "bone passage" failed to find any evidence of a Pleistocene bone deposit which might have been Tucci's living floor.

We were also not able to locate Tucci's (1986b:26) passageway between Durham Cave #1 and #2. Tucci probably picked up on a reference about Durham Cave #1 by Reich (1974:13) which indicates:

"In the left wall of the remaining room are two short passages. One of them, high on the wall near the entrance, is extremely difficult to reach. This passage pinches out; cold air, however, flows from it, and it may be an impassable connection with Durham Cave 2."

Michael Stewart climbed into this passage and confirmed it pinches out. He did not find any rock fall blocking the passage (Tucci 1986b:26), it naturally pinched out. Air does flow through this passage from somewhere. However, if it does connect to Durham Cave #2, we failed to locate the join during our visit to the caves. Stewart confirmed it is not a traversable passageway even if it did connect the two caves. Thus, no direct associations could ever be postulated between Durham Caves #1 and #2 based on the existence of this passageway.

After visiting Durham Cave #2, I find it difficult to believe that extensive Pleistocene deposits ever existed in this cave. Also, there is little evidence of charring along the roof indicative of prehistoric fires or long-term prehistoric habitation. The human remains recovered by Burlingame and Grady might represent deposits washed off of the ridge top into the cave's two existing entrances. Thus, Tucci must provide detailed plan maps, profiles, etc. of his excavations, produce the Pleistocene faunal remains for examination, and provide lab numbers for his radiocarbon dates before his data from Durham Cave #2 can be accepted as representing pre-Clovis Paleoindian remains.

Tucci (1985, 1986a) has also reported the recovery of four Clovis points and two possible fluted bifaces from the Sycamore site (36BK571), Berks County, Pennsylvania. He has shown various members of the Society for Pennsylvania Archaeology three Clovis points represented as coming from the Sycamore site. These artifacts were photographed (slides currently in my possession) and the specimens were identified by the viewers as casts of points. Bonnichsen (pers. comm.) identified them as casts of points from the Anzick and Vail sites and a site from Ontario excavated by Peter Storck. Tucci was contacted and was requested to produce the genuine Clovis specimens from Sycamore for examination. Tucci has not yet produced any genuine Clovis specimens. Judgement should be reserved concerning the Paleoindian component of the Sycamore site until such time as genuine Clovis points are made available for examination.

In my opinion, Harry Tucci has not provided any solid or convincting evidence for Paleoindian or pre-Clovis occupations from Durham Caves #1 and #2 or the Sycamore site. Based on his tract record, his interpretations of these sites must be viewed with skepticism until such time as unequivocal data are provided.

Sincerely yours,

Mark A. McConaughy, Ph.D.
Associate Curator, Section of Archaeology State Museum of Pennsylvania
Box 1026, Harrisburg, PA 17108-1026

References Cited

Barnsley, E.R. 1932 Durham Cave. In *Pennsylvania Caves*, by Ralph W. Stone, E.R. Barnsley, and W.O. Hickok, 4th, Pennsylvania Geological Survey, Fourth Series, Bulletin G3, Harrisburg.

Bonnichsen, R., and R.T. Will, 1980 Cultural Modification of Bone: the Experimental Approach in Faunal Analysis. In *Osteo-Archaeology: North America*, edited by B.M. Gilbert, pp. 7-30., Modern Printing Company, Laramie, Wyoming.

Kurtén, B., and E. Anderson 1980 *Pleistocene Mammals of North America*. Columbia University Press, New York.

Ray, C.E. 1966 The Identity of *Bison appalachicolus*. *Notulae Naturae* No. 384, pp. 1-7.

Reich, J.R., Jr., 1974 *Caves of Southeastern Pennsylvania*. Pennsyl-Geological Survey, Fourth Series, Harrisburg.

Tucci, H.J. 1985 The Sycamore Site and Its Role in Pennsylvania Prehistory. *Current Research in the Pleistocene* 2:29.

Tucci, H.J. 1986a The Sycamore Site 1985: An Update. *Current Research in the Pleistocene* 3:24.

Tucci, H.J. 1986b Archaeological Investigations of Durham Cave #2. *Current Research in the Pleistocene* 3:25-26.

Tucci, H.J. 1987a Durham Cave, a Pre-Clovis Occupation of Pennsylvania. *Current Research in the Pleistocene* 4:39-41.

Tucci, H.J. 1987b New Evidence for the Pleistocene Peopling of the Middle Atlantic Region. Paper presented at the 1987 Middle Atlantic Archaeological Conference Meeting, April 3-5, 1987, Lancaster, Pennsylvania.

To the Editor:

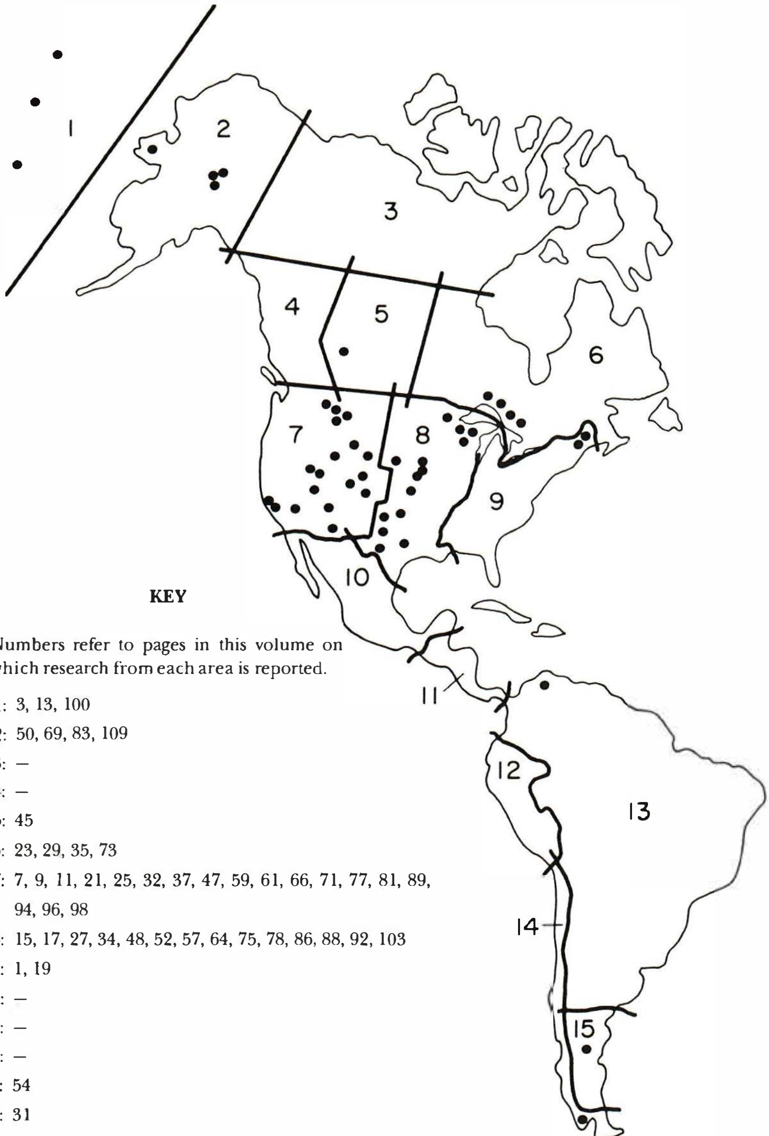
Recent allegations by a crazed colleague of mine have prompted the necessity of this letter. I find it hard to imagine that there exists any more concerns over my Durham Cave research. Many of the problems with this research are discussed at length in a recent commentary written for the *Journal of Middle Atlantic Archaeology*. The reader is referred to that article to answer any questions which may persist.

Concerns regarding 36 BK 571, the Sycamore site, are unfounded in this person's opinion. The Sycamore site was a verifiable upland Paleoindian site by one which the PHMC Pennsylvania Historical and Museum Commission wanted no involvement with. The site's discoverer found the reported fluted points and submitted sketches and photographs to the State Archaeologist's office in the early 80s. This resulted in the designation of the site as 36 BK 571. The casts of the points which seem to be a problem for this crazed person, as far as I know were true and original copies of the actual artifacts. Everything written about 36 BK 571 in previous *CRP Current Research in the Pleistocene* articles was accurate. There are no ^{14}C dates for 36 BK 571, but the presence of the fluted points firmly establishes this as a Paleoindian site. My colleague's allegations come about as a result of his failure to strong-arm the site's discoverer into disavowing the existence of the site. In reality he had no right to even interfere in a person's private life, especially when he was not asked.

I suggest to you that concerns over 36 BK 571 are illogical and concerns of Durham Cave are addressed at length elsewhere. There remains the uncertainty surrounding the Durham Cave ^{14}C dates. I can not state for certain that they exist. I did not contract for their dates and did not analyze them. I merely took it for granted that they were reputable. They were "provided" by a local entrepreneur who seemed to be above reproach. At such time in the future as the dates are verifiable all will be informed at an appropriate public forum. Those further interested in Durham Cave are referred to the following references: Tucci (1988), Grady (1969), Kranzel (1983), Kurtén and Anderson (1980), Ray (1966), and Spiess (1983).

Harry J. Tucci

Regional Index



KEY

Numbers refer to pages in this volume on which research from each area is reported.

1: 3, 13, 100
2: 50, 69, 83, 109
3: –
4: –
5: 45
6: 23, 29, 35, 73
7: 7, 9, 11, 21, 25, 32, 37, 47, 59, 61, 66, 71, 77, 81, 89, 94, 96, 98
8: 15, 17, 27, 34, 48, 52, 57, 64, 75, 78, 86, 88, 92, 103
9: 1, 19
10: –
11: –
12: –
13: 54
14: 31
15: 63

Archaeology

Archaeological Investigations at the Brockway Site in Central Maine

Robert N. Bartone, David E. Putnam, and James B. Petersen

The Brockway site (ME 90-3) is situated on the east bank of the Sebec River in central Maine. The site is located 4 km above the confluence of the Sebec and Piscataquis Rivers, where the ongoing investigation of important deeply stratified archaeological sites is currently being conducted as one aspect of the Piscataquis Archaeological Project (e.g., Petersen 1986; Petersen et al. 1986).

Proposed construction of a wastewater treatment facility that will partially disturb the Brockway site led to a mitigation excavation there in August, 1987. A total area of 67 m^2 was excavated by the Archaeology Research Center of the University of Maine at Farmington. Although the site has long been known to collectors (Macdougall 1984), recent professional testing (Petersen and Bartone 1987) revealed a multicomponent site with evidence of occupation or utilization spanning ca. 9,000-10,000 years. A basal fragment of a parallel flaked, lanceolate projectile point (Figure 1) represents the oldest recognized artifact recovered from the site and is attributable to the late Paleoindian period in Maine (e.g., Doyle et al. 1985). Through on-site excavation and collections documentation, archaeological components attributable to the late Paleoindian period (ca. 10,000-9,000 yr B.P.), possibly the middle Archaic period (ca. 7,500-6,000 yr B.P.), the late Archaic period (ca. 4,500-3,000 yr B.P.), early Woodland (Ceramic) period (ca. 3,000-2,100 yr B.P.), middle Woodland (Ceramic) period (ca. 2,100-1,350 yr B.P.), and late Woodland (Ceramic) period (ca. 1,350-400 yr B.P.) have been identified.

The Ceramic period remains were largely recovered from the plow zone and surface, although at least one in situ feature, feature 7, attributable to this period was identified directly beneath the plow zone in an intact stratum. In situ material included lithic flakes, fire-cracked rocks, and floral and faunal subsistance remains. Numerous lithic tools and ceramic sherds representative of various subdivisions of the Woodland period were recovered or have been identified in collections from the site.

Robert N. Bartone, David E. Putnam, and James B. Petersen, Archaeology Research Center, Department of Social Sciences and Business, University of Maine at Farmington, Farmington, ME 04938.

A large sample of artifacts were recovered from within and beneath the plow zone, including several large stemmed projectile points and unifaces diagnostic of the Atlantic phase of the Susquehanna tradition (ca. 3,800-3,500 yr B.P.). Several intact Archaic period features containing flakes, fire-cracked rocks, red ochre, lithic tools, charcoal, floral remains, and faunal subsistance remains, were also excavated. A radiocarbon assay of 3,740±100 yr B.P. (Beta-19970) was returned from charcoal associated with feature 1. Analogous artifacts are known from various nearby sites, including a similar association dated to 3,650±110 yr B.P. (Beta-20719) at the Sharrow site (ME 90-2D).

Other late Archaic period remains recovered from the Brockway site indicate the presence of an occupation attributable to the Moorehead complex, dated at the nearby Brigham site to 3,900±90 yr. B.P. (Beta-18879). No other in situ evidence of Archaic period components has been recovered to date, although artifacts of greater antiquity have been collected from the eroding riverbank at the site.

A single basal fragment of a parallel flaked, lanceolate projectile point suggests utilization of the site by late Paleoindian period populations. Although excavated from an undated context, this artifact is important evidence of the little-known late Paleoindian populations in Maine and the Northeast in general. A radiocarbon date of 10,290±460 yr B.P. (Beta-7183) from the deepest identified cultural feature at the nearby Brigham site may provide an appropriate date for the Brockway parallel flaked point and similar late Paleoindian tools. Continued documentation of local artifact collections in 1987 revealed the presence and local origin of several other artifacts diagnostic of this little-known period, as well as characteristic unifacial tools believed to be attributable to earlier Paleoindian fluted point assemblages. A minimum total of five probable Paleoindian period sites have thus far been identified within the research area of the Piscataquis Archaeological Project. In addition, at least two other probable Paleoindian period sites were identified during 1987 in the upper portions of the Kennebec River and the Penobscot River drainages during CRM surveys of hydroelectric reservoirs. The significance of these

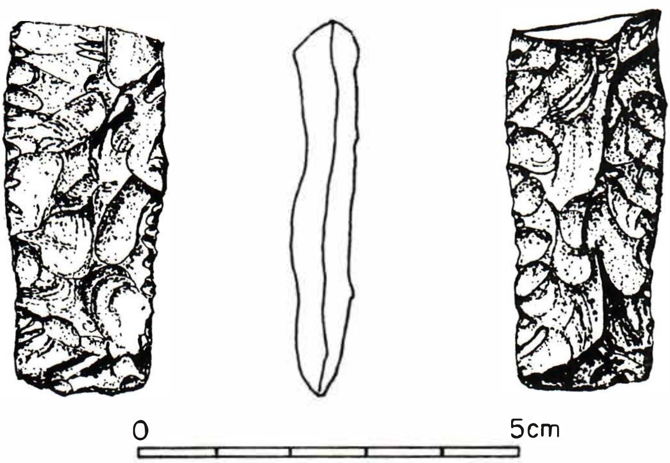


Figure 1. Parallel flaked lanceolate projectile point base from the Brockway site (ME 90-3).

combined finds is that they allow assessment of the antiquity of human utilization of the Piscataquis River drainage and surrounding areas. They also provide some insight into the correlation of cultural, stratigraphic, and environmental data preserved in various settings in the local region. Moreover, the ability to relate cultural samples from shallow contexts to the deeply stratified Rhoda, Derby, Brigham, and Sharrow sites (ME 90-2A, B, C, and D) provides an added dimension to archaeological research in the region.

Analysis of the data from the Brockway site is currently being conducted at the UMF Archaeology Research Center and a complete site report is expected by the fall of 1988. All Brockway research was funded by the town of Milo and the Federal Environmental Protection Agency through the Maine Department of Environmental Protection as mandated CRM research. The investigations at the Brockway site demonstrate the significance of CRM projects as an important facet of regional archaeological research.

References Cited

Doyle, R.A., N.D. Hamilton, J.B. Petersen, and D. Sanger 1985 Late Paleo-Indian Remains from Maine and Their Correlations in Northeastern Prehistory. *Archaeology of Eastern North America* 13:1-34.

Macdougall, W.M. 1984 Milo-Sebec Site. Ms. on file, University of Maine at Farmington, Archaeology Research Center.

Petersen, J.B. 1986 A Late Pleistocene and Holocene Archaeological Sequence in Central Maine. *Current Research in the Pleistocene* 3:16-18.

Petersen, J.B., and R.N. Bartone 1987 *Archaeological Phase I Survey and Phase II Testing of the Proposed Milo Wastewater Treatment Facilities in the Town of Milo, Piscataquis County, Maine.* University of Maine at Farmington, Archaeology Research Center. Submitted to the Town of Milo and A.E. Hodsdon Engineers.

Petersen, J.B., N.D. Hamilton, D.E. Putnam, A.E. Spiess, R. Stuckenrath, C.A. Thayer, and J.A. Wolford 1986 The Piscataquis Archaeological Project: A Late Pleistocene and Holocene Occupational Sequence in Northern New England. *Archaeology of Eastern North America* 14:1-18.

The Upper Paleolithic of Northeast Asia and its Relevance to the First Americans: A Personal View

G.A. Clark

My involvement with the "peopling issue" dates from the early 1980s, and came about as a consequence of interaction with a Korean graduate student, Seonbok Yi, who was interested in the Paleolithic of Northeast Asia. Our collaboration resulted in two papers published in *Current Anthropology*—one that dealt with the Asian Lower Paleolithic (Yi and Clark 1983), and one that was concerned with the so-called "Dyuktai Culture"—essentially the Upper Paleolithic of Northeast Asia (Yi and Clark 1985). I should point out that I am not a specialist on the peopling issue, but have read many, although certainly not all, of the papers that are generally available.

What we tried to do in the Dyuktai paper was to show, first of all, that paradigm differences between Soviet and American workers, and differences in canons of evidence, affected assumptions built into the research designs in the two areas. We

G.A. Clark, Department of Anthropology, Arizona State University, Tempe, AZ 85287.

pointed out that these paradigm differences affected perceptions of relationship in complex and subtle ways, and that differences in notions about the natural and cultural formation processes operative in the archaeological record played a significant role. Many Soviet workers were, and continue to be, inclined to take the archaeological record pretty much at face value. They appear to operate on the assumption that archaeological remains are primarily reflective of cultural entities of some kind (that is, identity-conscious social units). Pattern in stone tool assemblages is explained in cultural terms: the stone tools reflect actual groups of people who shared and participated in lithic manufacturing traditions over time. From an American perspective, there are obvious problems with this approach. Difficulties in comparing assemblages are exacerbated by typological problems. There is a lack of system in the typologies used by Soviet scholars, and an absence of formally defined types. Moreover, they fail to make explicit whether their typologies are oriented toward morphology or technology, a distinction long overlooked by most western scholars as well (but see, e.g., Marks 1983).

The central point of the Dyuktai paper, as it bears on the peopling issue, was simply that there is no good evidence for a sustained human presence in northeast Siberia prior to about 18,000 yr B.P.—thus effectively ruling out early early human claims in the New World. The history of the Dyuktai Culture, a concept created by Mochanov (1969) to describe the Dyuktai Cave material, was reviewed and it was noted that the temporal span assigned to it fluctuated quite a bit, ranging from 35,000+ to about 10,000 yr B.P. in the current version (Mochanov 1980), thus representing the entire period of time normally allocated to the Upper Paleolithic in the western part of the Old World (Mochanov 1969, 1972, 1975, 1980; Mochanov and Fedoseeva 1975). Geochronology (that is, the nature of the non-archaeological matrix in which Dyuktai sites were found) was also examined, along with the radiocarbon evidence, the archaeofaunas and the archaeology itself.

These evaluations showed that at Dyuktai Cave, and only at Dyuktai Cave, is there a reliable stratigraphic sequence free of geological disturbance that has produced an abundant archaeological assemblage with associated fauna. The ^{14}C dates at Dyuktai Cave are consistent, in correct stratigraphic order, and range between 14,000 and 12,000 yr B.P. - in other words, to a very late phase in Mochanov's postulated Dyuktai chronology.

The rest of the claimed Dyuktai sites are open sites situated in the Aldan River valley east of Yakutsk. It is these sites that are taken to represent the early phases of the "culture". An evaluation of the stratigraphy, archaeology, and radiocarbon determinations from Ust'Mil, Ikhine I and II, and Verkhne-Troitskoe showed that these are what Binford (1981) would call palimpsest deposits - that is, terrace sites and sites located in colluvial debris derived from the surrounding valley walls. They consist of more or less vertically concentrated accumulations of artifacts and fauna in alluvial and colluvial sediments. The artifact counts are invariably low—on the order of 6-50 artifacts per site, and these distributed over several meters of vertical distance. Ust'Mil is the oldest, with a major disconformity and inverted dates in the 35,000-12,000 yr B.P. range. Ikhine II has a radiocarbon chronology that ranges between 31,000 and 24,000 yr B.P., again with numerous inverted dates. Verkhne-Troitskoe is the best of the open sites with respect to stratigraphic and ^{14}C integrity. Here the dates are in correct stratigraphic order and range from 18,300 to 14,530 yr B.P.—significantly younger than the other Dyuktai open sites and more in keeping with those from the type site.

Given the geological circumstances and the evidence for cryogenic disturbance and erosion episodes at all the open sites, we looked at factors that could produce a fortuitious association between the artifacts and the material dated. There are two general kinds of geological processes that could have operated in these northerly locales to create situations in which associations between dated materials and archaeological remains could be called into question. They are: (1) translocation of archaeological materials by cryogenic processes, and (2) redeposition of the substance dated—fossil wood. Regarding the first, the Ikhine sites and Ust'Mil have been subjected to erosion, cryoturbation, soil heaving, and have ice-wedge casts in the sections. It is therefore a possibility that the small numbers of artifacts reported in the "early" strata might have been introduced into these levels by geological agencies. The dated material, fossil wood, could also have been dispersed by these same geological agencies. In arctic and subartic environments, wood decays very slowly, especially if buried and frozen. While this preserves it by precluding destruction due to oxidation, moving ground water and bacteria, in an active arctic landscape wood can also be readily eroded from older and redeposited in younger sediments. The most reliable section and the most consistent suite of radiocarbon determinations come from Dyuktai Cave. Here the dates range between 14,000 and 12,000 years ago. We concluded on the basis of these lines of evidence that there was good reason to suspect the antiquity of claimed "early" Dyuktai artifacts from the Aldan sites, and think it very likely that the Dyuktai Culture is in fact no older than about the middle of the Sartan glacial, or ca. 18,000 yr B.P. at the maximum and more likely 14,000-13,000 yr B.P.

If our evaluation of the geoarchaeology of Dyuktai I is credible, it is unlikely that humans were present in northeast Siberia much earlier than about 20,000 years ago. If they were not there, they could not have migrated from there over Beringia to the New World. Beringia was in existence at various points in the late Pleistocene—from about 70,000-50,000 yr B.P. and then again between 25,000 and 12,000 yr B.P. Evidence pertaining to the earlier period is so dubious that it can safely be dismissed. The oldest sites found on fragments of Beringia itself are about 11,000 years old (Hopkins et al. 1982).

In my view, then, the earliest New World data remain equivocal. Dumond's (1980) Paleoarctic Tradition is in the right place (Alaska) at the right time (13,000-11,000 yr B.P.), is associated with the right kind of paleoenvironment, and has the right assemblage composition to be a New World Dyuktai-derived assemblage. As such it might be the earliest recognizable industrial configuration in the New World, but it is only marginally older, if older at all, than Paleoindian materials lumped under the rubric of Clovis (Lewin 1987). While North American Paleoindian sites are well-dated to 12,850-9,700 yr B.P. (the mean of 11 Clovis determinations is 11,581 yr B.P.; that of 10 Folsom dates is 10,339 yr B.P.) and while careful excavations have produced good industrial samples with associated faunas in excellent contexts at these sites, the same cannot be said of New World sites prior to 13,000 yr B.P. There are contextual problems, questions of the authenticity of the artifacts, dating problems (e.g., controversial techniques like AAR, bad sample contexts) associated with all of them, and a lack of agreement amongst archaeologists as to what constitutes reasonable evidence for an ancient human presence in the Americas.

Regarding this last, Griffin (1979) has outlined a set of evidentiary criteria that he believes should be met by archaeological phenomena if they are to be accepted as valid. Griffin's evidentiary standards are: 1) a clearly identifiable geologic context, agreed upon by competent authority, 2) recovery of a sample of material cultural remains adequate to define a society's material culture, 3) floral and faunal data sufficient to define environmental and cultural relationships, 4) human skeletal remains which are concordant with the other classes of data, and 5) radiometric determinations to support geological, cultural, and other conclusions as to the age of the evidence. All of these criteria must be met, all of these issues must be resolved before the credibility of any of the earliest sites will become firmly established. Even so ferocious an advocate of early early Americans as MacNeish (1982) remains unconvinced by much of the pre-13,000 yr B.P. evidence. If there is some reason why the basic evidentiary standards of scientific archaeology should be suspended in the case of the peopling issue, it is not readily apparent to me.

As Owen (1984) has pointed out, if a pre-Clovis occupation is to take its place within the framework of existing Americanist archaeology, then we must find answers to a number of specific questions. If the hemisphere was occupied for more than 12,000 years, where are the cultural remains that worldwide archaeological knowledge would lead us to expect (to wit, stone tool assemblages, skeletal material, living floors, etc.)? Where are the American equivalents of the Old World Middle and Upper Paleolithic sites? Why do we not have any trace of them in deeply stratified cave and rockshelter contexts that contain Paleoindian and Archaic materials as their earliest components? Where are the early Beringian sites? If humans were present earlier than the Pleistocene/Holocene boundary, why did their arrival have no apparent effect on the Pleistocene megafauna? If pre-Clovis hunters were in fact present in the New World, would not scientific archaeology, practiced with great intensity in North America over the past 50 years, have come up with some unequivocal trace of them? It seems to me that Clovis hunter-gatherers were the first Americans. I can only agree with Owen: to date, scientific archaeology has not been able to demonstrate a pre-Clovis occupation in the Americas.

References Cited

Binford, L. 1981 *Bones: Ancient Men and Modern Myths.* Academic Press, New York.

Dumond, D. 1980 The Archaeology of Alaska and the Peopling of the Americas. *Science* 209:984-991.

Griffin, J. 1979 The Origin and Dispersion of American Indians in North America. In *The First Americans: Origins, Affinities and Adaptations,* edited by W. Laughlin and A. Harper, pp. 43-55. Gustav Fisher, New York.

Hopkins, D., J. Matthews, C. Schweger, and S. Young (editors) 1982 *Paleoecology of Beringia.* Academic Press, New York.

Lewin, R. 1987 The First Americans are Getting Younger. *Science* 238:1230-1232.

MacNeish, R. 1982 A Late Commentary of an Early Subject. *Peopling of the New World,* edited by J. Ericso, R.E. Taylor, and R. Berger, pp. 311-316. Ballena Press Anthropological Paper no. 23, Los Altos.

Marks, A. 1983 The Middle-to-Upper Paleolithic Transition in the Levant. *Advances in World Archaeology* 2:51-98.

Mochanov, Y. 1969 The Dyuktai Upper Paleolithic Culture and Certain Aspects of its Genesis (in Russian). *Sovetskava Arkheologiya* 1969 236-239.

Mochanov, Y. 1972 New Data on the Bering Sea Route of the Peopling of America (in Russian). *Sovetskava Etnografiya* 1972:98-101.

Mochanov, Y. 1975 Stratigraphy and Absolute Chronology of the Paleolithic of Northeast Asia (in Russian). In *Yakutiya i ee sosedi v drevnosti,* pp. 9-30. SO AN SSSR, Yakutsk.

Mochanov, Y. 1980 Early Migrations to America in Light of a Study of the Dyuktai Paleolithic Culture in Northeast Asia. In *Early Native Americans,* edited by D. Browman, pp. 119-131. Mouton, The Hague.

Mochanov, Y., and S. Fedoseeva 1975 The Periodization and Absolute Chronology of the Archaeological Sites of Yakutia (in Russian). In *Sootnoshenie drevnikh kul'tur Sibiris kul'turami sopredel'nykh territorii,* pp. 56-78. SO AN SSSR, Novosibirsk.

Owen, R. 1984 The Americas: The Case Against an Ice-Age Human Population. In *The Origins of Modern Humans,* edited by F. Smith, and F. Spencer, pp. 517-564. Alan Liss, New York.

Yi, S. and G. Clark 1983 Observations on the Lower Paleolithic of Northeast Asia. *Current Anthropology* 24:181-202.

Yi, S. and G. Clark 1985 The 'Dyuktai Culture' and New World Origins. *Current Anthropology* 26:1-20.

Early Paleoindian Site Reconnaissance in the Lower Yellowstone Badlands Area, Southwestern Montana

Leslie B. Davis and Stephen A. Aaberg

In May 1987, Montana State University initiated a month-long archaeological site survey of private property in a badlands locality south and east of Glendive, Montana, in the lower Yellowstone River drainage. Attention had been drawn to this area by an unusually large number, variety of types, and high density of Paleoindian projectile points (Clovis, Folsom, Agate Basin, Hell Gap, Alberta, Scottsbluff, and Eden) collected by Oscar T. Lewis. He was a pioneer Montana archaeologist who supervised excavations at Pictograph and Ghost caves and the Hagen site in the Yellowstone drainage during the 1930s. Mr. Lewis and his family homesteaded and ranched in this area in the 1920s and 1930s, during which time he collected artifacts and recorded site locations.

The 1987 survey was designed to re-locate and inspect Paleoindian point localities in order to evaluate possible buried cultural deposits and to determine their research potential, as well as to identify other sites of Paleoindian affiliation. The 6 mi^2 core area that had yielded more than two dozen Paleoindian points was foot surveyed selectively. The study area is bounded west and south by the Cedar Creek anticline, with Glendive Creek to the east and the Yellowstone River to the north. Consisting principally of badlands, the southern portion includes some extensive stable upland prairie surfaces, probably peneplain remnants. Of particular interest is Blue Mountain on the west edge of the project area. Blue Mountain and elevated areas nearby are erosional remnants of the Hell Creek and overlying Fort Union formations. Terrain at lower elevations is unstable and dynamic, where older landforms have been eroded from extremely friable deposits. The Blue Mountain locality has an inordinate number of freshwater springs; it is unclear whether the springs associate with aquifers or are a function of groundwater discharge and drainage factors. Early period points found by Oscar Lewis seem to cluster near areas of high relief, but the relationship between the high-density of Paleoindian sites and local hydrology and geomorphology remains to be determined through site testing and extended reconnaissance in 1988.

Leslie B. Davis and Stephen A. Aaberg, Department of Sociology, Montana State University, Bozeman, MT 59717.

Nearly a dozen Oscar Lewis sites were re-located or visited and surficially appraised for possible buried cultural deposits. Paleosols, weathered mammal bone, fire-broken rock, and lithic detritus were detected at two sites represented by Clovis, Folsom, Agate Basin, Scottsbluff, Alberta, and Eden points in the Lewis collection. Additional early period points were not found during 1987 site visits. However, neither site is eroding and surface visibility is more limited than it was when points were collected decades earlier.

Seven Paleoindian points were recovered from five new sites, including Goshen (probable), Agate Basin, Jimmy Allen (probable), and Eden (types confirmed by S.T. Greiser). Site-bearing landforms at four of the new localities are comprised of colluvium and alluvium, while the fifth is contained in an aeolian unit within which a prominent paleosol developed. This and possibly other paleosols are visible across eroded landforms in the study area; the number and interrelationships of the paleosols remain to be discerned.

The 1987 survey led to the recognition of a major source area for porcellanite, silicified wood, and a platey brown chalcedony near the eastern margin of the project area near Glendive Creek. All Paleoindian points in the 1987 collection were made from these locally available lithic materials.

The 1987 survey confirmed expectations based on examination of the Lewis collection, namely, that this area hosts an unusually high frequency of Paleoindian sites as evidenced by the number of surface-exposed fluted and later dart or spear points collected. Prehistoric occupation of the study area was not limited to the early period, however, as indicated by the Lewis collection which also contains numerous points from all culture complexes and phases characteristic of the Northwestern Plains Region; middle period points predominate, with late period arrow points lightly represented. Fieldwork planned for 1988 includes the testing of three Paleoindian sites, the mapping, description, and dating of paleosols, and the extension of site reconnaissance into contiguous locales where specific geological conditions suggest potential for finding preserved Paleoindian site deposits.

The significance of the Blue Mountain Archaeological Project area was brought to our attention by Joseph L. Cramer (Denver) who sponsored the 1987 fieldwork.

Paleoindians in Transmontane Southwestern Montana: The Barton Gulch Occupations, Ruby River Drainage

Leslie B. Davis, Stephen A. Aaberg, and Sally T. Greiser

Discovered in 1972 by garnet collectors unfamiliar with the area, the Barton Gulch site (24MA171) is stratified and contained within the valley of a perennial stream that flows westward into the Ruby River. The 8.5+ m-thick culture-bearing unit was exposed by erosion subsequent to gold placer mining disturbance of the narrow valley. The stream heads in the Sheep Mountain/Baldy Mountain area of the Greenhorn Range, a western division of the Gravelly Range in the Northern Rocky Mountain Physiographic Province. The Greenhorn Range lies between the Madison and Ruby River drainages in the western reaches of the Missouri watershed. Since the Ruby Basin is typical southwestern Montana intermountain sagebrush-grassland, vegetation at the site is dominated by sagebrush, grasses, and forbs. The site is situated on the north side of the Barton Gulch valley, with a pediment consisting of Pleistocene fill dominating nearby landscapes south and west. Tertiary-age deposits, including a prominent tephra bed, form a ridge that delimits the valley north of the site. Local bedrock is dominated by the Precambrian Cherry Creek series, an interlaminated deposit of gneiss, schist, marble, and quartzite (Mann 1954).

The site's geological section is predominantly colluvium that began accumulating in mid- to late Pleistocene times and continued for a long period until slope stability was reached. Little alluvium is present in the profile. Intervals of surface stability are suggested by multiple buried soils tentatively identified by William P. Eckerle (pers. comm.).

The initially uncertain location of the find was tested on a small scale in 1979, 1980, and 1985 to establish original provenience for the large, thick, lanceolate, indented-base projectile points and graver in the Kalispell artifact collection. Although no points were found, a thin, charcoal-bearing stratum containing fragmentary bones and dentitions of deer (*Odocoileus* sp.) and swift fox (*Vulpes velox*); two quartzite biface blanks/preforms; a quartzite side scraper and an elongate uniface; basalt, quartzite, chert, and obsidian debitage; and a shallowly excavated, basin-shaped, unlined hearth were recorded. The hearth was dated to 8,780±260 yr B.P. (RL-1376) in Locality B; the same occupation in Locality A was dated to 8,740±210 yr B.P. (RL-1377). Larger scale testing of this occupation floor in 1987 yielded another quartzite biface blank/preform, a basalt biface fragment, a reworked basalt point (Figure 1c), a chert end scraper, and numerous flakes of quartzite and basalt, thereby establishing provenience for the 1972 collection.

The terminal occupation of the north Barton Gulch terrace dates to the late middle Prehistoric period (3,880±60 yr B.P. (Beta-23217)), while an occupation 1 m below the late Paleoindian occupation described above dates to 9,410±140 yr B.P. (Beta-23215). Charcoal from still deeper natural and possibly cultural events is being dated by the accelerator method. The depth of the culture-bearing part of this section and span of occupation is comparable to that presented at the deeply

Leslie B. Davis and Stephen A. Aaberg, Department of Sociology, Montana State University, Bozeman, MT 59717.

Sally T. Greiser, Historical Research Associates, Missoula, MT 59807.

stratified Indian Creek site (24BW626) (10,980 to 3,400 yr B.P.) 140 km to the northeast on the east flank of the Elkhorn Mountains adjacent to the Townsend Basin and Missouri River (Davis 1984).

The biface lithic subassemblage from Barton Gulch includes 6 blanks/preforms and 11 lanceolate dart or spear points in varied states of completeness and rework. The unfinished bifaces and one uniface are quartzite in shades of yellow, rose, and gray; the sugary sheen is reminiscent of Spanish Diggings quartzite. However, local sources are predicted from the dominance of quartzite and because quartzite is ordinarily not preferred for manufacturing scraping tools (Greiser and Sheets 1979). The quartzite blanks/preforms appear to have been thermally pretreated: a change in color was exposed by flaking, the exterior yellow contrasting with a pale grey interior.

Only one of the points appears to have retained its original morphology, the others having been broken and modified extensively. This basalt point (Figure 1a) is 145 mm long, 37 mm wide, and weighs 52.9 g. It is lanceolate, lenticular in cross section, and widest at body midpoint, with transverse-parallel flaking similar to that noted for Jones-Miller Hell Gap points (Stanford 1974, 1975) and a concave base formed using a "pseudo-fluting" technique. This point lacks basal and marginal grinding, but the others have heavily ground lower lateral and basal edges. The basal configuration is a rounded basal concavity with relatively wide, rounded basal corners, or ears. The ears range in width in proportion to the depth of the basal concavity, i.e., the deeper the concavity, the narrower the ears.

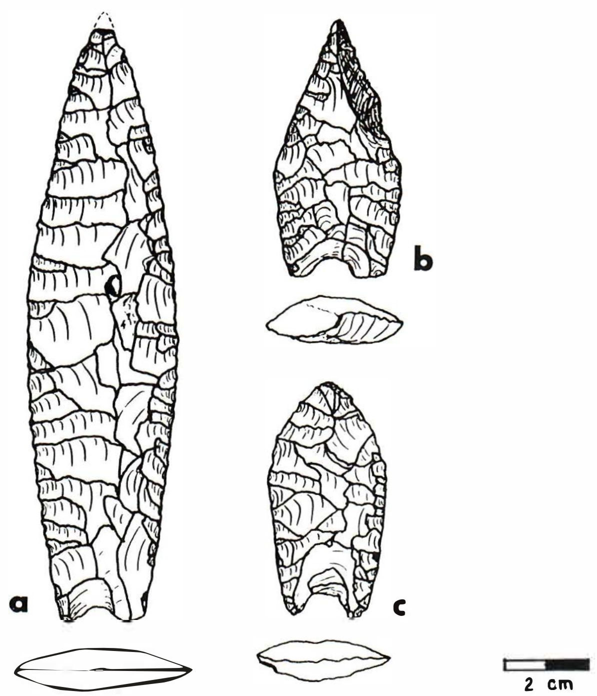


Figure 1. Projectile points from the 8,780 yr B.P. Paleoindian occupation at Barton Gulch.

Given the dominance of reworked points in this late Paleoindian occupation, it is interpreted as principally a retooling campsite, supported by local lithic and food procurement and processing activities. Most of the points were discarded, effete specimens (Figure 1b, c) such as, for example, that recorded at the Jurgens Paleoindian site in Colorado (Wheat 1979).

Fieldwork in 1988 will significantly increase the surface area and archaeological sample from the subject Paleoindian occupation, isolate and extensively sample underlying Paleoindian occupations, and initiate multidisciplinary paleoenvironmental studies in anticipation of a large scale, long-term investigation.

We are grateful to property owner Harold Kelly of Alder, MT for permitting continuing investigations at the Barton Gulch site; to Lorraine Hardinger and Vernon Schmid of Kalispell, MT for loaning their artifact collection for study; to Ruthann Knudson for site referral and Tom Roll for ground truthing and cooperation that made this research project possible; to the Museum of the Rockies for funding initial radiocarbon dating in 1979-1980; and to Joseph L. Cramer of Denver, CO for sponsoring 1987 excavation.

References Cited

Davis, L.B. 1984 Late Pleistocene to Mid-Holocene Adaptations at Indian Creek, West-Central Montana. *Current Research* 1:9-10.

Greiser, S.T., and P.D. Sheets 1979 Raw Materials as a Functional Variable in Use-Wear Studies. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 289-296. Academic Press, New York.

Mann, J.A. 1954 Geology of Part of the Gravelly Range, Montana. *Yellowstone-Bighorn Research Association Project*, Contribution 190.

Stanford, D.J. 1974 Preliminary Report of the Excavation of the Jones-Miller Hell Gap Site, Yuma County, Colorado. *Southwestern Lore* 40:29-36.

Stanford, D.J. 1975 The 1975 Excavations at the Jones-Miller Site, Yuma County, Colorado. *Southwestern Lore* 41:34-38.

Wheat, J.B. 1979 The Jurgens Site. *Plains Anthropologist*, Memoir 15.

Stewart's Cattle Guard: A Folsom Site in Southcentral Colorado

Margaret A. Jodry and Dennis J. Stanford

Ongoing research at Stewart's Cattle Guard site, located in an intermontane basin of the Rocky Mountains, provides additional information regarding Folsom site structure and bison butchering. The site lies amidst a vast sea of undulating sand dunes located along the west flank of the Sangre de Cristo Mountains in the San Luis Valley, Colorado. The area is situated within an internally drained, hydrologic basin that was dotted with springs, small interdunal ponds, and large, interconnected lakes and marshes during the early Holocene.

Aeolian sands, derived from the Rio Grande's alluvial fan, buried the Folsom material. The site was discovered in a blowout in the 1970s after wind erosion

Margaret A. Jodry and Dennis J. Stanford, Department of Anthropology, Smithsonian Institution, MNH 304, Washington, D.C. 20560.

exposed a lithic and bone scatter. Testing revealed a shallowly buried bison bone level associated with Folsom artifacts and, to date, a contiguous block measuring 740 m^2 has been excavated. Analyses are completed for 393 bison bones and nearly 11,900 lithic specimens recovered from approximately one-third of the total area excavated (Jodry 1987).

The site functioned as a residential camp(s) occupied in conjunction with the butchering of a minimum of eight bison. Innominates, vertebrae, and crania are under-represented and the assemblage appears to have been transported to the camp from a nearby kill. The killsite has not been located and the exact hunting strategy is uncertain. The majority of the skeletal elements were disarticulated and the long bones were fractured during marrow recovery. Evidence of bipolar impact to several humeri suggests that these specimens were resting on anvils when broken. Six combination hammerstone/anvil tools were recovered in association with the broken bones. No fragmentation suggestive of additional processing for bone grease is evident.

The analyzed lithic assemblage includes 55 Folsom points and fragments, 22 preforms, 14 endscrapers, 11 gravers, 17 composite unifacial tools, 44 uniface fragments, 2 sandstone abraders, 18 pieces of red pigment, 135 channel flakes, 75 utilized flakes, and 11,509 unmodified flakes. Raw materials from source areas to the east of the Rocky Mountain Front Range in central Colorado, the Chuska Mountains in northwestern New Mexico, and the Canadian River Valley in the Texas Panhandle are represented. The initial reduction evidently occurred at the quarries and flake blanks and/or bifaces were brought to Stewart's Cattle Guard site

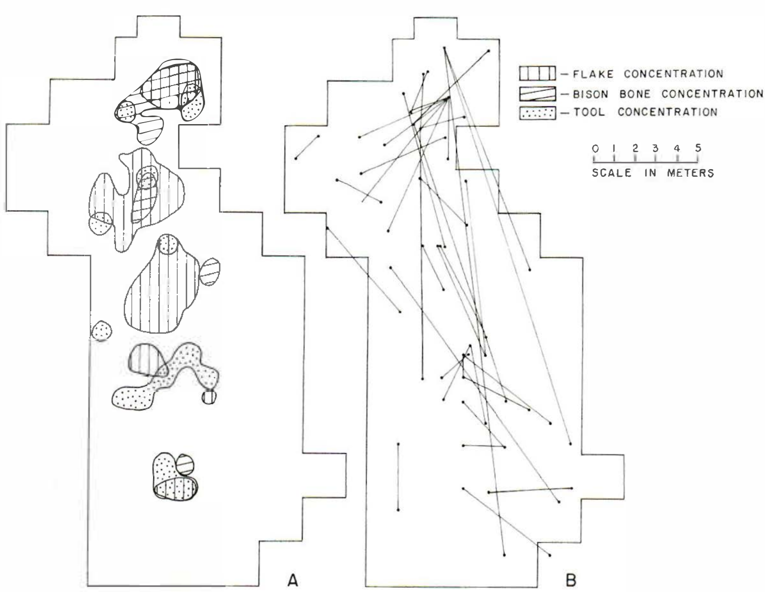


Figure 1. Horizontal distribution of cultural material concentrations (A); Horizontal distribution of conjoined lithics (B).

where further reduction accompanied tool manufacture and maintenance. Much of the chipped stone debris results from projectile point production and a minimum of 28 Folsom points were completed at the site. The general absence of patination and sand abrasion indicates that the lithic assemblage was rapidly buried.

Five concentrations of cultural material, including butchered bone, stone tools, and manufacturing debris, were uncovered in an area measuring roughly 10 m × 28 m (Figure 1a). The distance from the center of one cluster to the center of the next is approximately 4.5 m, exhibiting rather even spacing. Clusters of calcined bone fragments and burned lithics occur in the concentrations and strongly suggest the former presence of hearths. The current working hypothesis regarding the site's structure envisioned hearths as focal points around which many of the camp activities were undertaken and near which archaeologically visible concentrations of debris accumulated (see Binford 1983; O'Connell 1987; Yellen 1977).

Conjoined fragments of broken and rejuvenated stone tools interrelate the artifact concentrations (Figure 1b). An analysis of the nature and distribution of the refits suggests the possible contemporaneity of these concentrations. The data thus far analyzed suggests that Stewart's Cattle Guard site may represent the remains of a single, temporary campsite associated with a small bison kill event. If continued analysis demonstrates the likelihood that multiple Folsom occupations are represented, then the redundant content of and spacing between the concentrations seems to suggest that the site was used in similar ways from one episode of use to the next.

References Cited

Binford, L.R. 1983 *In Pursuit of the Past: Decoding the Archaeological Record.* Academic Press, New York.

Jodry, M.A. 1987 *Stewart's Cattle Guard Site: A Folsom Site in Southern Colorado, A Report of the 1981 and 1983 Field Seasons.* Unpublished Master's thesis, Department of Anthropology, University of Texas at Austin.

O'Connell, J.F. 1987 Alyawara Site Structure and its Archaeological Implications. *American Antiquity* 27:587-589.

Yellen, J.E. 1977 *Ethnoarchaeology: Archaeological Approaches to the Present.* Academic Press, New York.

Recent Advances in Pleistocene Archaeology in Northern Japan

Charles T. Keally

The past 10 years have seen notable increases in excavation work and publication, and consequent improvements in chronological studies in northern Japan, specifically Tohoku and Hokkaido. Excavations of at least 20 major Pleistocene sites have been fully published in the past 5 years alone. These excavations unearthed from 400 to 8,000 m^2 each, and recovered between 2,000 and 10,000 lithic artifacts. The details of the regional cultural sequences and their dating are now much clearer than just a few years ago, but many problems remain.

Charles T. Keally, Sophia University, 4 Yonban-cho, Chiyoda-ku, Tokyo 102, Japan.

Unfortunately, most sites in northern Japan are unstratified, either apparently single occupations or mixed deposits, and the strata are relatively thin. Few sites contain inter-regionally comparable geological strata or key beds. And chronometric dates (radiocarbon, fission-track, and obsidian hydration) are almost entirely from sites in Hokkaido and often give conflicting ages for the same stratum.

At present there still are no widely accepted sites in Tohoku or Hokkaido believed to be older than 30,000 years, so-called "Early Palaeolithic" sites. In fact, sites predating 24,000 yr B.P. are lacking in both regions, with the possible exception of a few in Miyagi prefecture (Oda and Keally 1979, 1986).

In Hokkaido, according to the chronological scheme elaborated by Chiba (1985a, 1985b, 1985c), the oldest securely dated assemblages of human origin are between 19,000 and 24,000 years old. These lack the blade technique. But assemblages between 18,000 and 19,000 yr B.P. are characterized by points and blade-flakes, and those between 15,000 and 18,000 yr B.P. are dominated by tools made on blades. These latter parallel the backed-blade tools that are abundant in sites in Tohoku and regions farther to the south. Some of these early sites in Hokkaido are stratified, but sites younger than these are usually unstratified or mixed (Chiba 1985c). The microcore-microblade complex in Hokkaido seems to evolve gradually between 15,000 and 10,000 yr B.P., a comparatively long time. Chiba (1985c) feels the Togeshita type cores are the oldest in the sequence, followed by the Sakkotsu and Shirataki types, and these followed by the Rankoshi and Oshorokko type cores. He assigns the Araya type burin to the early stage of microcore development, the Horoka type core (or burin) to the middle stage, and the oldest stemmed points to the late stage. Stemmed points, especially the distinctive Tachikawa point, mark the final phase of preceramic cultural evolution in Chiba's scheme. These are found in sites 9,000 to 10,000 yr B.P., contemporary with similar forms found in sites in the lower Amur River valley. Blade-arrow points are distinctive of assemblages, in Hokkaido and on the continent, transitional from the preceramic to the ceramic stages.

Most of the newly published assemblages from Hokkaido are microlithic, often containing several supposedly sequent microcore types, and some of their dates conflict with Chiba's chronology. Several olivine and amber beads and pendents, associated with pits and probably indicating burials, have been reported at the 11,300-11,500 yr B.P. Yunosato 4 site (Hata 1985) and the nearby, roughly contemporary Pirika site (Hokkaido Maizo Bunkazai Centa 1984).

In Tohoku, the cultural sequence closely parallels the stratigraphically established and well-dated sequence of South Kanto and easily fits the chronology proposed by Oda and Keally (1979). Only a few sites in Tohoku have yielded assemblages of amorphous flakes, blade-flakes and ovoid ax-like tools, or backed knife-like tools on short, wide flakes, which are diagnostic of 16,000-30,000 yr B.P. assemblages in South Kanto. In contrast, assemblages dominated by beautifully symmetrical backed knife-shaped tools made on blades are abundant in Tohoku and are typologically extremely close to the equally abundant 13,000-16,000 yr B.P. assemblages in South Kanto. The slender Sugikubo and the roundish Higashiyama type knife-like tools seem to be regional variants mostly found in sites on the Sea of Japan side of Tohoku. The succeeding microlithic assemblages in Tohoku are much less common and probably date roughly 12,000-13,000 yr B.P., as in South Kanto. On the other hand, quite a few sites have yielded large bifacial foliate points which are very much like those that are characteristic of 10,000-12,000 yr B.P. assemblages in South Kanto, where they sometimes are associated with very early pottery.

Most of the Tohoku sites lack radiometric dates, most are unstratified, and some seem to be mixed. Consequently, this regional chronology can be worked out only by typological comparison to the South Kanto materials. Further, the apparently older assemblages in Tohoku are invariably small, making them extremely difficult to assign to a chronological position solely on the basis of artifact typology. The abundance of backed knife-shaped tool assemblages in Tohoku, compared to Hokkaido, and the probably longer duration and greater number of microlithic assemblages in Hokkaido are notable contrasts between these two northern Japanese regions.

References Cited

Chiba, E. 1985a Nippon no Kyusekki, Dai-ikkai, Hokkaido, 1 (Japanese Palaeolithic Stone Tools, Part 1, Hokkaido, Part 1). *Kokogaku Janaru* (Archaeological Journal) 245:20-25.

Chiba, E. 1985b Nippon no Kyusekki, Dai-nikai, Hokkaido, 2 (Japanese Palaeolithic Stone Tools, Part 2, Hokkaido, Part 2). *Kokogaku Janaru* (Archaeological Journal) 248:20-26.

Chiba, E. 1985c Nippon no Kyusekki, Dai-sankai, Hokkaido, 3 (Japanese Palaeolithic Stone Tools, Part 3, Hokkaido, Part 3). *Kokogaku Janaru* (Archaeological Journal) 249:28-31.

Hata, H. (editor) 1985 *Yunosato Isekiqun* (The Yunosato Site Group). Hokkaido Maizo Bunkazai Centa (Hokkaido Buried Cultural Resources Center), Sapporo.

Hokkaido Maizo Bunkazai Centa 1984 Showa 58 Nendo Hakkutsu Chosa no Seika kara (Results of Excavations in Fiscal Year 1983). *Kokogaku Journal* 230:18-24.

Oda, S., and C.T. Keally 1979 *Japanese Paleolithic Cultural Chronology*. Privately published monograph.

Oda, S., and C.T. Keally 1986 A Critical Look at the Palaeolithic and "Lower Palaeolithic" Research in Miyagi Prefecture, Japan. *Jinruigaku Zasshi* (Journal of the Anthropological Society of Nippon) 94:325-361.

A Possible 18,000-Year-Old Hunting and Fishing Camp on the Texas Coastal Plain

C.R. Lewis

Erosion in the bank of Petronila Creek in southern Texas has exposed a thin (25 cm) sand layer overlain by 5 m of stratified sandy clay. The sand layer contains a dense deposit of bones. Partial faunal identification includes mammoth (*Mammuthus columbi*), ground sloth, camel (*Camelops* sp.), horse (*Equus* sp.), peccary (*Platygonus* sp.), antelope (*Breameryx* sp.), coyote (*Canis latrans*), prairie dog (*Cynomys* sp.), packrat (*Neotoma* sp.), grasshopper mouse (*Onychomys* sp.), alligator (*Alligator mississippienisis*), turtle, snake, lizard, amphibian, gar (*Lepisosteus* sp.), catfish (*Ictalurus* sp.), and other fish. Over 10,000 bones and bone fragments have been removed from 5 m^2 ranging in size from an intact mammoth femur to objects recovered on 1/16″ mesh screen.

C.R. Lewis, FCB #112, Corpus Christi, TX 78477.

The bone bed appears to be a primary deposit. There is no sorting by size, no stream-transport rounding of sharp fragments, large bones are crushed and friable yet intact, multiple skeletal elements of individual animals appear to be represented, and mixing within the sand is not uniform (a 10 cm layer is greatly enriched in bones and the horizontal distribution is patchy).

There is nothing to indicate that the bones are in some kind of natural trap. Caves, fissures, sinkholes and the like do not exist in this area; boggy ground is ruled out by the thinness of the bone layer and the clean sand matrix; and, in any event, it seems unlikely that a natural trap would ensnare such diverse fauna.

The deposit appears to have been formed on a sand bar beside a large slow-flowing river. The characteristics of the bone deposit are consistent with accumulation by a predator. Unless a variety of predators were involved, man alone is capable of capturing the range of animals represented.

Direct evidence of human involvement is given by cut marked bones and by an apparent tool-making industry based on mammoth molar teeth. One intact molar, five fist-size chunks, and one smaller piece all exhibit deliberate modification and/or evidence of use. This represents 100% of the mammoth molar sample; no unmodified specimens have been found. Hundreds of molar flakes, chips, and pieces seem to be waste from manufacture of tools. The putative tools appear to be abraders, grinders, and pounders. The intact molar has wear along one edge that has removed the enamel and polished and striated the dentine in nine of the plates. One molar chunk appears to have been used as a grinder; wear on the side of the chunk (not the chewing surface) has produced a slightly convex surface (at least 1 cm of material has been worn away) on which the exposed edges of the enamel layers exhibit a sandpapered texture and the cement is worn below the level of the enamel and highly polished. The layers of dentine, enclosed by loops of enamel, are worn level with the enamel. This type of wear would result if the molar chunk were used as the mano in a mano-metate system. One molar chunk has a deep crescent-shaped multiple-furrowed gouge 4 cm long on a surface that would be in the interior of an intact tooth, and polish on other surfaces. Three other chunks have extensive polish on surfaces normally in the interior of the tooth and a final chunk is simply heavily battered on all surfaces, yet portions of the chewing surface are still intact and absolutely pristine. The action of wind, water or ice would not be expected to batter 95% of the surface and leave 5% untouched. Finally, the reduction of mammoth molars into fist-size chunks is itself suggestive; these teeth are exceedingly durable and are commonly found intact in secondary deposits in gravel beds when everything else of the skeleton is gone.

Cut marks on bones are of the sort that are difficult to produce by natural elements, gnawing, or trampling. They include such features as the apparently deliberate removal of a buttress on the inner surface of a turtle shell, perhaps to facilitate its use as a container.

Lithic material is represented by a few small (1 cm) flakes and a few marble-size rounded pebbles that seem out of place in the gravel-free sediments. This part of Texas is poor in usable stone.

The contained organic material in the clay layer over the bone deposit has been dated at 16,880±380 yr B.P. (Tx-5373). Bone from the deposit is dated at 18,180±330 yr B.P. (Tx-5835); (apatite fraction, collagen is no longer present). The site is designated 41 NU 246.

The Yellow Hawk Site: A Clovis Quarry Workshop in North-Central Texas

Robert J. Mallouf

The Yellow Hawk site (41TA148) is located on the crest of the Callahan Divide, a linear ridge-like outlier of the Edwards Plateau in north-central Texas. Rising up to 200 m above the surrounding plains, the erosionally dissected, flat-to-undulating surface of the divide is up to 30 km in width. The divide serves as the headwaters for numerous local streams and was a major source of high-quality Edwards chert for stone toolmaking through time. Relict hydrologic patterns suggest the likelihood there of a complex network of interconnected ponds and marshes at the end of the Pleistocene.

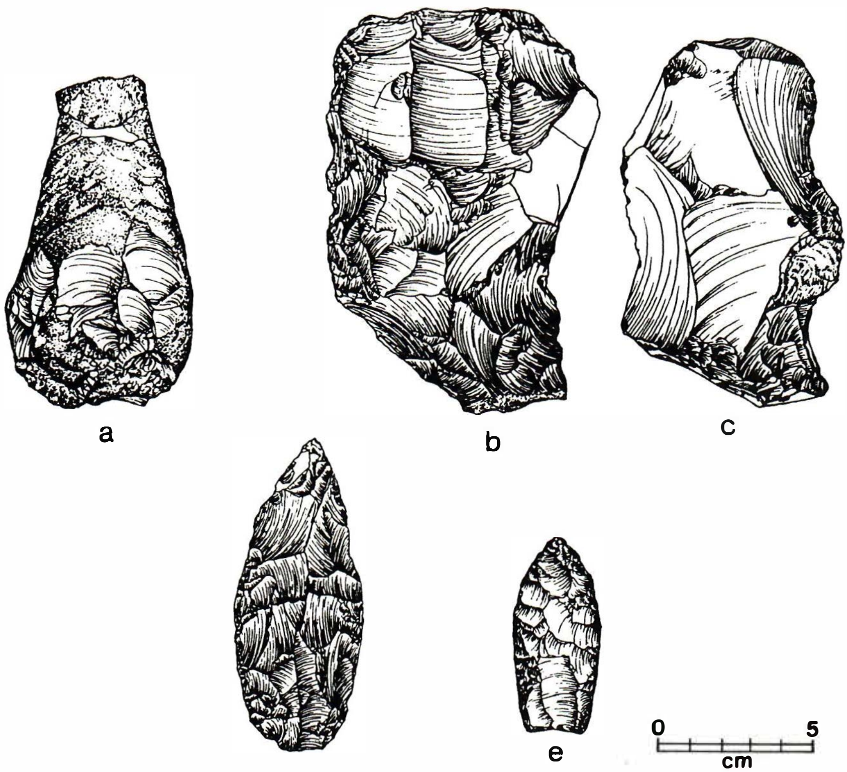


Figure 1. Key elements of the Clovis manufacturing sequence at the Yellow Hawk site include: a, chert nodule hammerstone; b-c, examples of large blade-flakes; d, convex-pointed bifacial preform; e, refurbished Clovis point.

Robert J. Mallouf, Office of the State Archeologist, Texas Historical Commission, P.O. Box 12276, Austin, TX 78711.

Recent construction of a stock pond near the headwater of an arroyo resulted in the partial exposure of a lithic workshop of inferred Clovis affiliation. The site was reported to the Office of the State Archeologist in 1986 by Roger Carter, a local resident. During pond construction, the slopes of the arroyo were beveled with heavy machinery. Subsequent rainfall and fluctuating water levels exposed the in situ workshop feature consisting of blocky core fragments, large blade-flakes, a few true blades, a chert cobble hammerstone, a large pointed-ovate biface, and miscellaneous flake and chip debitage. A complete Clovis projectile point (Figure 1) was exposed 7.5 m from the debitage cluster at the same elevation as the feature and at the same location relative to the arroyo. Prior to construction both the feature and the point were deeply buried in a stable matrix of dense, limestone-derived clays and narrow limestone ledges, a factor that supports their association.

Association of the Clovis point and the feature is also supported by analysis. The point, like the feature debitage, is unpatinated and exhibits a surface sheen identical to that of the workshop specimens. Also, the Clovis point is manufactured from a raw material nearly identical to that of the feature debitage. The likelihood that a Clovis knapper produced the workshop feature is further reinforced through comparison of feature specimens with debitage resulting from modern replication of Clovis points (Callahan 1979).

Preliminary findings suggest that the Clovis knapper responsible for the workshop feature was using the chert hammerstone to reduce blocky cores through direct percussion into large, flat blade-flakes. Multidirectional flake removals on the dorsal faces of the large blade-flakes suggest that the manufacturing process was surprisingly unsystematic. A few large removals appear to have been made to rejuvenate the core. Suitable blade-flakes would in turn have been made into points and other tools. The pointed-ovate biface (Figure 1) found in direct association with the feature appears to represent a rejected projectile point preform. Key elements of the manufacturing process at the site are provided in Figure 1.

Ed Aiken is gratefully acknowledged for the artifact drawings.

References Cited

Callahan, E. 1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flintknappers and Lithic Analysts. *Archaeology of Eastern North America* 7:1-180.

A Stratigraphic Sequence at the Sharrow Site in Central Maine

James B. Petersen, Thomas R. Baker, and Michael J. Heckenberger

Research of the Piscataquis Archaeological Project included excavation of a stratigraphic trench at the Sharrow site (ME 90-2D) in 1987, along with other excavations, collections analyses, and radiocarbon dating of select cultural features. The 1987 trench at the Sharrow site, 8 m × 1 m in size, reached a depth of about 3.0 m, and further revealed the deep, well-stratified nature of the cultural deposits (Petersen and Putnam 1987a). This cultural sequence, when taken in conjunction with ongoing analyses of artifact, ecofact, radiocarbon, and sediment samples from the site, promises to be one of the longest and best preserved records of human presence during the Holocene epoch in northern New England (Figure 1).

Six radiocarbon dates have been recently assayed to augment those previously obtained for the Sharrow site. The nearly deepest cultural deposits in the 1987 stratigraphic trench have been dated to 8,730±70 yr B.P. (Beta-23424), 9,020±460 yr B.P. (Beta-23427), and 8,130±130 yr B.P. (Beta-23426) in ascending stratigraphic order. These and other dates (Petersen 1986, 1987; Petersen and Putnam 1987a;

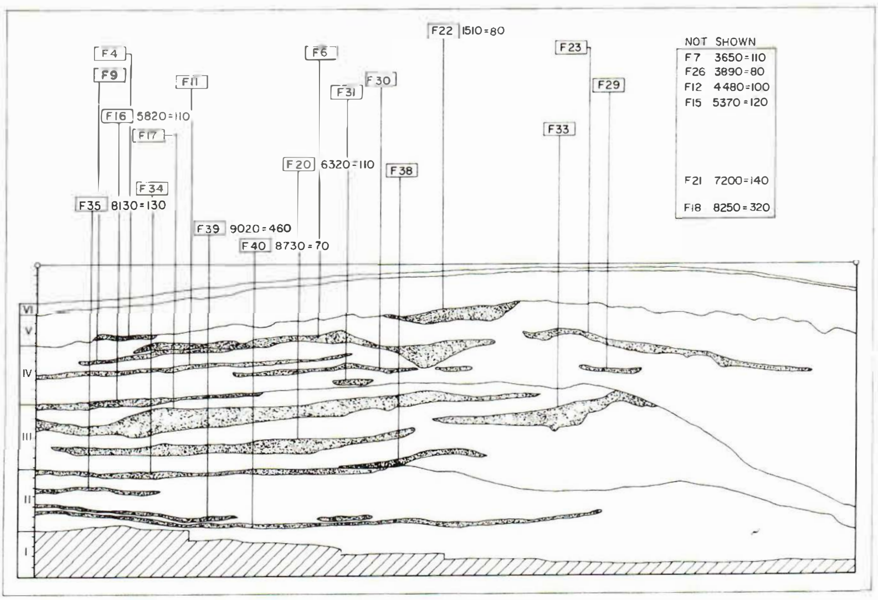


Figure 1. Stratigraphic profile at the Sharrow site (ME 90-2D) showing macrostrata, cultural features, and radiocarbon dates (yr B.P.). Section represents an 8 m × 3 m section.

James B. Petersen, Thomas R. Baker, and Michael J. Heckenberger, Archaeology Research Center, Department of Social Sciences and Business, University of Maine at Farmington, Farmington, ME 04938.

Petersen et al. 1986) document the presence of humans during the early Archaic period when alluvial sediments first began local accumulation on the riverbanks of the Piscataquis River. Although diagnostic early Archaic period artifacts have yet to be identified at the Sharrow site, these deposits and others at nearby sites allow reevaluation of once-held notions that the region was unpopulated during the early Holocene (Petersen 1987; Petersen and Putnam 1987b).

Diagnostic artifacts of the middle Archaic period were recovered at the Sharrow site in 1987. These include square stemmed slate and contracting stemmed rhyolite projectile point forms, along with groundstone tools, and tool fragments from a context dated previously between ca. 7,200 yr B.P. and 6,300 yr B.P. More recent Archaic period deposits yielded various Laurentian tradition artifacts, dated previously between ca. 5,800 yr B.P. and 4,400 yr B.P., and a Moorehead complex "ceremonial" deposit outside of the trench was newly dated to 3,890±80 yr B.P. (Beta-23425). This circular, basin-shaped feature was capped with large tabular graywacke cobbles and fragments and had several plummets, flaked slate "preforms", ochre stains and calcined bone fragments of a yet to be determined species within or near it. In addition, a late Archaic period Susquehanna tradition feature was dated to 3,650±110 yr B.P. (Beta-20719) and a middle Woodland (Ceramic) period feature yielded a date of 1,510±80 yr B.P. (Beta-23423) in association with a crushed ceramic vessel.

Of particular note, analysis of the 1986 sample of calcined bone remains from the Sharrow site (46,000+) by A. Spiess has documented the persistence of a broad spectrum subsistence pattern from the early Archaic period, ca. 8,300 yr B.P., onward (Spiess 1987). Mixed usage of beaver, muskrat, shad, eel, salmonids, turtles, and other mammal, bird, and fish species is recognizable, with few apparent changes throughout the long sequence.

References Cited

Petersen, J.B. 1986 A Late Pleistocene and Holocene Archaeological Sequence in Central Maine. *Current Research in the Pleistocene* 3:15-16.

Petersen, J.B. 1987 The Piscataquis Archaeological Project: 1985 and 1986 Seasons. Paper presented at the 52nd annual meeting of the Society for American Archaeology, Toronto.

Petersen, J. B., N.D. Hamilton, D.E. Putnam, A.E. Spiess, R. Stuckenrath, C.A. Thayer, and J.A. Wolford 1986 The Piscataquis Archaeological Project: A Late Pleistocene and Holocene Occupational Sequence in Northern New England. *Archaeology of Eastern North America* 14:1-18.

Petersen, J.B., and D.E. Putnam 1987a Another Holocene Sequence and Recent Progress of the Piscataquis Archaeological Project in Central Maine. *Current Research in the Pleistocene* 4:23-24.

Petersen, J.B., and D.E. Putnam 1987b Early Holocene Archaeological Sequences in the Piscataquis River Drainage of Central Maine. Paper presented at the 27th annual meeting of the Northeastern Anthropological Association, Amherst.

Spiess, A.E. 1987 Archaic Period Subsistence in New England and the Atlantic Provinces. Paper presented at the 27th annual meeting of the Northeastern Anthropological Association, Amherst.

The Drake Clovis Cache

Dennis J. Stanford and Margaret A. Jodry

The Drake cache consists of 13 Clovis projectile points found in association with small fragments of ivory in a wheat field in northcentral Colorado. The cache was situated near the top of a low ridge amidst the gently rolling topography of the Colorado Piedmont between Pawnee Buttes and the South Platte River. Presently, there is no discernible geophysical feature which distinguishes the locality from similar settings nearby. It is possible that the cache was marked in prehistoric times by perishable materials such as antlers or perhaps by trees or other vegetation.

Orvil Drake of Fort Collins, Colorado discovered the cache in 1978 while hunting artifacts. Three of the projectile points were exposed by plow disturbance and aeolian erosion and the remainder were quickly uncovered by Drake and his associates. Drake recalls that the specimens were clustered and shallowly buried. No red ochre was seen, but tiny, white fragments were collected in association with the points. Thin section analysis has determined these fragments to be ivory. No human bone was identified.

The site was tested by Bruce Lutz of the University of Northern Colorado. He found that an area approximately 1.5 m^2 surrounding the discovery was completely disturbed. The cache appeared to be an isolated feature that was not associated with a larger Clovis site. During testing, a projectile point midsection was recovered from Drake's backdirt that conjoins tip and base fragments found in the cache (Figure 1a). The fragments refit along fracture surfaces that appear to result from plow damage.

At Lutz's request, Stanford continued the investigation and visited the site with Drake. On this occasion, additional ivory fragments and a hammerstone were collected from the immediate vicinity of the initial find. The hammerstone is made of a local chert cobble measuring 55.1 mm × 35.2 mm and weighing 84.4 g (Figure 1b). Although both ends were pitted from use, one end was favored over the other. Chert hammerstones of this nature have been found at other Clovis sites including Blackwater Draw (Hester 1972) and, more recently, the Yellow Hawk site in Texas (Mallouf, pers. comm.).

The Smithsonian Institution made arrangements to study and cast the 13 projectile points which had been divided among five collections. As a group, these specimens are technologically very similar. They range in length from 89.4mm to 164.9 mm and in width from 30.6mm to 39.5 mm. All have slightly concave bases with short, multiple flute flakes removed from both faces. Six of the projectile points appear to have been used and resharpened, but the remaining artifacts are unmodified and may represent newly manufactured points. All 13 weapon tips are extremely sharp and were cached in a ready-to-use state. The points are made of high quality, colorful, raw materials. The flintknapper(s) appears to have deliberately incorporated the color patterns into the design of the artifacts in ways that enhance their beauty. Eleven points are made of Alibates Dolomite from Texas, but positive identification of the remaining two materials has not been made.

Dennis J. Stanford and Margaret A. Jodry, Department of Anthropology, Smithsonian Institution, MNH 304, Washington, DC 20560.

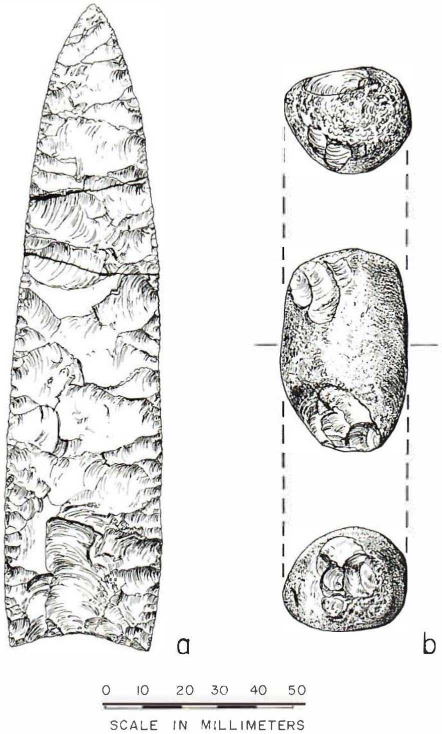


Figure 1. Clovis projectile point from the Drake cache (a); hammerstone thought to be associated with the Drake cache (b).

Although large bifaces and other unifacial tools are absent in the Drake cache, the projectile points compare favorably to those found in both the Simon (Butler 1963; Butler and Fitzwater 1965) and Anzick (Lahren and Bonnichsen 1974) caches. The Anzick material appears to be a burial cache containing human bone and Clovis artifacts covered in red ochre. Red ochre was also observed on the artifacts from the Simon cache (Bonnichsen, pers. comm.). It is possible that the Simon and Drake caches represent further expressions of the Clovis mortuary practices suggested by the Anzick cache.

References Cited

Butler, B.R. 1963 An Early Man Site at Big Camas Prairie. South-Central Idaho. *Tebiwa* 6:22-33.

Butler, B.R., and R.J. Fitzwater 1965 A Further Note on the Clovis Site at Big Camas Prairie, South-Central Idaho. *Tebiwa* 8:38-40.

Hester, J.J. 1972 Blackwater Draw Locality No. 1: A Stratified, Early Man Site in Eastern New Mexico. *Ft. Burgwin Research Center. No. 8,* Southern Methodist University, Dallas, Texas.

Lahren, L., and R. Bonnichsen 1974 Bone Foreshafts from a Clovis Burial in Southwestern Montana. *Science* 186:147-150.

Recent Excavations at the Udora Site: A Gainey/Clovis Occupation Site in Southern Ontario

Peter L. Storck

Excavations in 1987 at the Udora site have provided additional information on the as yet poorly known Gainey complex which was first defined by Simons et al. (1984) from a site of that name in Michigan. The Udora site was discovered by the Royal Ontario Museum (ROM) in 1979 during the course of survey work along the former strandline of glacial Lake Algonquin. This work was conducted as part of an ongoing Paleoindian site survey and excavation project that began in 1975 (Storck 1982). The Udora site was excavated extensively in 1980 with funds from the ROM and the Social Sciences and Humanities Research Council of Canada (SSHRCC). A total of five of the nine artifact concentrations on the cultivated portion of the site were excavated to determine more precisely the cultural identity of the occupants, the depositional context of the artifacts, whether any undisturbed deposits or features were present, and the "structural organization" of the artifact concentrations/ activity areas, both individually and with respect to one another. A geologist, Dr. Q.H.J. Gwyn, Department de Geographie, Universite de Sherbrooke, conducted altimetric studies at the site and in the general area to determine the physical relationship of the site to the Algonquin strandline. The purpose of the 1987 project, also funded by the ROM and the SSHRCC, was to determine whether undisturbed occupation areas might exist in the geographic center of the site area, among the farm buildings and associated stock corrals, and if so, to search for features that would provide faunal and/or floral material for identification and dating.

The project succeeded in discovering and excavating a previously unknown occupation area situated in a present day stock drive lane and adjacent poultry pen. The occupation area consists of two artifact/debitage concentrations each about 6 m in diameter separated by a zone of low productivity about 3 m wide. The two artifact concentrations each produced a similar range of artifacts consisting in total of 1 complete and 13 fragments of fluted points of the Gainey/Clovis type (Figure 1), a variety of other tools, and at least 48 and possibly as many as 88 end scrapers (the final count will depend on the number of refitted fragments), many with graver spurs and hafting notches. The fluted point sample includes several examples with deeply concave bases (especially 1, 2, and 4, Figure 1) similar to those found on points at such northeastern sites as Vail in Maine (Gramly 1982) and Debert in Nova Scotia (MacDonald 1968), thus further documenting the westerly occurrence of this attribute in the Great Lakes region. Both artifact concentrations produced features below the plow zone. The northern concentration produced abundant debitage and some artifacts adjacent to a large glacial boulder which may have served as "site furniture" such as a seat, backrest or windbreak. The southern concentration produced a feature delimited by a concentration of over 2000 pieces of debitage and artifacts (many damaged by heat), and 293 g of calcined animal bone. Analysis

Peter L. Storck, Department of New World Archaeology, Royal Ontario Museum, 100 Queens Park, Toronto, ON, Canada M5S 2C6.

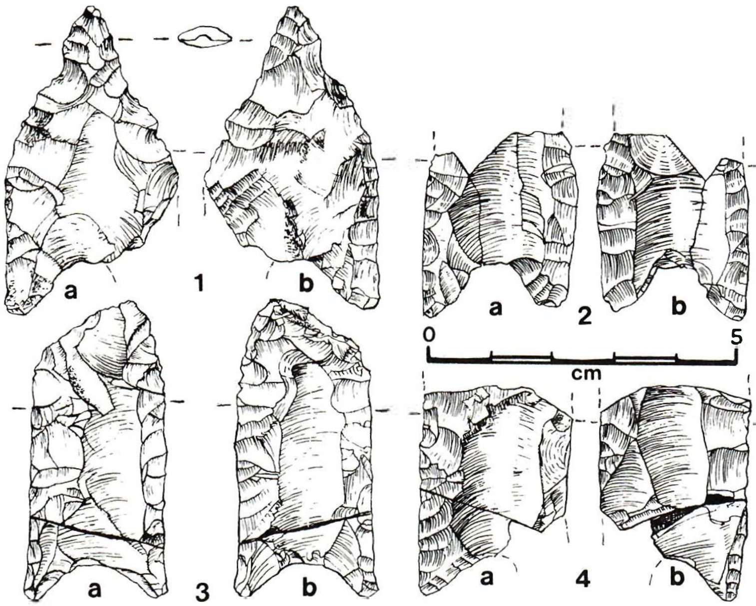


Figure 1. Complete and fragmentary projectile points from Area A-East, Udora site. 1) basal fragment reworked into bifacial drill, 2 and 4) basal fragments broken during use, 3) extensively resharpened point also broken during use.

of the latter resulted in the identification of seven complete and fragmentary bones belonging to Cervidae (cf. white-tailed deer or caribou), Leporidae (cf. hare or rabbit), and Canidae (cf. fox) (Previc 1987). Samples of calcined bone have been submitted for radiocarbon dating.

Data from the Udora site will help to define the lithic technology of the Gainey complex in the Great Lakes region and its relationship to other complexes in adjacent regions. It will also contribute to our knowledge of early Paleoindian settlement and community patterns and subsistence. If radiocarbon dating is successful, it will also provide a temporal placement and environmental context for the Gainey complex and a basis for interpreting patterns of cultural/ecological adaptations.

References Cited

Gramly, R.M. 1982 *The Vail Site: A Palaeo-Indian Encampment in Maine.* Bulletin of the Buffalo Museum of Natural Sciences: No. 30.

MacDonald, G.F. 1968 *Debert: A Palaeo-Indian Site in Central Nova Scotia. Anthropology Papers No. 16, National Museums of Canada.*

Previc, R. 1987 The Udora Site (BbGt-4) Faunal Report. Unpublished manuscript.

Simons, D.B., M.J. Shott, and H.T. Wright 1984 The Gainey Site: Variability in a Great Lakes Paleo-Indian Assemblage. *Archaeology of Eastern North America* 12:266-279.

Storck, P.L. 1982 Palaeo-Indian Settlement Patterns Associated with the Strandline of Glacial Lake Algonquin in Southcentral Ontario. *Canadian Journal of Archaeology* 6:1-31.

Lithic Methods

Paleoindian Tradition Fluted Points in Montana

Leslie B. Davis

In comparison to the relative abundance of fluted Paleoindian projectile points from primary and exposed contexts in Wyoming (Frison 1978), and "Dirty 30s" point collections from southern Saskatchewan (Kehoe 1966) and Alberta (Gryba 1985), only a few excavated sites and little surficial evidence are on record for the initial early prehistoric period in the northern Rocky Mountains and northwestern Plains regions of Montana. An unsponsored statewide survey of surface-collected, typically isolated and widely scattered fluted points has revealed widespread occurrence except west of the Continental Divide.

Twenty-seven sites or more general locations in Montana montane, high plains, and riverine settings have yielded one or more Clovis, Folsom, or other apparently fluted, lanceolate projectile points. The spatial distribution of these finds and a few excavated early prehistoric sites suggests a ubiquitous early Paleoindian presence. The overall implications for predicting the whereabouts of other such sites, however, remains to be determined.

Investigated early Paleoindian sites do provide some indication of what can be expected. Dates of 14,590±300 yr B.P. and 10,530±140 yr B.P. from False Cougar Cave (24CB84) (Bonnichsen et al. 1986) in the Pryor Mountains of southern Montana and dates earlier than 11,000 B.P. from the Lindsay mammoth site (24DW501) in eastern Montana (Davis 1982; Davis and Wilson 1985) possibly associate with human activity, but points are lacking in both instances. Points associated with the Goshen complex at the Mill Iron site (24CT30) in southeastern Montana, which dates ca. 11,300 yr B.P. (Frison, pers. comm.), lack fluting, but are coeval with the Clovis complex. The Anzick-Wilsall Clovis burial/cremation/cache site (24PA506) in suthwestern Montana (Lahren and Bonnichsen 1974) is dated to 10,470±490 yr B.P. (Taylor et al. 1985). The Folsom complex at the MacHaffie site (24JF4) in west-central Montana has not yet been radiocarbon dated (Forbis and Sperry 1952). A Folsom component(s) at the Indian Creek site (24BW626), 10 km south of the MacHaffie site, dates to 10,980±150 yr B.P. (Davis 1984) and 10,630±280 yr B.P. (Davis et al. 1987). These several cases constitute the totality of in situ, radiocarbon dated Montana pre-Clovis age, Clovis, Goshen, and Folsom components thus far investigated.

Leslie B. Davis, Department of Sociology, Montana State University, Bozeman, MT 59717.

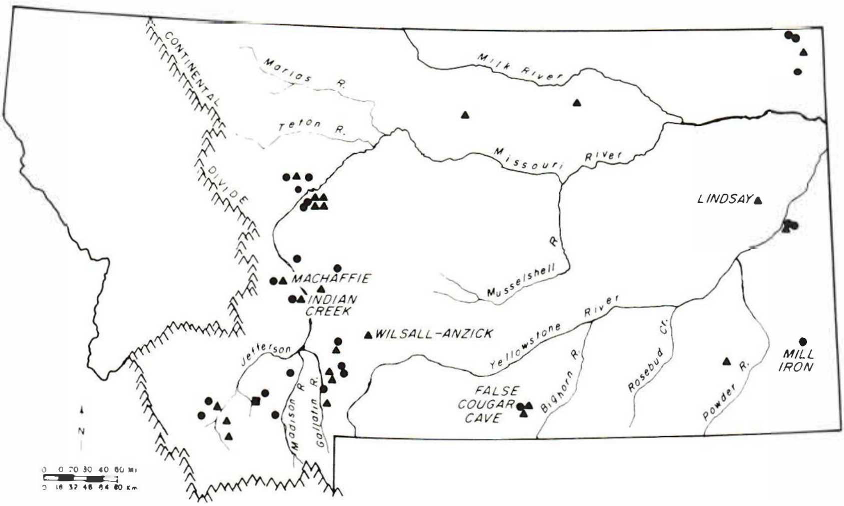


Figure 1. Early Paleoindian sites and surface-collected fluted point distribution in Montana.

These limited examples set some expections for locating at least partially preserved subsurficial contexts in Montana that contain 11,500 to 10,000 yr B.P., or possibly earlier, cultural remains. Some excavated Paleoindian sites (MacHaffie, Mill Iron) were identified indirectly as a consequence of visibility due to shallow stream or deep, large-scale natural erosion, as an effect of placer mining (Indian Creek), road (Lindsay) or facility construction (Anzick-Wilsall), the purposeful search for early deposits (False Cougar Cave). or cultural resource-inspired surveys (Indian Creek, Mill Iron).

Small fluted point samples from excavated sites, with the exception of Anzick-Wilsall, provide minimal comparative perspective for understanding the variability of fluted points from Montana surface collections, which are collectively impressive for their lack of conformance to established point types. Most display impact fractures, with modified and reshaped distal and proximal ends, some showing reuse. Similar patterns are reported from similar regional settings (cf. Kehoe 1966; Gryba 1985; Meltzer 1986). A wide range of lithics (basalt, obsidian, chert, quartzite, porcellanite, chalcedony, Knife River flint) was selected for fluted point manufacture, not all of which were necessarily derived from Montana sources. Most often, collected fluted points do not co-occur with later Paleoindian points. The stratified MacHaffie (Folsom and Scottsbluff, and possibly Clovis and Eden) and Indian Creek (Folsom, Hell Gap, and Agate Basin) sites reflect such reoccupation, however. Spatial co-occurrence of fluted points with later Paleoindian types is most common at deflated, deeply eroded locations in north-central and southeastern Montana.

An organized and sustained effort to locate fluted point sites and study associated natural settings is requisite for developing models which predict resource use and consequent subsistence and settlement patterns for peoples of the Fluted Point tradition during the early prehistoric period in Montana. Detailed studies of preferred lithics, technology, and artifact use histories will contribute substantially to understanding the use and distribution of fluted points in time and space.

References Cited

Bonnichsen, R., R.W. Graham, T. Geppert, J.S. Oliver, S.Oliver, D. Schnurrenberger, R. Stuckenrath A. Tratebas, and D.E. Young 1986 False Cougar and Shield Trap Caves, Pryor Mountains, Montana. *National Geographic Research* 2:276-290.

Davis, L.B. 1982 Montana Archaeology and Radiocarbon Chronology (1962-1981). *Archaeology in Montana, Special Issue* No. 3.

Davis, L.B. 1984 Late Pleistocene to Mid-Holocene Adaptations at Indian Creek, West-Central Mountain Rockies. *Current Research* 1:9-10.

Davis, L.B., S.T. Greiser, and T. W. Greiser 1987 Spring Cleanup at a Folsom Campsite in the Montana Rockies. *Current Research in the Pleistocene* 4:5-6.

Davis, L.B., and M.C. Wilson 1985 The Late Pleistocene Lindsay Mammoth (24DW501): A Possible Man-Mammoth Association. *Current Research in the Pleistocene* 2:97-98.

Forbis, R.G., and J.D. Sperry 1952 An Early Man Site in Montana. *American Antiquity* 18:127-133.

Frison, G.C. 1978 *Prehistoric Hunters of the High Plains.* Academic Press, Inc. New York.

Gryba, E. 1985 Evidence of the Fluted Point Tradition in Alberta. *Alberta Archaeological Review* No. 11, pp. 3-11.

Kehoe, T.F. 1966 The Distribution and Implications of Fluted Points in Saskatchewan. *American Antiquity* 31:530-539.

Lahren L.A., and R. Bonnichsen 1974 Bone Foreshafts from a Clovis Burial in Southwestern Montana. *Science* 186:147-150.

Meltzer, D. 1986 A Study of Texas Clovis Points. *Current Research in the Pleistocene* 3:33-36.

Taylor, R.E., L.A. Peyn, C.A. Prior, P.J. Slota, Jr., R. Gillespie, J.A.J. Gowlett, R.E.M. Hedges, A.J.T. Jull, T.H. Zabel, D.J. Donahue, and R. Berger 1985 Major Revisions in the Pleistocene Age Assignments for North American Human Skeletons by C-14 Accelerator Mass Spectometry: None Older Than 11,000 C-14 Years B.P. *American Antiquity* 50:1326-1340.

Paleoindian Obsidian Artifacts from Texas: A Review

Thomas R. Hester

Several recent studies have documented the occurrence of obsidian Paleoindian artifacts at archaeological sites in Texas and adjacent states. These are of importance since artifact-quality obsidian does not outcrop in Texas, and the presence of these Paleoindian artifacts are indicative of either long-distance trade or travel (or both) in these early times. Johnson et al. (1985) have reported obsidian points and bifaces from the Lubbock Lake site and from the site of Blackwater Draw in New Mexico. The obsidian artifact from Lubbock Lake and an obsidian Clovis point from Blackwater Draw are both linked by x-ray fluorescence analysis (XRF) to the Valles Caldera (New Mexico) source area 350-500 km from the two sites. A broken biface of obsidian from Blackwater Draw has an unknown geologic provenience based on its XRF chemical characterization.

In another recent paper, Hester et al. (1985) reported a fragmentary obsidian bifacial point found associated with late Pleistocence fauna at Kincaid Rockshelter in Uvalde County, southcentral Texas. At that time, the specimen was the southernmost Paleoindian obsidian artifact known in the state. Analysis by neutron activation, as

Thomas R. Hester, Texas Archeological Research Laboratory, University of Texas, Austin, TX 78758-4497.

well as by XRF, demonstrated that the Kincaid obsidian point is attributable to outcrops in Queretaro, Mexico, about 165 km northeast of Mexico City and about 1,000 km south of Kincaid Rockshelter.

In July 1987, the author was shown an obsidian Clovis point found on the surface of site 41CL72, near Port Lavaca, Calhoun County, Texas. The site is situated on a strip of beach along the edge of Lavaca Bay on the central Texas coast. Indeed, the artifact has been heavily weathered and abraded from wave action. Typologically, the specimen clearly fits into the Clovis category. It measures 47 mm long, 23 mm wide, and 6 mm thick. Weight is 9.1 g. It is fluted on both faces, the flutes being 23 mm on one side (a single flute) and 22-30 mm on the other (two adjacent flutes). The material is a smokey, clear gray obsidian. Non-destructive XRF analysis by Frank Asaro, Fred Stross, and Helen Michel (Lawrence Berkeley Laboratory) proved inconclusive. The obsidian could not be linked to any known source. Although there were some similarities to a source area in Washoe County, Nevada, the Berkeley team did not consider the data sufficient to attribute the material to that source.

The XRF data were further compared to the Blackwater Draw obsidian biface of unknown geologic provenience (noted above) and no similarities were found. Additionally, comparisons were made with XRF data obtained on a spurred uniface of possible Paleoindian age (8132-Q; site 16CD118, Cross Lake, Louisiana), and again there were no relationships in terms of chemical characterization. Finally, comparisons were made with XRF data for two lanceolate obsidian points (probably Plainview) from a surface locality near Comstock, Val Verde County, Texas (TEX 17,18; Asaro and Stross, pers. comm.; Carroll 1978). There was no link with these two specimens and, indeed, no similarities between or among any of these five Paleoindian obsidian artifacts from Texas, Louisiana, and New Mexico. These data suggest that Paleoindians often utilized obsidian outcrops that, based on our present knowledge, were not exploited in later times.

Paleoindian artifacts are, in general, relatively rare along the Texas coast (Hester 1980). The late Pleistocene coastline was likely 80-225 km east of the present coastal margin (LeBlanc and Hodgson 1959). There is an important Paleoindian locality at McFaddin Beach in Jefferson County on the upper Texas coast. Beach erosion has exposed Pleistocene fauna, along with a number of Clovis points (none made of obsidian), and later Paleoindian types (San Patrice, Plainview, Scottsbluff, etc.; Long 1977, 1986; for details on the local geomorphology, see Pearson and Weinstein 1983).

The author would like to thank Nic Harrison of Port Lavaca, Texas for the loan of the obsidian Clovis point found at 41CL72. My gratitude is also expressed to Frank Asaro, Fred Stross, and Helen Michel for their efforts in XRF analysis of Texas obsidian artifacts.

References Cited

Carroll, W.B. 1978 Notes on Two Obsidian Paleo-Indian Points from Val Verde County, Texas. *La Tierra* 5:15-16.

Hester, T.R. 1980 A Survey of Paleo-Indian Archaeological Remains Along the Texas Coast. In *Papers on the Archaeology of the Texas Coast,* edited by L. Highley, and T. R. Hester, pp. 1-12. Special Report 11, Center for Archaeological Research, The University of Texas at San Antonio.

Hester, T.R., G.L. Evans, F. Asaro, F. Stross, T.N. Campbell, and H. Michel 1985 Trace Element Analysis of an Obsidian Paleo Indian Projectile Point from Kincaid Rockshelter, Texas. *Bulletin of the Texas Archeological Society* 56:143-153.

Johnson, E., V.T. Holliday, F. Asaro, F. Stross, and H. Michel 1985 Trace Element Analysis of Paleoindian Obsidian Artifacts from the Southern High Plains. *Current Research in the Pleistocene* 2:51-53.

LeBlanc, R.J. and W.D. Hodgson 1959 Origin and Development of the Texas Shoreline. In *Second Coastal Geography Conference,* edited by R.J. Russell, pp. 57-102. Washington, D.C.

Long, R.J. 1977 *McFaddin Beach.* Patillo Higgins Series of Natural History and Anthropology, Spindletop Museum, Lamar University, Beaumont, Texas.

Long, R.J. 1986 Two Clovis Points from McFaddin Beach, Texas. *Ohio Archaeologist* 26:9.

Pearson, C.E., and R.A. Weinstein 1983 *Cultural Resources Addendum, Big Hill Storage Complex Pipeline, Nederland to the Gulf of Mexico, Jefferson County, Texas.* Coastal Environments, Inc., Baton Rouge, Louisiana.

Burins from the Cummins Paleoindian Site, Thunder Bay, Ontario

P.J. Julig

Burins are rarely recovered from fluted point sites. They have, however, been reported in Plano components of certain Plains Paleoindian sites (e.g., Hell Gap, Irwin and Wormington 1970; Levi, Alexander 1962; Parkhill, Ebell 1980). This paper reports a small collection of burins recovered from the Cummins Paleoindian (Plano) site at Thunder Bay, Ontario.

Cummins is a large, stratified quarry-workshop and habitation site located on a proglacial Lake Minong beach. Most of the cultural deposits at Cummins date ca. 8,000 to 9,500 yr B.P., although a deeply buried, waterworn component may date to an earlier lake phase (Julig 1984; Julig et al. 1986). Procurement of local taconites from bedrock outcrops and surficial deposits, and the production of biface preforms and flake blanks were major site functions embedded in general habitation and maintenance activities.

Excavations at five locations yielded large quantities of taconite industrial debitage, failed biface preforms, and numerous used implements. Included in a sample of 293 unifacial tools were 9 burins, with representative examples shown in Figure 1. The expedient use of corners and facets of split and snapped flakes is common on Cummins unifaces, however, the implements being considered in this report have all been retouched by burin blows. All nine specimens are multipurpose or combination tools, having one or more used edges or projections in addition to the burin facet. Three specimens retain remnants of striking platforms, with the remainder fashioned from tabular debitage or flake fragments. Four of the specimens are scraper-burins, with burin blow(s) used to form projections (e.g., Figure 1a, d). Specimen a (Figure 1) is similar to the Levi site specimens designated by Alexander (1962) as burin type 1, formed by intersecting (dihedral) end blows. Single burin blows were also used to fashion broad, strong projections on large flakes and fragments (e.g., Figure 1b, c). Snaps and splits were used as striking platforms to form right-angle burins (Figure 1e, f), similar to the Levi site burin types 2 and 3 (Alexander 1962).

P.J. Julig, Department of Anthropology, University of Toronto, Toronto, ON Canada M5S 1A1.

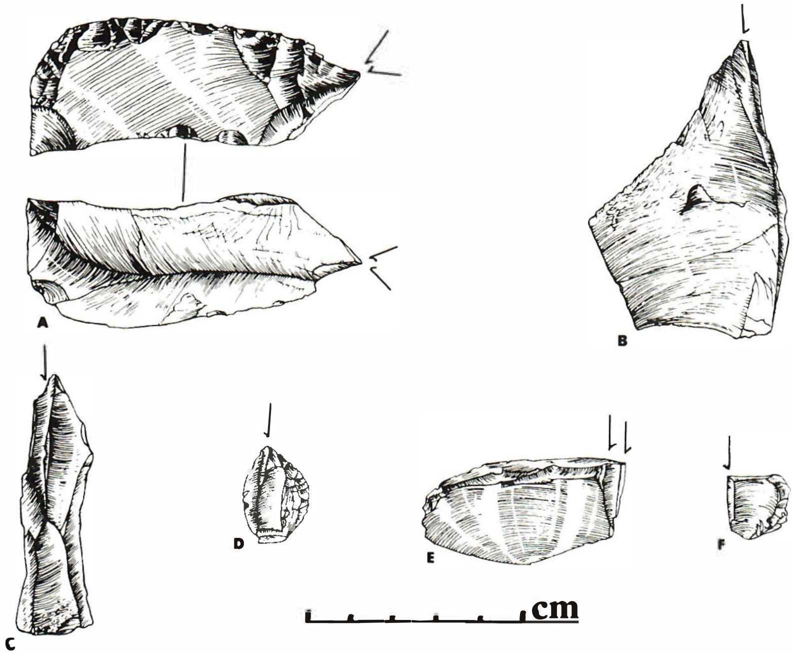


Figure 1. Representative burins from Cummins site. A, dihedral burin; B, C, D, graver-burins; E, F, right-angle burins.

The presence of burins on approximately 3% of the Cummins lithic tools is roughly similar to the burin percentages reported for the Hell Gap (2.8%) and Frederick (2.3%) complexes at Hell Gap site (Irwin and Wormington 1970), but less than the 6.9% reported for Levi (Alexander 1962). Since burins are uncommon in early Paleoindian lithic assemblages, and only occasionally reported from Plano sites, this tool form may not always be recognized. Their occurrence in association with parallel and obliquely flaked lanceolate points at Levi, Hell Gap, and Cummins may be a significant association, and should be further investigated.

References Cited

Alexander, H.S., Jr. 1962 The Levi Site: A PaleoIndian Campsite in Central Texas. *American Antiquity* 28:510-528.

Ebell, S.B. 1980 The Parkhill Site: An Agate Basin Surface Collection in South Central Saskatchewan. *Pastlog No. 4.* Manuscript Series in Archaeology and History, Saskatchewan Ministry of Culture and Youth. Regina, SK.

Irwin, H.T., and H.M Wormington 1970 Paleo-Indian Tool Types in the Great Plains. *American Antiquity* 35:24-34.

Julig, P.J. 1984 Cummins Paleo-Indian Site and Its Paleoenvironment Thunder Bay, Canada. In *New Experiments on the Record of Eastern Paleo-Indian Cultures,* edited by M. Gramly, pp.192-209. Archaeology of Eastern North America 12.

Julig, P.J., J. McAndrews, and W.C. Mahaney 1986 Geoarchaeological Investigations at the Cummins Paleo-Indian Site, Thunder Bay, Ontario. *Current Research in the Pleistocene* 4:59-63.

The Raw Material Used by the Paleoindians of the Cueva Del Medio, Ultima Esperanza, Chile

Hugo G. Nami and Ana M. Casé

As we have stated (Nami 1987) Cueva del Medio, Ultima Esperanza in the southern part of South America is a significant Paleoindian discovery. According to our archaeological design the Paleoindian research included different specialists in charge of interdisciplinary work. This paper reports some observations about the sources of raw material available and used by the inhabitants of the Cueva del Medio.

According to Luedtke (1979) and Olausson (1982-83) the source of raw material for manufacturing stone tools could be classified as primary and secondary sources. The primary sources are those where the raw material is presented in their place of origin and the secondary sources are those where the material has been transported by different natural agents (rivers, glaciers, etc.).

Geomorphologically and structurally, Cueva del Medio is placed in Cerro Benitez conglomerate, (Wellman 1972). Glacial action is evident surrounding the cave. These gemorphological formations contain a variety of different rock types. All clasts are pebbles, cobbles, and boulders (Dunbard and Rogers 1957; Taylor 1968). Our technological research includes the raw material from procurement to the finished product, and as part of this experiment the potential sources of raw material were examined. It was found that among different rocks and with different lithologies, there was the type that the ancient inhabitants of the Cueva del Medio used for the manufacturing of stone tools. Its sources were as follows: a) pebbles and cobbles available in the same cave that fall from the cave conglomerate (secondary sources), b) veins that are include in the Cerro Benitez conglomerate, located in the mouth of the cave (primary source), and c) glacial deposits surrounding the site (secondary sources).

Samples of these raw materials were studied using petrographic methods and a photomicroscope. According to the type of rock, its texture, and mineralogy we find crystalline quartz, cryptocrystalline quartz, old glassy structures completely devitrified, alkaline feldspars, iron minerals, and several silicates. These volcanic rocks are principally fine grained, with concoidal fracture, hard, and compact, and are identified as rhyolites, dacites, and devitrified tufas.

From the flintknapper's viewpoint these rocks have all the characteristics that the raw material needs to be manufactured into stone tools (Crabtree 1967; Nami 1985). According to the lithic grade scale, some of these rocks have 5.0-5.5 lithic grade and 9-10 in the scale proposed for Argentine lithic studies (Nami 1986).

References Cited

Crabtree, D. 1967 Notes on Experiments in Flintknapping: 3. The Flintknappers' Raw Materials. *Tebiwa* 10:8-24.

Hugo G. Nami Programa de Estudios Prehistóricos (UBA-CONICET). B. Mitre 1970 5th "A", Buenos Aires (1039), Argentina.

Ana M. Casé, Direccion General de Minería, C.C. 110, Zapala (8340), Neuquén, Argentina.

Dunbard, C. and Rogers, J. 1957 *Principles of Stratigraphy*, John Wiley and Sons, Inc., New York.

Luedtke, B.E. 1979 The Identification of Sources of Chert Artifacts. *American Antiquity* 44:744-756.

Nami, H.G. 1985 El subsistema technológico de la confección de instrumentos líticos y la explotacióon de los recursos del ambiente: Una nueva vía de aproximación. Paper presented at 45th Congreso Internacional de Americanistas, Bogotá, Colombia.

Nami, H.G. 1986 Experimentos para el estudio de la techología bifacial de las ocupanciones tardías en el extremo sur de la Patagonia Continental. *PREP. Informes de investigación* No. 5, Buenos Aires, Argentina.

Nami, H.G. 1987 Cueva del Medio: A Significant Paleoindian Site in Southern South America. *Current Research in the Pleistocene* 4:157-159.

Olausson, D.S. 1982-83 Flint and Goundstone Axes in Scanian Neolithic: An Evaluation of Raw Materials Based on Experiment. *Scripta Minora* No. 2, Lund, Sweden.

Taylor, F. 1968 Detrital Silica Rocks for the Archaeologist. *Newsletter of the Archaeological Society of Alberta* 16:2-10.

Wellman, R.W. 1972 Origen de la Cueva del Mylodón en Ultima Esperanza. *Anales del Instituto de la Patagonia* 1-2:97-101.

Formalized Point Resharpening: A Paleoindian Example From Southern Utah

Richard M. Ryan and Donald R. Keller

An apparent Paleoindian projectile point which has been resharpened in a distinctive fashion has been recently recovered in Kane County, southern Utah. It was collected as an isolated surface find in the Gray Cliffs area approximately 30 km north of Kanab. The locality is pinyon-, juniper-, and sagebrush-covered tableland at an elevation of 1,980 m, part of a large hunting-gathering resource area surveyed by the Museum of Northern Arizona through the sponsorship of BHP-Utah International (Keller et al. 1987).

Flaking on the point is by well-controlled soft hammer direct percussion. Stem lateral edges are smoothed but not heavily ground. Unfortunately, tip and stem are broken. The material is a translucent, smoky chalcedony with white patina, very heavy on one face. The resharpening technology employed is very unusual. Both blade edges are steeply retouched, or beveled, on one side only (arrows in Figure 1). This is produced by short, steep flaking of the blade edge on one face. The artifact is then rotated 180° onto the other face and the opposite edge flaked. This alternate face beveling results in a characteristic rhomboidal cross section, referred to as alternate edge-beveling or simply bi-beveling. The southern Utah specimen has a right-handed bevel. The bevel face is thought to indicate the handedness of the knapper.

Some researchers believe that bi-beveling is evidence that resharpening occurred while the artifact was hafted. This is probable, although Frison and Grey (1980) have seen occasional instances where a point stem as well as blade are beveled. This occurs on Pryor Stemmed points, a Montana-Wyoming terminal Paleoindian type

Richard M. Ryan, Prescott National Forest, 344 S. Cortez, Prescott, AZ 86303.

Donald R. Keller, Museum of Northern Arizona, Route 4, Box 720, Flagstaff, AZ 86001.

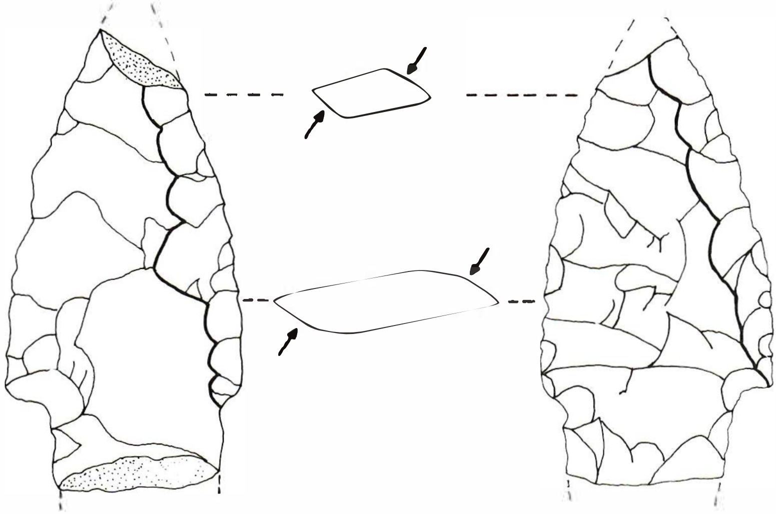


Figure 1. Bi-beveled projectile point or hafted knife from Kane County, southern Utah (actual size).

(ca. 8,000 yr B.P.). Bi-beveling is also present on Dalton-Meserve points in the central Plains and the Southeast (Myers and Lambert 1983), where it is likely of Folsom/Plainview age (10,500-9,500 yr B.P.).

Several studies have determined that bi-beveling is a progressive treatment. That is, the first application is applied only after the artifact is dulled or damaged. Beveling proceeds in succeeding stages until the blade is too small to sharpen further. The points thus sharpened may have been either hafted knives or projectile points, or both.

Although the technique was used during the Archaic and later periods in some areas of North America, it is largely unknown in the Desert Archaic. The Paleoindian ascription of the illustrated point is based on size and morphology, resharpening technique, and relative degree of patination compared with Archaic and later artifacts of similar material collected on this same project. It may be determined with greater certainty through associational contexts and independent dating whether hafted bi-beveling is a Paleoindian diagnostic here in the desert Southwest.

References Cited

Frison, G.C., and D.C. Grey 1980 Pryor Stemmed: A Specialized Late Paleo-Indian Ecological Adaptation. *Plains Anthropologist* 25:27-46.

Keller, D.R., W.F.X. Hurley, R.M. Ryan, T.L. Samples, V. Clark, D. Rea, and N. Weintraub 1987 Archaeological Survey and Cultural Site Evaluation of the Alton Coal Project Area. Ms. on file, Department of Anthropology, Museum of Northern Arizona, Flagstaff.

Myers, T.P., and R. Lambert 1983 Meserve Points: Evidence of a Plains-ward Extension of the Dalton Horizon. *Plains Anthropologist* 28:109-114.

The Exploitation Frontier of Hixton Quartzite

Kenneth B. Tankersley

Hixton quartzite is a petrographically distinct silicified sandstone that outcrops on an isolated hill known as Silver Mound near the town of Hixton in western Jackson County, Wisconsin. Because of the brittle nature and aesthetic qualities of Hixton quartzite, early Paleoindians quarried this material for the manufacture of fluted projectile points. While these points have been found many kilometers east of the raw material's source (Mason 1986), none have been documented from comparable distances to the south, i.e., in the unglaciated regions of the midwestern United States.

In many areas of the Midwest, Hixton quartzite may be mistaken for quartzite or pegmatitic quartz from glacial till or outwash deposits in Indiana and Ohio, quartzite from bedrock deposits in Kentucky, "sugar" quartzite from bedrock deposits in Pennsylvania, or chalcedonic quartz from Indiana and Kentucky. Fortunately, each of these raw materials have their own unique petrographic textures that can be microscopically distinguished from Hixton quartzite.

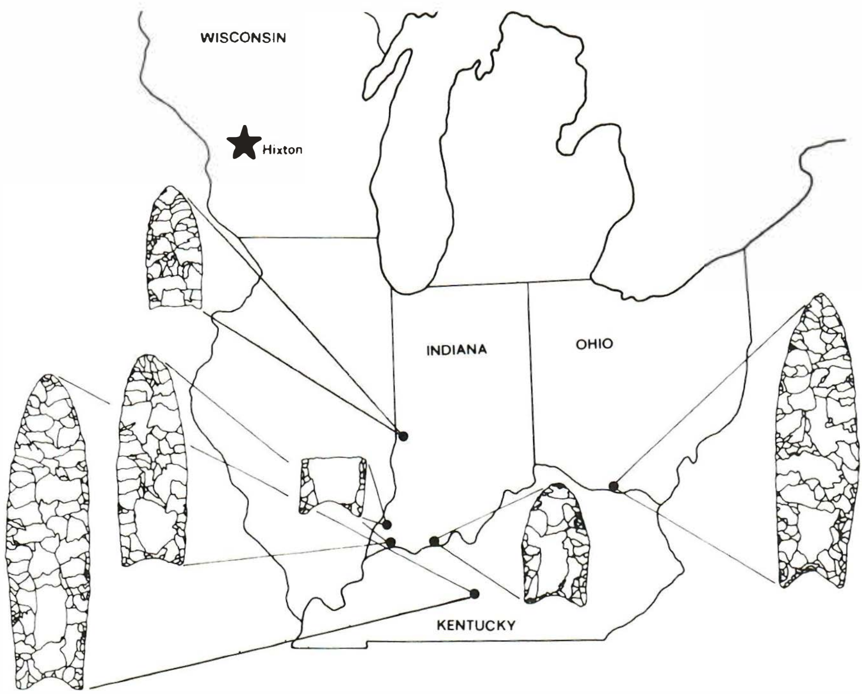


Figure 1. Clovis projectile points manufactured from Hixton quartzite and their findspots in relation to the raw material's source area.

Kenneth B. Tankersley, Glenn A. Black Laboratory of Archaeology, Indiana University, Bloomington, IN 47405.

Recently, the raw material composition of six Clovis projectile points were petrographically identified as Hixton quartzite. Their findspots and distances from Silver Mound, Wisconsin (Figure 1) include: the Hale site, Vigo County, Indiana (700 km); the Kuester site, Gibson County, Indiana (730 km); the Newburgh site cluster, Vanderburgh-Warrick County, Indiana (780 km); the Rockport site cluster, Spencer County, Indiana (800 km); the Sandy Springs site cluster, Adams County, Ohio (900 km); and an unnamed site located near the Historic Entrance of Mammoth Cave, Edmonson County, Kentucky (900 km).

The correlation of these artifacts with this distant lithic source demonstrates that exotic raw materials do occur in the artifact assemblages of certain early Paleoindian sites in the unglaciated midwestern United States. The localities of these artifacts represent the southern limit or frontier of Hixton quartzite exploitation by early Paleoindians. However, the exact means by which this raw material was obtained, i.e. by direct procurement or exchange, has yet to be established.

This study was made possible by a grant from the L.S.B. Leakey Foundation and the Division of Historic Preservation and Archaeology, Indiana Department of Natural Resources. Special thanks to Ayla Akin for drafting the figure.

References Cited

Mason, R. J. 1986 The Paleo-Indian Tradition. *Wisconsin Archeologist* 67:181-206.

Engineering Use-wear Studies of Early Paleoindian Tools

John Tomenchuk

Fisher and Udora are two early Paleoindian sites in south-central Ontario associated with the strandline of Glacial Lake Algonquin. Both sites were excavated and reported upon by Storck (1977, 1978a, 1978b, 1979, 1982, 1983).

Of interest here are the engineering use-wear studies that were conducted on selected samples of informal chert tools from each site. Briefly, two use-wear parameters are routinely obtained from each parametrically analyzed specimen, namely, the sustained in-service force and the apparent hardness(es) of the material(s) worked. Despite the total lack of organic preservation at the Fisher site, parametric use-wear studies indicate that a host of activities occurred at the site, including butchering, hide working, wood working, and probably also fish processing (Tomenchuk 1988). The inclusion of jack pine (*Pinus banksiana*) and white birch (*Betula papyrifera*) among the species of wood tentatively identified on the basis of their apparent hardnesses suggests an occupation of the Fisher site between 10,600 and 10,500 yr B.P. Also of interest is the possible evidence for gender- and age-related division of labor among the Fisher site inhabitants. Briefly, the principle underlying this inference is the tendency for individual tool-users of different strengths to apply

John Tomenchuk, Center for the Study of Early Man, University of Maine, 495 College Avenue, Orono, ME 04473.

different loads during the execution of suites of identical tasks. Two important sources of strength differences are age and sex. Depending upon whether the tasks are ostensibly shared or divided, observed strength differences are attributed to either age or sex respectively.

At the Udora site, a cache of some 80 informal flake tools was the object of a recent engineering use-wear study (Tomenchuk and Storck 1989). More than 90% of the analyzable pieces appeared to have been used for the same task. Certain parametric and non-parametric features of the study were totally unfamiliar to the author and could not be equated with any experimental results previously produced. The overall subjective impression of the use-wear is that the tools were used to process tree roots. Unfortunately, attempts to experimentally duplicate the archaeological parametric values and certain discrete use-wear features using white spruce (*Picea glauca*) as the contact material proved unsuccessful. Consequently, the precise identity of the material worked and the identity of the task itself remain unresolved.

Albeit provisional, the cache of tools from the Udora site is not suspected of having been used to strip and split black spruce *(Picea mariana)* roots in order to produce wood fibers. Again based on the patterned differences in the sustained force, it would appear that the tools were used by at least three individuals. These interpretations raise several questions about the nature of site use and storage practices during the early Paleoindian period in northeastern North America. However, owing to the opportunity that exists for independent post hoc evaluation of all parametric interpretations, future experimental research will almost surely dispel present uncertanties.

In summary, the results of the engineering use-wear studies provide new and provocative insights into early Paleoindian culture and society in Ontario.

References Cited

Storck, P.L. 1977 The Fisher Site. *Early Man News* 2 (Newsletter of the Commision for the Paleoecology of Early Man of INQUA, Tubingen, Germany.).

Storck, P.L. 1978a Some Recent Developments in the Search for Early Man in Ontario. *Ontario Archaeology* 29:3-16.

Storck, P.L. 1978b *Preliminary Report on the Fisher Project: 1978.* Submitted to the Ontario Ministry of Culture and Recreation, Toronto, and the Social Science and Humanities Research Council of Canada, Ottawa.

Storck, P.L. 1979 *Preliminary Report on the Glacial Lake Algonquin Survey: Udora-Kirkfield.* Submitted to the Ontario Ministry of Culture and Recreation, Toronto.

Storck, P.L. 1982 Paleo-Indian Settlement Patterns Associated with the Strandline of Glacial Lake Algonquin in Southcentral Ontario. *Canadian Journal of Archaeology* 6:1-31.

Storck, P.L. 1983 The Fisher Site, Fluting Techniques and Early Paleo-Indian Cultural Relationships. *Archaeology of Early North America* 11:80-97.

Tomenchuk, J. 1988 A Parametric Use-Wear Study of Areas C and C-East at the Fisher Site. In *The Fisher Site: An Early Paleo-Indian Site in Southern Ontario,* edited by Peter L. Storck, Royal Ontario Museum Monograph Series, in press.

Tomenchuk, J., and P.L. Storck 1989 An Engineering Use-Wear Study of a Cache of Flakes and Flake Tools from the Early Paleo-Indian Udora site in Southern Ontario, in press.

Secondary use of a Folsom Point at the Foley Site in Wyoming

Alice M. Tratebas

The Foley site is a Folsom occupation identified from sparse surface remains. The site is in the open Plains of southeastern Wyoming, 25 km east of the Laramie Range. Other Folsom sites are known from this region, including the Lindenmeier site 50 km to the south. The Foley site is in a small basin at the head of a dry tributary of Crow Creek, a perennial stream which flows into the South Platte River. The substrate in the area is Oglalla sandstone and conglomerate.

The surface evidence for the site consisted of a Folsom point midsection fragment, a utilized flake, several rough cores and flakes made from local cobbles, and a scatter of weathered bone. Preliminary test excavations did not result in further site definition. Two 1.0 m × 0.5 m test units excavated in the bone scatter did not produce evidence for the age or association of the highly fragmented bone. A single 1.0 m square excavated in the location of the point fragment yielded two more pieces of the midsection at a shallow depth. Although more testing will be needed to determine whether subsurface cultural remains are present or if the site is largely eroded, the point midsection does provide additional information about Folsom tool technology.

The three fragments of the midsection were produced by radial fracturing. The point was made from high quality pink chert containing light pink and gray inclusions. The distal end was broken by an impact fracture which left a horizontal break. The proximal break was also horizontal. Initially, a burin flake was struck off along one retouched edge of the point midsection and an adjacent flake was removed. Apparently, these modifications did not produce a usable tool and a radial fracture was tried. An impactor was struck vertically near one upper corner of the midsection and created a diagonal break that split the midsection into two triangular pieces. A third piece that resulted is a small curved fragment of the point retouched edge. This fragment expands toward the opposite face and resembles part of a cone of force. Usually, radial fractures are initiated by striking the center of a flake or biface to produce pie-shaped pieces and a cone of force is not produced.

Radial fracturing creates triangular pieces with tips and squared edges that are immediately usable as gravers and scrapers. One of the triangular pieces recovered from the Foley site has a natural tip enhanced by creation of a small notch. An extremely narrow burin-like flake extends down from the tip along the other edge. It is not clear if crushing damage within the notch was the result of manufacture or use. Notching near a corner to increase the structural strength of a graver tip has been reported for Folsom tools produced by bend break fracturing (Frison and Bradley 1980). The graver tip on the Foley site specimen, however, is already strong because of the thickness of the piece and backing by the retouched point edge. Since notches are a common tool type in Folsom assemblages (Frison and Bradley 1980; Frison and Stanford 1982), the notch on the Foley site specimen may have been intended for use. The other triangular piece does not exhibit any use-wear or

Alice M. Tratebas, Archaeologist, 90th CSG/DEEV, Warren AFB, WY 82005.

modifications to produce more usable tool edges. The radial fracturing likely took place at the site because we would expect the cone fragment to be discarded at the manufacturing location. Possibly only the modified triangular fragment was actually used.

Because radial fractures as a tool producing technique were not recognized until recently, it is difficult to tell whether reuse of broken Folsom points by radial fracturing is uncommon. In an analysis of Folsom lithic technology at the Hanson site in north-central Wyoming, Frison and Bradley (1980) observed that radial fracturing was used on flakes and on bifaces broken during various stages of manufacture or use. None of the Folsom points in the Hanson assemblage had been radially fractured. At the Lindenmeier site, Folsom points broken during manufacture were reused most often as graver tips and scrapers (Wilmsen and Roberts 1984). The same functions are the most satisfactory uses of radial break pieces. Many of the Lindenmeier specimens are longitudinal splits which have corners ready for immediate use. The thickness and angles of retouched edges on Folsom points broken horizontally are not conducive to immediate use for tools. The radial fracture technique may have been employed occasionally to increase the utility of such point fragments. A reexamination of assemblages recovered from Folsom sites excavated earlier might turn up more examples of this technique.

References Cited

Frison, G.C., and B.A. Bradley 1980 *Folsom Tools and Technology at the Hanson Site, Wyoming.* University of New Mexico Press, Albuquerque.

Frison, G.C., and D.J. Stanford 1982 *The Agate Basin Site.* Academic Press, New York.

Wilmsen, E.N., and F.H.H. Roberts, Jr. 1984 *Lindenmeier, 1934-1974: Concluding Report of Investigations.* Smithsonian Contributions to Anthropology No. 24. Smithsonian Institution Press, Washington, D.C.

Methods

Archaeological Taphonomy

Robson Bonnichsen

The challenge that the fossil and/or archaeological records pose to the modern-day faunal analyst is how to determine which specific causal mechanisms were responsible for the accumulation, the spatial, and the morphological dimensions of a particular bone assemblage undergoing analyses. Archaeological taphonomy is an emergent area of taphonomy that seeks to use a scientific approach for developing objective criteria for discriminating between the products of human behavior and other agencies (Bonnichsen 1988a, 1988b).

Binford (1981), in addressing the problem, borrowed the concept of middle-range theory from sociology (Rabb and Goodyear 1984). This approach was originally developed to offset the tendency of some theorists to develop abstract general theories which could not be tested against empirical data. Middle-range theory has been adopted to archaeological problem-solving for the purpose of developing a secure knowledge of the past by specifying scientific procedures for linking modern processes and patterns to the fossil and/or archaeological record.

The term middle-range theory is widely cited and has become a primary pursuit in archaeological taphonomy. Unfortunately, use of the term is ambiguous. Anyone conducting archaeological taphonomic analyses has a series of critical choices to make regarding which assumptions will be used in formulating taphonomic reconstructions. Often, these choices are not made explicit. For purposes here, I will briefly outline key alternative assumptions used in middle-range research that one must choose from in formulating an approach to middle-range research (see Bonnichsen 1988a, 1988b for a detailed discussion).

The first assumption is the choice of whether or not the fossil and/or archaeological record should be regarded as a dependent or independent variable. Most taphonomists agree that the record is the product of complex interactions among interdependent climatic, geologic, paleoecologic, and possibly cultural subsystems. It is no longer appropriate to simply assume that the archaeological and/or fossil record is a dependent variable; it is not simply the product of a cultural system.

The second assumption entails making a choice between whether to regard bone as a stable (properties remaining constant through time) or an unstable material.

Robson Bonnichsen, Center for the Study of Early Man, University of Maine, 495 College Avenue, Orono, ME 04473.

While many have assumed that bone is a stable material reflecting modification conditions prior to the time of interment, it has become increasingly clear that bone is a rather unstable material which undergoes a series of changes from green to dry to fossilized state, depending on the environment of deposition (Johnson 1985; Morlan 1980, 1984).

The third choice has to do with assumptions as to what constitutes an adequate explanation. While there are many forms of explanation (Salmon 1982), there is a divergence of opinion as to what constitutes an adequate explanation of taphonomic phenomena. Binford (1981), for example, advocates "if and only if" explanations (Grayson 1982, 1986) that can be applied universally for linking process and pattern. Binford's notion of explanation precludes consideration of conditional or limiting factors. By contrast, Bonnichsen (1988a, b) draws on Achestein's (1965) situational model of explanation. This model of explanation proposes that it is imperative to understand the details of local contexts to understand which of several competing mechanisms produced a specific pattern.

The fourth assumption has to do with ideas of how systems operate and the nature of the phenomena they produce. The normative view holds that where a representative of the behavior or phenomena is under consideration, one or few observations can be averaged together and variation is not important. Consequently, normative information used as a control study for decoding the past begins with inference in how process and pattern are linked. By contrast, the particularistic focus emphasizes that the proper subject matter of archaeological taphonomy is how individual processes produce patterns. Linked patterns and processes provide a secure starting point for comparing the prehistoric record with modern actualistic and experimental studies.

In summary, I propose the term "individualistic approach" to define this method of conducting middle-range research. This approach assumes that: 1) the fossil and/or archaeological records are products of complex interaction between linked climatic, geologic, paleoecologic, and archaeological subsystems; 2) bone is a non-static material that is modified by its depositional environment; 3) situational analysis is the most appropriate form of explanation in the embryonic subfield of taphonomy; and 4) actualistic and experimental studies in which specific processes and patterns have been linked will provide the most secure starting point for interpreting the archaeological and/or fossil record.

References Cited

Achestein, P. 1965 Explanation. In *Studies in the Philosophy of Science,* edited by N. Rescher, pp. 9-20. American Philosophical Quarterly, Monograph No. 3.

Binford, L.R. 1981 *Bones: Ancient Men and Modern Myths.* Academic Press, New York.

Bonnichsen, R. 1988a An Introduction to Archaeological Taphonomy. In *Bone Modification,* edited by R. Bonnichsen and M.H. Sorg. Center for the Study Early Man, University of Maine. Orono, in press.

Bonnichsen, R. 1988b Archaeological Taphonomy: Assumptions and Theory. In *Bone Modification,* edited by R. Bonnichsen and M.H. Sorg. Center for the Study of Early Man, University of Maine, Orono, in press.

Grayson, D.K. 1982 Review of Bones: Ancient Men and Modern Myths. *American Anthropologist* 84:439-440.

Grayson, D.K. 1986 Eoliths, Archaeological Ambiguity, and the Generation of "Middle-Range" Research. In *American Archaeology Past and Future,* edited by D.J. Meltzer, D.D. Fowler, and J.A. Sabloff, pp. 77-134. Smithsonian Institution Press, Washington D.C.

Johnson, E. 1985 Current Developments in Bone Technology. In *Advances in Archaeology*, vol. 8, edited by M.B. Schiffer, pp. 157-235. Academic Press, New York.

Morlan, R.E. 1980 *Taphonomy and Archaeology in the Upper Pleistocene of the Northern Yukon Territory: A Glimpse of the Peopling of the New World.* National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 94.

Morlan, R.E. 1984 Toward the Definition of Criteria for the Recognition of Artifactial Bone Alterations. *Quaternary Research* 22:160-171.

Raab, M.L., and A.C. Goodyear 1984 Middle-Range Theory in Archaeology: A Critical Review of Origins and Applications. *American Antiquity* 49:255-268.

Salmon. M.H. 1982 *Philosophy and Archaeology.* Academic Press, New York.

Accelerator ^{14}C Dating of Late Pleistocene Megafauna

Thomas W. Stafford, Jr.

A significant application of tandem accelerator mass spectrometry ^{14}C dating has been attempting to resolve two decades-old controversies: the timing of human migrations into the New World and the dating of late Pleistocene megafaunal extinctions which are nearly coincident with the Clovis-period hunters.

The precise dating of the Clovis culture (Haynes 1984) has not been accomplished for the extinct, terminal Pleistocene faunas, which are dated to 10,000-12,000 yr B.P. (Martin 1984) and into the Holocene (Kurtén and Anderson 1980). Two questions remain to be resolved. Are post-10,500 yr B.P. ^{14}C dates accurate? What is the time range within which the genera became extinct? Direct dating of fossils is mandatory because this approach eliminates uncertainty from stratigraphic interpretation, bioturbation, and sediment recycling. Although the problems with bone dating are long-standing (Protsch 1986; Stafford et al. 1987; Taylor 1982), fossil bone can now be dated accurately if a rigorous biochemical and geochemical approach is taken (Stafford et al. 1988).

Fossil bones are divisible into two major groups, those with collagenous compositions and those with non-collagen compositions. The former have a high probability of yielding accurate ^{14}C ages, whereas the latter poorly preserved specimens have an extremely low probability of accuracy. Bones with <0.1-0.2% N characteristically have non-collagen compositions and lack hydroxyproline, have decreased abundances of glycine and proline, and have two- to three-fold increases in the abundances of aspartic and glutamic acids. Bones with >0.2-0.5% N customarily have collagenous compositions and some or several of the physicochemical properties of modern bone.

Bones with non-collagen amino acid compositions should not be dated, regardless of their nitrogen content, because these severely-degraded fossils can comprise predominately exogenous organic matter. The known age (11,000 yr B.P.) Escapule mammoth (Hemmings and Haynes 1969) is an example of these poorly preserved fossils. Escapule dated 8,500±470 yr B.P. (AA-834) to 5,210±270 yr B.P. (AA-835)

Thomas W. Stafford, Jr. Center for Analytical Chemistry, National Bureau of Standards, Gaithersburg, MD 20899.

(Stafford et al. 1987) on the same chemical fractions (weak-HCl-insoluble residue and "gelatin") as are commonly used by radiocarbon laboratories. The protein hydrolyzate, which dated 4,610±280 (AA-836), was fractionated into its individual amino acids with the following results: aspartic acid—3,320±590 yr B.P. (AA-2656), glutamic acid—3,350±350 yr B.P. (AA-2657), and glycine—4,540±710 yr B.P. (AA-2661). The Holocene ages on the Clovis-period mammoth are an indication that accelerator ^{14}C dates without accompanying geochemical evidence are not incontrovertible evidence of a bone's geologic age.

Fossil bones with collagenous compositions represent an entirely different geochemical system, one in which contamination can be quantified by the radiocarbon dating of individual amino acids. Accelerator ^{14}C dates on the 11,000 yr B.P. Dent mammoth illustrate the potential for dating fossils with collagenous compositions. The Clovis-period Dent mammoth (Haynes 1974) has 0.8% N and would be considered a good candidate for collagen ^{14}C dating by standard methods. Originally, four fractions were analyzed: weak-HCl-insoluble collagen (8,250±520 yr B.P. (AA-830)), gelatin (9,240±350 yr B.P. (AA-831)), XAD-purified collagen hydrolyzate (10,590±500 yr B.P. (AA-832)), and XAD-purified gelatin hydrolyzate (10,950±480 yr B.P. (AA-833)) (Stafford et al. 1987). The collagen hydrolyzate was subsequently separated into its individual amino acids and each was dated. The fractions were: XAD-purified collagen hydrolyzate (10,890±90 yr B.P. (AA-2941)), aspartic acid (10,660±170 yr B.P. (AA-2942)), glutamic acid (10,800±110 yr B.P. (AA-2943)), threonine (10,380±140 yr B.P. (AA-2944)), hydroxyproline (10,600±90 yr B.P. (AA-2945)), glycine (10,710±90 yr B.P. (AA-2946)), and alanine (10,670±120 yr B.P. (AA-2947)).

Weak-HCl-insoluble collagen and gelatin are commonly dated fractions. Their geologically young ages from Dent are an example of how Holocene dates can be obtained from Pleistocene-age fossils. The young ages are due to fulvic acid contamination remaining in the dated fractions. Dates of 9,000 yr B.P. and more recent (Kurtén and Anderson 1980) on extinct fauna and even <10,000 yr B.P. (Mead and Meltzer 1984) are probably due to improper sample pretreatment, not to Holocene ages for the bones.

Although all Dent mammoth amino acids dated within 2 sigma of one another, the threonine value should be excluded from averaging calculations because threonine is less stable than the other amino acids in geologic environments (Kvenvolden 1975).

If only fossils meeting minimum criteria for chemical composition are used and several individual amino acids are dated, accuracy similar to the Dent mammoth example is attainable. Multiple-fraction dating will enable ^{14}C results on bone to be evaluated on geochemical criteria instead of subjective ones. Radiocarbon dates on individual amino acids from properly selected bones should enable late Wisconsin extinction events to be dated within ±100 years or less. When this degree of precision and accuracy is achieved on a large suite of fossils, then and only then can extinction causes and extinction contemporaneity with early North American humans be evaluated.

Funding for this research was provided by the Carnegie Institution of Washington Geophysical Laboratory, Washington, D.C., the National Research Council, National Science Foundation Grant BNS 86-16891, and the Center for Analytical Chemistry, National Bureau of Standards.

References Cited

Haynes, C.V., Jr. 1974 Archaeological Geology of Some Selected Paleo-Indian Sites. In *History and Prehistory of the Lubbock Lake Site,* edited by C.C. Black, pp. 383-398. The Museum Journal XV, West Texas Museum Association, Lubbock.

Haynes, C.V., Jr. 1984 Stratigraphy and Late Pleistocene Extinctions in the United States. In *Quaternary Extinctions: A Prehistoric Revolution,* edited by P.S. Martin, and R.G. Klein, pp. 345-353. University of Arizona Press, Tucson.

Hemmings, E.T., and C.V. Haynes 1969 The Escapule Mammoth and Associated Projectile Points, San Pedro Valley, Arizona. *Journal of the Arizona Academy of Science* 5:184-188.

Kurtén, B., and E. Anderson 1980 *Pleistocene Mammals of North America.* Columbia University Press, New York.

Kvenvolden, K.A. 1975 Advances in the Geochemistry of Amino Acids. *Annual Reviews in Earth and Planetary Sciences* 3:183-212.

Martin, P.S. 1984 Prehistoric Extinction: The Global Model. In *Quaternary Extinctions: A Prehistoric Revolution,* edited by P.S. Martin, and R.G. Klein, pp. 354-403. University of Arizona Press, Tucson.

Mead, J.I., and D.J. Meltzer 1984 North American Late Quaternary Extinctions and the Radiocarbon Record. In *Quaternary Extinctions: A Prehistoric Revolution,* edited by P.S. Martin, and R.G. Klein, pp. 440-450 University of Arizona Press, Tucson.

Protsch, Reiner R.R. 1986 Radiocarbon Dating of Bones. In *Dating and Age Determination of Biological Materials,* edited by M.R. Zimmerman, and A.J. Lawrence, pp. 3-38. Croom Helm, London.

Stafford, T.W., Jr., A.J.T. Jull, K. Brendel, R.C. Duhamel, and D. Donahue 1987 Study of Bone Radiocarbon Dating Accuracy at the University of Arizona NSF Accelerator Facility for Radioisotope Analysis. *Radiocarbon* 29:24-44.

Stafford, T.W., Jr., K. Brendel, and R. Duhamel 1988 Radiocarbon, ^{13}C and ^{15}N Analysis of Fossil Bone: Removal of Humates with XAD-2 Resin. *Geochimica et Cosmochimica Acta,* in press.

Taylor, R.E. 1982 Problems in the Radiocarbon Dating of Bone. In *Nuclear and Chemical Dating Techniques,* edited by L.A. Currie, pp. 454-473. American Chemical Society, Washington, D.C.

Paleoenvironments: Plants

Preliminary Opal Phytolith Analysis of Modern Analogs from Parklands, Mixed Forest, and Selected Conifer Stands in Prince Albert National Park, Saskatchewan

Steven R. Bozarth

Opal phytoliths are microscopic silica bodies formed by the silicification of plant cells, cell walls, and intercellular spaces. Phytoliths form in most plants and are produced in many varied shapes and sizes due to the many different types of cells in any particular plant (Rovner 1975). Phytoliths formed in arboreal dicots, such as aspen, usually consist of fragile silicifed cell walls (Wilding and Drees 1971) whereas solid polyhedral-shaped phytoliths are characteristic of conifers. Specific types of phytoliths differentiate the Pooideae, Panicoideae, and Chloridoideae grass subfamilies. Pooids are adapted to cool-moist environments (Twiss 1987) and are the dominant grasses in the North American boreal forest (Pohl 1978). Panicoids are dominant in warm areas with high available soil moisture (Twiss 1987), and occur only rarely in the boreal forest (Pohl 1978). Chloridoids are mostly steppe, desert, and warm climate grasses, although several Chloridoid species are adapted to moist environments and are found in boreal forests (Pohl 1978). Grasses produce several times more phytoliths than most non-grasses. Most grass and polyhedral phytoliths are well preserved in soil, whereas most dicot phytoliths are not well preserved.

I have analysed phytoliths isolated from surface soil samples collected during August, 1987 from the principal types of vegetation characteristic of North American boreal forest for use as modern analogs in the interpretation of Pleistocene phytolith assemblages isolated from the sedimentary record in the central Plains. Phytoliths were isolated from 10 g samples using a heavy liquid floatation and centrifugation procedure reported by Rovner (1971).

Over 100 Pooid, Panicoid, Chloridoid, and polyhedral phytoliths were counted in each of the modern analogs (Figure 1). Dicot phytoliths were not preserved. As expected, the phytolith assemblage from the grassland analog is dominated by Pooid grasses. However, Pooid grasses are overrepresented in the phytolith assemblages in the other analogs. The presence of Chloridoid phytoliths in the aspen analogs differentiates them from the grassland analog. The three conifer analogs are

Steven R. Bozarth, Department of Geography, University of Kansas, Lawrence, KS 66045-2121.

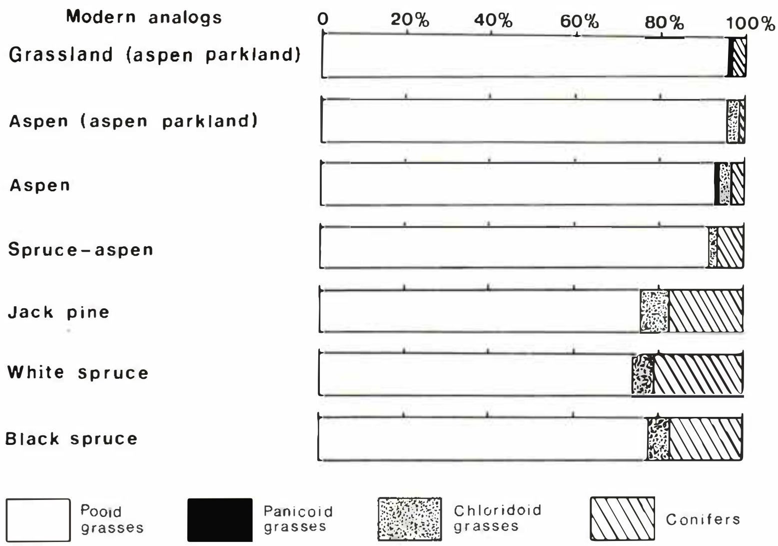


Figure 1. Relative frequency of phytolith types isolated from modern analogs collected in Prince Albert National Park in central Saskatchewan.

distinguished from the others by the presence of at least 17% polyhedral phytoliths. The frequency of polyhedral phytoliths in the spruce-aspen analog is significantly more than what occurs in the aspen and grassland analogs but considerably less than what is produced in the conifer analogs.

This study demonstrates that selected types of vegetation characteristic of a boreal forest produce distinctive types of phytolith assemblages. A comparison of these modern analogs with Pleistocene phytolith assemblages isolated from sediment in the central Plains will allow a more precise reconstruction of Pleistocene environments in the central Plains.

This study was partially funded by a grant from Sigma Xi.

References Cited

Pohl, R. W. 1978 *How to Know the Grasses.* Wm. C. Brown Company Publishers, Dubuque, Iowa.

Rovner, I. 1971 Potential of Opal Phytoliths for Use in Paleoecological Reconstruction. *Quaternary Research* 1:343-359.

Rovner, I. 1975 Plant Opal Phytolith Analysis in Midwestern Archaeology. *Michigan Academician* 8:129-137.

Twiss, P.C. 1987 Grass-Opal Phytoliths as Climatic Indicators of the Great Plains Pleistocene. *Quaternary Environments of Kansas,* edited by W.C. Johnson, pp. 179-188. Kansas Geological Survey Guidebook, Series 5.

Wilding, L.P., and L.R. Drees 1971 Biogenic Opal in Ohio Soils. *Proceedings of the Soil Science Society of America* 35:1004-1010.

Late Wisconsin Macroscopic Remains of Pinyon Pine on the Southern Colorado Plateau, Arizona

Steven K. Cinnamon and Richard H. Hevly

The distribution of pinyon pine (*Pinus edulis*) in the American Southwest during the Wisconsin has become a controversial topic. Analysis of packrat middens has previously failed to disclose the presence of this species in the Great Basin and on the Colorado Plateau during the late Wisconsin and early Holocene, yet pollen analysts have consistently reported the presence of its pollen (Wright et al. 1973; Hevly 1985; Fine-Jacobs 1985). Pinyon pine has been previously thought by some investigators to have retreated to warm, southern environments during the mid-Wisconsin and entered the Colorado Plateau region no earlier than 8,000-10,000 yr B.P. (Van Devender et al. 1987). Older pinyon records in southeast New Mexico and western Texas were thought to have been the stock from which the present communities of pinyon pine on the Colorado Plateau were derived (Betancourt 1987).

However, four late Wisconsin-early Holocene packrat middens containing abundant 2-needle fascicles, cones, and nut fragments of pinyon pine have now been located on the southern Colorado Plateau at Wupatki National Monument, 56 km north of Flagstaff, Coconino County, Arizona. The radiocarbon dates on needles are: 10,890±680 yr B.P. (WS-413 N, GX-12392); 11,210±185 yr B.P. (Antelope Wash 1, GX-12948); 11,500±380 yr B.P. (Raptor-l, GX-12947); and 13,670+1,160/-1,010 yr B.P. (Citadel Wash-l, GX-13677). Pretreatment included a hot dilute hydrocholoric acid rinse to remove any carbonates and with hot dilute sodium hydroxide to remove humic acids and other organic contaminants. All middens were removed from crevices and shallow alcoves of Permian age Kaibab limestone at an elevation of approximately 1,530 m and were within 1 km of one another. Based on vegetation present at the sites, the area would be considered as a southern extension of the Great Basin Desert. The middens were incidentally collected as part of a series used to determine environmental changes associated with prehistoric and historic human occupation, as well as climatic change and cinder deposition from nearby Sunset Crater (Cinnamon 1988).

Pinyon pine is absent in the lower elevation parts of the monument today, but scattered individuals do occur within 2 km and at elevations about 200 m higher than the late Wisconsin-early Holocene middens reported here. The pinyon dates extend the documentation of the presence of pinyon pine on the southern Colorado Plateau back 3,000 years prior than previous records and into the late Wisconsin. The associated macroscopic remains include *Opuntia* spp. (cactus), *Sheperdia rotundifolia* (buffalo-berry), *Artemisia* spp. (sagebrush), *Purshia neomexicana* (antelope brush), *Juniperus scopulorum* (Rocky Mountain juniper), and several grasses. Pollen extracted from the rehydration medium of the middens includes riparian species such as *Alnus* (alder), *Betula* (birch), *Celtis* (hackberry), *Juglans* (walnut), *Populus* (aspen/ cottonwood), and *Salix* (willow), with which *Juniperus scopulorum* are locally absent today in the monument.

Steven K. Cinnamon, Wupatki-Sunset Crater National Monuments, HC33 Box 444A, Flagstaff, AZ 86004.
Richard H. Hevly, Department of Biology, Box 5640, Northern Arizona University, Flagstaff, AZ 86011.

The Wupatki records suggest that either the invasion of the Colorado Plateau by pinyon pine from southern sources occurred much more rapidly than previously anticipated or more likely, in our opinion, that pinyon pine persisted during the Pleistocene on the Colorado Plateau in relictual populations in low elevation canyon systems. The later alternative also provides a much closer seed source for rapid establishment of the widely distributed communities of pinyon pine previously documented on the Colorado Plateau in the early Holocene (Wells 1983; Van Devender et al. 1987).

References Cited

Betancourt, J.L. 1987 Paleoecology of Pinyon-juniper Woodlands: Summary. In *Proceedings of Pinyon-Juniper Conference,* edited by R.L. Everett, pp. 129-139, U.S. Department of Agriculture, Forest Service, General Technical Report Int-215.

Cinnamon, S.K. 1988 Vegetation Community in Response to Prehistoric and Historic Environmental Change at Cedar Canyon, Wupatki National Monument, Arizona. Ms in possession of author.

Hevly, R.H. 1985 A 50,000 Year Record of Quaternary Environments; Walker Lake, Coconino Co., Arizona. In *Late Quaternary Vegetation and Climates of the American Southwest,* edited by B. Fine-Jacobs, P.L. Fall, and O.K. Davis, pp. 141-154. American Association of Stratigraphic Palynologists No. 16.

Fine-Jacobs, B. 1985 Identification of Pine Pollen from the Southwestern United States. In *Late Quaternary Vegetation and Climates of the American Southwest,* edited by B. Fine-Jacobs, P.L. Fall, and O.K. Davis, pp. 155-168. American Association of Stratigraphic Palynologists No. 16.

Van Devender, T.R., R.S. Thompson, and J.L. Betancourt 1987 Vegetation History of the Deserts of Southwestern North America. In *North American and Adjacent Oceans During the Last Deglaciation,* edited by W.F. Ruddiman and H.E. Wright, Jr., pp. 323-352. The Geology of North America No. K-3, Geological Society of America, Boulder, Colorado.

Wells, P.V. 1983 Paleobiogeography of Montane Islands in the Great Basin Since the Last Glaciopluvial. *Ecological Monographs* 53:341-382.

Wright, H.E., Jr., A.N. Bent, B.S. Hansen, and L.J. Maher, Jr. 1973 Present and Past Vegetation of the Chuska Mountains, Northwestern New Mexico. Geological Society of America Bulletin 84:1155-1180.

Use of Green Algae Abundances for Augmenting Palynological Interpretation

James K. Huber

Preliminary investigations of green algae recovered in conjunction with pollen in a 12,040-year-old sequence from Big Rice Lake, St. Louis County, Minnesota indicate that the lake has undergone three periods of hypertrophism as a result of changes in nutrient influx into the lake. Big Rice Lake, with an area of 840 ha, is located at 92° 29′W, 47° 42′N, approximately 20 km north of Virginia, Minnesota. Previous analysis of the pollen assemblages indicates that the vegetation progressed from a

James K. Huber, Archaeometry Laboratory, University of Minnesota-Duluth, Duluth, MN 55812.

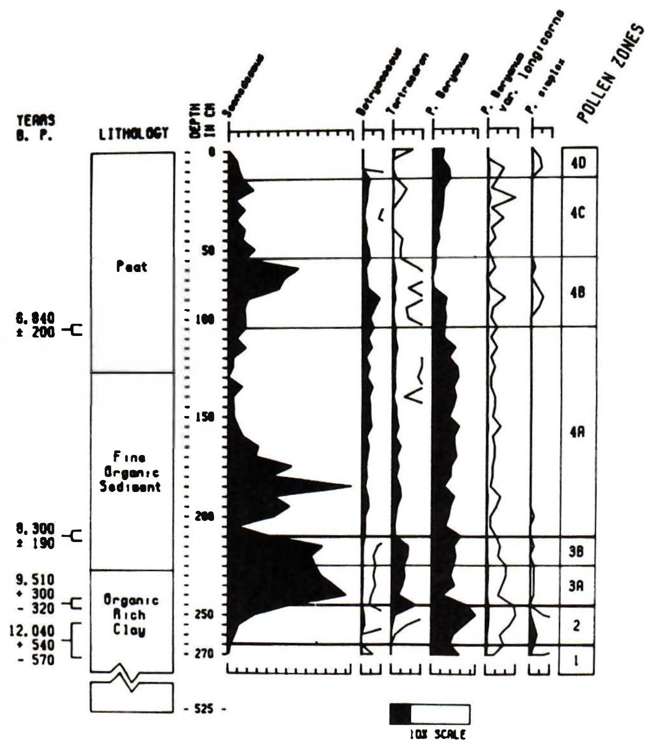


Figure 1. Algae percentage diagram of selected taxa from Big Rice Lake, St. Louis County, Minnesota.

shrub tundra-like environment to a mixed conifer-hardwood forest similar to that found in the watershed today (Huber 1987).

A 525 cm core extracted from the lake was composed of three stratigraphic units: peat, overlying a layer of fine organics, above an organic-rich clay. Four of six radiocarbon samples submitted for dating are currently available. They are 102-107 cm, 6,840±200 yr B.P. (DIC-3319); 207-212 cm, 8,300±190 yr B.P. (DIC-3320); 242-247 cm, 9,510+300/-320 yr B.P. (DIC-3321); and 255-272 cm, 12,040+540/-570 yr B.P. (DIC-3322). Estimated sedimentation rates for the core are: 0.10 mm/yr for 12,40-9,510 yr B.P.; 0.29 mm/yr for 9,510-8,300 yr B.P., 0.72 mm/yr for 8,300-6,840 yr B.P.; and 0.15 mm/yr for 6,840 yr B.P.-present. The average estimated accumulation rate for Big Rice Lake sediments is 0.22 mm/yr.

The sequence found at Big Rice Lake is visualized as representing dynamic change in environment and sedimentology. In early stages the lake was oligotrophic and the algae assemblage was represented by pioneer species such as *Pediastrum integrum* and *P. simplex*. As sediment began to infill the lake, the water column became more eutrophic, as indicated by the increase in *P. boryanum* (Figure 1). Shifts in the abundance of *Scenedesmus*, as indicator of high nutrient concentration (Cronberg 1982), indicate that Big Rice Lake has undergone three periods of hypertrophism. The first occurred after 9,510 yr B.P. when the watershed was covered by an open conifer-hardwood forest conducive to a high nutrient influx to the lake through runoff. The second period of hypertrophism correlates well with the maximum of the mid-Holocene warm and dry period when sediment accumulation increased and the water level probably dropped, concentrating available nutrients. The third period of hypertrophism can be correlated with an increase in deciduous trees such as *Quercus* (oak) and *Ulmus* (elm) that may have increased available nutrients in the lake as a result of leaf litter influx.

Continuing efforts to correlate algal abundances with the pollen records, radiocarbon dates, estimated sedimentation rates, and chemical reconstructions will provide a more complete climatic and vegetational reconstruction of the Big Rice Lake watershed.

References Cited

Cronberg, G. 1982 *Pediastrum* and *Scenedesmus* (Chlorococcales) in Sediments from Lake Vaxjosjon, Sweden. *Arch. Hydrobiol. Suppl.* 60:500-507.

Huber, J.K. 1987 A Vegetational Reconstruction from Big Rice Lake, St. Louis County, Minnesota. *Current Research in the Pleistocene* 4:89-91.

Thaw Lake Development and its Effect on Plant Macrofossil Deposition

Janet G. Kidd

A recent study of thaw lake development on the northern Seward Peninsula in Alaska has important ramifications for interpreting plant macrofossil assemblages from Pleistocene thaw lake deposits. Thaw lakes have been forming on the Seward Peninsula for the last 100,000 years (Hopkins and Kidd 1988) and thus provide a unique opportunity for a detailed analysis of the paleoenvironmental history of this area during the peak of the last glacial cycle. From observations of the process of thaw lake development in active lakes, we can better understand how plants become incorporated into thaw lake deposits and how the process of thaw lake development affects their preservation and deposition.

Thaw lakes are initiated by disruption of the vegetation from ice wedges and the thawing of ice-rich sediment (Hopkins 1949). The melting of the ice causes the ground to subside, and water accumulates in the depression to form a small pool. In summer, the pool expands as it absorbs radiant energy and continues to melt the permafrost at its margins. As the pool enlarges, vegetation is engulfed in its path. The pools often expand so rapidly that aquatic vegetation does not establish. Thus, it is predominantly the non-aquatic vegetation surrounding a thaw lake that is preserved in the sediments.

Janet G. Kidd, Department of Biology and Wildlife, University of Alaska Fairbanks, Fairbanks, AK 99775-0180.

During the summer of 1987 I studied two active thaw lakes (informally named Egg Lake and Berry Lake) near the Kitluk River on the northern Seward Peninsula in Alaska. A series of macrofossil cores were taken along the shore of the lakes, and another series were taken 2-10 m from the shore. The selection of the core sampling areas was designed to study the process by which terrestrial plant material becomes incorporated and preserved in the lake sediment.

The stratigraphy of the near-shore cores of the two lakes was very similar in the recording of vegetation that had recently fallen into the lake. There were commonly two zones of material present in the cores. The upper zone contained remains of terrestrial vegetation with its associated peat, and a few aquatic mosses. The lower zone was an organic-poor silt.

The distant-shore cores differed markedly between the two lakes. The cores from Berry Lake contained an uppermost zone of aquatic mosses and detritus, a lower zone of organic-poor silt and/or redeposited tephra, and a lowest zone of compacted terrestrial plant remains. This last zone is the basal transgressive layer as described by Hopkins and Kidd (1988). In contrast, the distant-shore cores of Egg Lake differed: they penetrated an upper zone of aquatic mosses and detritus; a lower zone of terrestrial plant remains; and a lowest zone of silt, redeposited tephra, or a mixture of both. This zonation was not always well-defined and frequently there were several lenses of organics separated by silt and redeposited tephra below the uppermost zone.

The differences found between the distant-shore cores of Egg Lake and Berry Lake can be explained in terms of the differences in their topographic setting. Egg Lake formed in a plateau that contained syngenetic ice wedges which upon thawing caused the plateau to subside to form a deep basin. The lake is expanding into drained thaw lakes to the north and south, but it is flanked by steep 7 m bluffs to the east and west. The bluff sediment is ice-saturated and in response to exposure and wave erosion slumps into the lake as mudflows, incorporating mats of vegetation from the top of the bluff into the lake. The high sediment yield reduces the rate of lake expansion. The lenses of organics found in the distant-shore cores of Egg Lake probably represent repeated episodes of turf sliding into the lake. When the turf reaches the lake it may be buried as a single mass by a mudslide from the bluff, or it may fragment into smaller units and slowly drift toward the center of the lake where it is buried by lake sediment.

The distant-shore cores from Berry Lake illustrate more closely the pattern of thaw lake development as described by Hopkins (1949), Hopkins and Kidd (1988), and Britton (1966). Berry Lake formed in the basin of a thaw lake that drained about 1,500 years ago. Most of the periphery of the bank is less than 1.5 m high, but at the west end Berry Lake is eroding into a high bluff similar to that of Egg Lake. Syngenetic ice wedges that might have formed here have long since thawed, and shallow epigenetic ice wedges and ice-rich permafrost are responsible for the development of the lake. Because the banks of the lake are low, vegetation is undercut and calves off the top of the bank instead of slumping downslope. The shallow depth of the lake (1-3 m) allows wave action to churn up lake sediment and quickly bury vegetation that has subsided into the lake. Wave action also causes some collapsed mats of vegetation to drift to other parts of the lake before becoming deposited in the sediment.

When using plant macrofossils collected from thaw lake sediments to reconstruct past vegetation, the problem of redeposition must be considered. Berry Lake formed in an ancient thaw lake basin and likely contains plant remains from the ancient thaw lake. With a greater understanding of the taphonomy of plant macrofossils from thaw lake sediments, it may be possible to recognize redeposited plant remains. Investigations of thaw lakes in non-tundra regions will expand our knowledge of how other environmental factors such as vegetation physiogamy affect thaw lake development and plant macrofossil deposition. Ancient thaw lake deposits are undoubtedly a resource that should be tapped in future paleoenvironmental studies.

I thank Dr. David M. Hopkins for his insightful observations in the field and for his helpful suggestions in the preparation of this manuscript. I would also like to thank the National Park Service for field equipment and logistical support during the 1987 field season.

References Cited

Britton, M.E. 1966 *Vegetation of the Arctic Tundra.* Oregon State University Press, Corvallis.

Hopkins, D.M. 1949 Thaw Lakes and Thaw Sinks in the Imuruk Lake Area, Seward Peninsula, Alaska. *Journal of Geology* 57:119-131.

Hopkins, D.M. and J.G. Kidd 1988 Thaw Lakes and Thaw Lake Sediments in Tundra Regions in Alaska. *Fifth International Permafrost Conference,* Trondheim, in press.

Use of Algae for Inferring Paleolimnologic Water Quality

Barbara W. Liukkonen and James K. Huber

Continuing investigation of a 75 cm core from August Lake (93° 37′ 33″N 47° 42′ 30″W), Lake County, Minnesota, indicates that shifts in non-siliceous algae correlate with the previously presented paleoecological reconstruction (Wonson-Liukkonen and Huber 1987). Palynological interpretation described a watershed undergoing vegetative transition from a post-glacial open parkland to a mixed conifer-hardwood forest. Analysis of diatom assemblages indicated that the major changes in August Lake were a decrease in water transparency and variation in species diversity. A reconstruction based on diatom abundance and pH preferences showed no significant shift in pH.

Trends in green algae abundance correlate with the four zones identified through original analyses of pollen and diatoms (Figure 1). In zone 1 the abundance of non-siliceous algae is low, averaging 2.6% of the total palynomorphs counted. In zone 2 algae increase to an average of 13.6%. In zone 3 algae decrease to an average of 10.7% and pollen from aquatic macrophytes increase. Zone 3 is also characterized by greater concentrations and species diversity for both diatoms and non-siliceous algae. In zone 4 green algae decrease to 7.3%; however there are slight increases in the percentages of *Scenedesmus, Pediastrum boryanum,* and *Botryococcus.*

Barbara W. Liukkonen, Minnesota Sea Grant Program, 208 Washburn Hall, University of Minnesota, Duluth, MN 55812.

James K. Huber, Archaeometry Laboratory, Research Lab Building, University of Minnesota, Duluth, MN 55812.

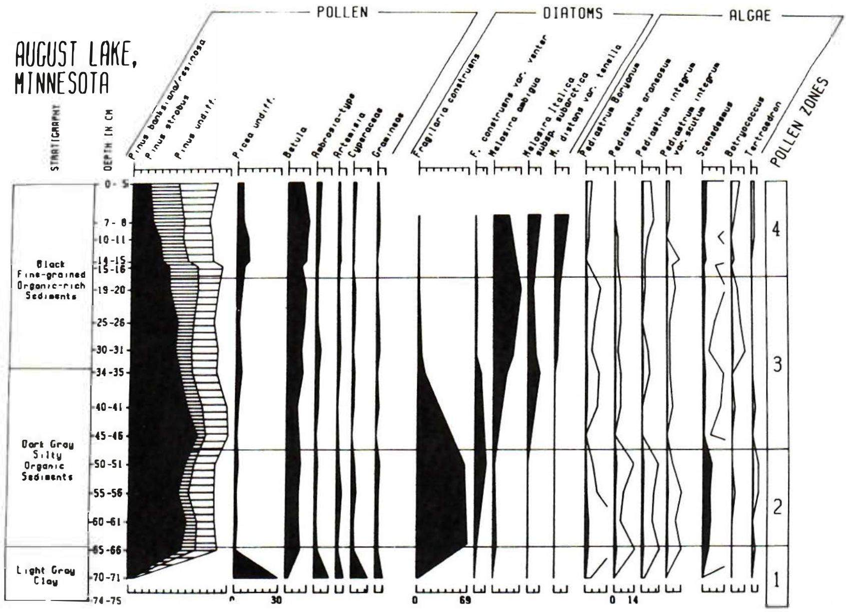


Figure 1. Percentage diagram of selected pollen, diatom, and green algae taxa for August Lake, Minnesota. Shaded silhouettes are actual percentages, unshaded silhouettes are 10x exaggerations.

Zone 1 is interpreted as representing the period immediately following glacial retreat when sedimentation was high and nutrient availability was very low. The pollen spectra during this period are dominated by spruce *(Picea)* and herbs typical of parkland. No identifiable diatoms were counted in zone 1. Zone 2 represents a period of slightly higher nutrient influx, indicated by increases in pioneer species such as *P. integrum, P. boryanum,* and *Botryococcus,* and an increase in diatom concentrations. The lake was oligotrophic; diatom assemblages are dominated by clearwater, benthic *Fragilaria* spp. In zone 3 the number of algal species, aquatic macrophytes, and productivity increased in response to increased nutrient availability. Increased macrophytic growth would have provided additional sites for the growth of epiphytic and periphytic *P. boryanum* and *Scenedesmus,* which were the predominant non-siliceous algae in zone 4. By this time, the diatom assemblages are dominated by planktonic *Melosira* with very low percentages of benthic taxa, implying decreased water column transparency. The pollen record indicates a mixed conifer-hardwood forest. It was during this time that logging of the region occurred and preliminary estimates indicate a higher rate of sedimentation. Greater nutrient influx to the lake and decreased transparency may have resulted from increased leaf litter and sediments transported to the lake by runoff.

Algal abundances have been used to indicate periods of hypertrophism (Cronberg 1982; Huber 1988). Although August Lake has not undergone severe eutrophication, use of algal records helps provide a more complete history.

References Cited

Cronberg, G. 1982 *Pediastrum and Scenedesmus* (Clorococcales) in Sediments from Lake Vaxjosjon, Sweden. *Arch. Hydrobiol. Suppl.* 60:500-506.

Huber, J.K. 1988 Use of Green Algae Abundances for Augmenting Palynological Interpretation. *Current Research in the Pleistocene* 5, in press.

Wonson-Liukkonen, B., and J.K. Huber 1987 A Paleoecological Reconstruction from August Lake, Lake County, Minnesota. *Current Research in the Pleistocene* 4:98-100.

Palynological Studies in the Venezuelan Guayana Shield: Preliminary Results

Valenti Rull, Carlos Schubert, and Ramón Aravena

Palynological analyses of sediments in the Venezuelan Guayana Shield were recently begun (Schubert and Salgado-Labouriau 1987) in order to document: 1) the existence (or not) of the late Pleistocene Pantepui Refuge (which includes most of the shield; Huber 1987), its age, and geographic extent; and 2) the Quaternary vegetational and climatic history of the region.

The first analyses were done on peat sequences from the summits of the Guaiquinima and Chimantá Massifs (Figure 1), composed of quartzite table mountains. The main features of these peats, as well as their radiocarbon ages, were published by Schubert et al. (1986). The detailed study of the present pollen deposition is still in progress, and some important pollen types from Guaiquinima remain unidentified; however, some general tendencies can be deduced. The oldest peat (Guaiquinima) found to date is about 8,000 yr B.P. (after correction for modern contamination and bomb effect), and their pollen content reflects an inundated herbaceous environment, where Gramineae probably dominated. Therefore, a humid climate is inferred, in which precipitation (P) was higher than evaporation (E). This agrees well with previous geomorphological and sedimentological studies, showing a climatic shift from late Pleistocene aridity to more humid early Holocene conditions (Schubert et al. 1986). Figure 1 shows the oscillations of pollen assemblages in the Chimantáa sequences; the pollen grains were grouped according to the vegetational types of Huber (1986). The main pollen components are: 1) forest: *Bonnetia roraimae* (the dominant species in the gallery forests), *Podocarpus*, and *Weinmania*; 2) shrubs: *Chimantaea* (indicator of *páramo*-like vegetation), *Ilex*, *Cyrilla*, Melastomataceae, and Ericaceae; 3) herbaceous communities: *Xyris*, *Stegolepis*, Gramineae, and Ciperaceae. The forest curves show variations in the importance of this vegetational type, which probably reflects changes in drainage patterns, because gallery forests are the most common type. The phases of low importance of shrubs generally coincide with the presence of algae (Zygnemataceae), suggesting inundation (van Geel 1979). It is known that several table-mountain shrubs do not tolerate anoxic conditions in their roots (Cuevas 1988); therefore, the hypothesis favoring humidity changes is reinforced.

Valenti Rull, Carlos Schubert, and Ramón Aravena, Centro de Ecología, I.V.I.C., Apartado 21827, Caracas 1020A, Venezuela.

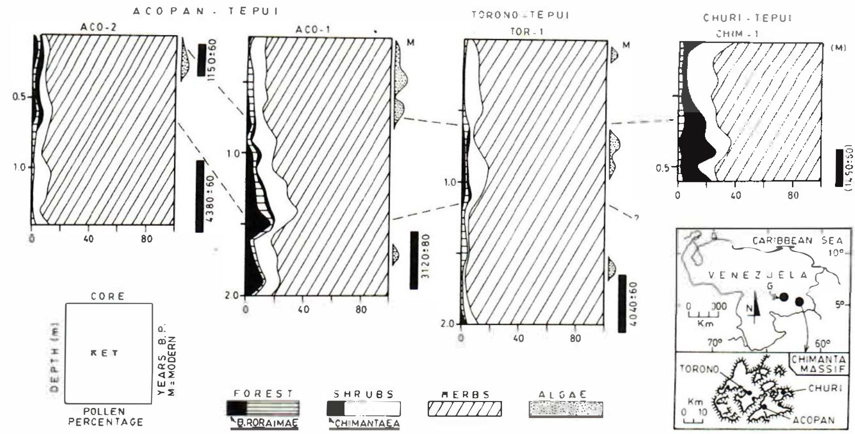


Figure 1. Preliminary pollen diagrams and tentative correlations from the Chimantá Massif (G: Guaiquinima Massif).

A very preliminary palynostratigraphical correlation is also shown in Figure 1. The gallery forest and the *páramo*-like vegetation probably reached their maximum extend between approximately 2,500 and 1,000 yr B.P. (corrected ages: 3,000 to 1,300 yr B.P.). The ecological relationships between these plant communities and climate are still poorly known, but some hydrological factor, probably related to the P/E ratio, is assumed to be important.

Our results show the Holocene variation of climate and vegetation on the summit of the table mountains studied. Pleistocene climatic changes were nearly everywhere stronger than the Holocene ones (Fairbridge 1970); therefore, the assumed Pleistocene biotic constancy accompanying the refuge hypothesis (Haffer 1982) is not supported. Very interesting also is the fact that pollen assemblages from the base of all peat sections reflect plant communities with a certain degree of complexity, not to be expected in early stages of colonization. This may be due to the removal of older peat by groundwater flow, but it is also possible that small vegetation stands grew in certain favorable sites (microrefuges?) during the Pleistocene dry phases. When the climate changed to a more humid one, recolonization proceeded from these more or less complex stands, and relatively rich pollen assemblages might have been deposited.

Current efforts in our work are center on: 1) pollen morphological studies, in order to increase the number of identified pollen types; 2) the study of the modern pollen deposition in relation to the present vegetation and climate, to facilitate the interpretation of pollen diagrams; and 3) the search for new localities (both in the high-and lowlands), to amplify the geographical correlationsand to find chronologically longer peat sections.

This study is part of a long-term collaborative project with CVG-EDELCA, the Department of Earth Sciences (University of Waterloo, Canada), and with the support of CONICIT Grants S1-1343 (O. Huber) and S1-1834 (C. Schubert).

References Cited

Cuevas, E. 1988 Perfil Nutricional de la Vegetación de Turberas en el Macizo del Chimantá, Estado Bolívar. *Acta Científica Venezolana,* in press.

Fairbridge, R.W. 1970 World Paleoclimatology of the Quaternary. *Rev. Géog. Phys. et Géol. Dyn.* 12:97-104.

Haffer, J. 1982 General Aspects of the Refuge Theory. In *Biological Diversification in the Tropics,* edited by G.T. Prance, pp. 6-24. Columbia University Press, New York.

Huber, O. 1986 La Vegetación de la Cuenca del Río Caroní. *Interciencia* 11:301-310.

Huber, O. 1987 Concideraciones Sobre el Concepto de Pantepui. *Pantepui* 2:2-10.

Schubert, C., H.O. Briceno, and P. Fritz 1986 Paleoenvironmental Aspects of the Caroní-Paragua River Basin (Southeastern Venezuela). *Interciencia* 11:278-289.

Schubert, C., and M.L. Salgado-Labouriau 1987 Alluvial and Palynological Studies in the Venezuelan Guayan Shield. *Current Research in the Pleistocene* 4:162-164.

van Geel, B. 1979 Preliminary Report on the History of Zygnemataceae and the Use of Their Spores as Ecological Markers. *Transactions of the IV International Palynological Conference* 1:467-469.

Paleoenvironments: Invertebrates

Pilot Study of Fossil Beetles at the Lubbock Lake Landmark

Scott Elias and Eileen Johnson

Excavations in well-stratified, well-dated deposits at the Lubbock Lake Landmark (41LU1) in Yellowhouse Draw on the southern High Plains of Texas have focused on the relationship of the cultural, natural history, and geological records that span the last 12,000 years. Water processing of all excavated sediments through a series of nested, size-graded screens has produced a tremendous data base from which to study the past environments through natural history proxy data (Johnson 1986).

A pilot study was undertaken to determine the potential of Lubbock Lake fossil insect assemblages. Six water-processed but unsorted fine-screen residue samples were selected based on time period, previously generated proxy data, and high organic content of the sediments. Each sample was washed through a 300 μm sieve. Because the sieve residues were very small (less than 50 ml), they were sorted directly rather than processed by the kerosene flotation method. After sorting, robust specimens were mounted on modified micropaleontology cards and fragile specimens were stored in vials of alcohol.

Because of the small sample size, most of the samples contained little or no fossil insect material, but two samples contained identifiable specimans of beetle (Coleoptera) exoskeletons. The samples are from lacustrine sediments in stratum 2 that date ca. 10,000 yr B.P. (Holliday et al. 1985). Both are associated with *Bison antiquus* (bison) kill/butchering locales from different areas of the Landmark. Sample MS-30N44E-17 contained the paired elytra (wing covers) and abdominal sternites of *Agonum* (*Rhadine*) sp. This subgenus of ground beetles is flightless and generally confined to subterranean habitats such as caves and rockshelters (Elias 1987). The presence of such beetles at Lubbock Lake is surprising because neither caves nor rockshelters are known in the vicinity.

Sample MS-68N78E-2 contained an almost entire exoskeleton of the ground beetle *Calosoma porosifrons*. The only major element of the exoskeleton that was missing from the specimen was the pronotum (dorsal thoracic shield). This beetle is a caterpillar hunter and its modern range apparently is restriced to the Mexican

Scott Elias, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO 80309.
Eileen Johnson, The Museum, Texas Tech University, Lubbock, TX 79409.

state of Durango (Gidaspow 1959). It is known only from a few localities in that region (Figure 1), the closest of which is over 900 km south of Lubbock Lake. The modern collecting localities in Durango fall within a range of elevations from valley floor to mountains, where vegetation zones include mesquite and desert grassland to pine-oak forest. Annual precipitation ranges from 400-600 mm and mean July temperatures are mostly about 25° C (Tamayo 1962).

While paleoenvironmental interpretations based on one fossil species cannot be made, the preliminary results from the small test samples are intriguing. The presence of *Agonum* may indicate the occurrence of now-buried small rockshelters updraw from the Landmark, although geomorphic data do not support this possibility. The general parameters of *Calosoma porosifrons* fall within the proposed cooler temperatures and greater rainfall pattern at 10,000 yr B.P. for the southern High Plains (Johnson 1986). The results of the pilot study warrant a more thorough analysis of larger samples, both those collected specifically for paleoinsect recovery and those of water-processed but unsorted residues.

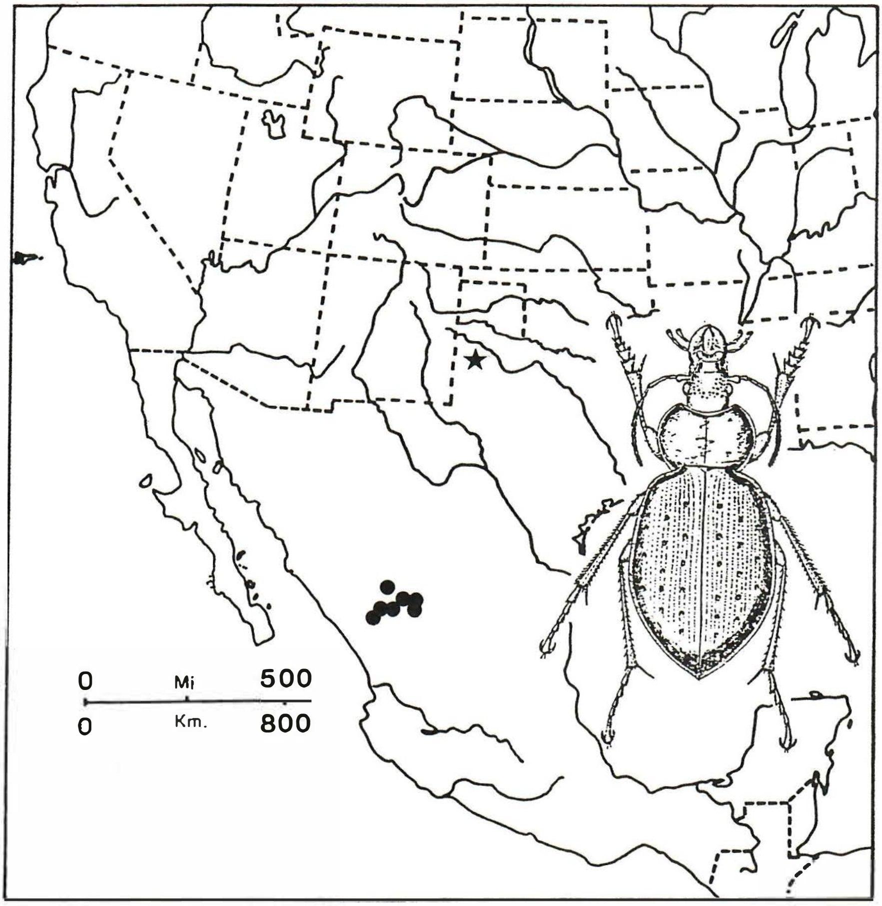


Figure 1. Modern distribution (circles) and fossil locality (star) of *Calosoma porosifrons.*

This work is part of the on-going research of the Lubbock Lake Project. Fund ing for the data base was provided by the National Science Foundation (SOC75-14857; BNS76-12006; BNS76-12006-A01; BNS78-11155), National Geographic Society, Texas Historical Foundation (National Register Program), Center for Field Research (EARTHWATCH), Moody Foundation (Galveston), City and County of Lubbock, Museum of Texas Tech University, West Texas Museum Association, and the Lubbock Lake Landmark Community Volunteers. Fossil insect analyses were facilitated by a National Science Foundation grant (BSR-87-15810) to Elias.

References Cited

Elias, S.A. 1987 Paleoenvironmental Significance of Late Quaternary Insect Fossils from Packrat Middens in South-Central New Mexico. *Southwestern Naturalist* 34:383-390.

Gidaspow, T. 1959 North American Caterpillar Hunters of the Genera *Calosoma* and *Callisthenes* (Coleoptera, Carabidae). *Bulletin of the American Museum of Natural History* 116:225-344.

Holliday, V.T., E. Johnson, H. Haas, and R. Stuckenrath 1985 Radiocarbon Ages from the Lubbock Lake Site: 1981-1984. *Plains Anthropologist* 30:277-291.

Johnson, E. 1986 Late Pleistocene and Early Holocene Vertebrates and Paleoenvironments on the Southern High Plains, U.S.A. *Geographie Physique et Quaternaire* 40:249-261.

Tamayo, J.L. 1962 *Geografica General de Mexico.* Instituto Mexicano de Investigaciones Economicas, Mexico City.

Mollusks Associated with Articulated Vertebrate Remains from Rancho La Brea

Richard V. Lamb and George T. Jefferson

Since the report of articulated vertebrate remains discovered during the construction of the George C. Page Museum at Rancho La Brea (Jefferson and Cox 1986), sedimentary samples from the first jacketed block have been prepared. In addition to the larger skeletal materials, small vertebrates, invertebrates, and plants were also preserved. These microfossils aid taphonomic analyses of the depostional enviroment of this unique deposit.

Mollusks were the first invertebrate group to be examined. The molluscan faunule consists of seven taxa, the unionid bivalve *Anodonta californiensis,* the lymnaeid aquatic snails *Fossaria modicella, Bakerilymnaea bulimoides, B. cockerelli, B. cubensis,* the physid aquatic snail *Physella virgata,* and land snails of the family Succineidae. Additionally, material assignable only to Lymnaeidae but probably from one of the identified lymnaeids and material assignable either to *Bakerilymnaea* cf. *B. bulimoides* or *B. cockerelli,* the two large members of this genus, are also present.

Based on the preferred living conditions of extant taxa (Hibbard and Taylor 1960; Taylor 1981), five habitat associations are represented by the assemblage (Figure 1). The presence of *Anodonta californiensis* (first association) indicates permanent ponds or sluggish streams at least 30 cm deep. *Physella virgata* (the second association) presently prefers permanent sluggish streams with scattered stones, leaves, or wood

Richard V. Lamb and George T. Jefferson, George C. Page Museum, 5801 Wilshire Boulevard, Los Angeles, CA 90036.

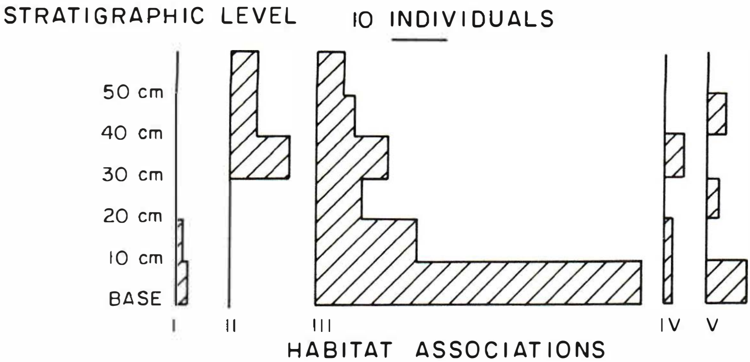


Figure 1. Stratigraphic distribution of individual mollusks in each habitat association.

on a mud bottom. The third association includes *Bakerilymnaea bulimoides* and *B. cockerelli.* These snails presently live in ephemeral ponds that may contain water for only a few months each year and have vegetation rooted in a mud bottom. *Fossaria modicella* and *B. cubensis* compose the fourth association. These snails presently live on mud banks of ephemeral and permanent streams and ponds. The fifth association consists solely of Succineidae. These snails live most commonly on vegetation just above the waterline or along streambanks, but may occupy moist areas in any terrestrial enviroment.

A histogram of the abundances of the identified taxa from sequential stratigraphic intervals within the block show several striking features (Figure 1). The absolute number of all mollusks decreases upwards through the section. This may be due to an increase in the rate of deposition, which results in fewer specimens per sediment volume.

Lymnaeid snails, indicative of ephemeral pond conditions, dominate the lower stratigraphic levels. Their shells are well-preserved and abundant. The presence of *Anodonta californiensis* only in the lowest levels appears to contradict the lymnaeid evidence, suggesting permanent pond conditions during deposition. However, *A. californiensis* has a very lightweight shell and is easily rafted under moderate flow conditions. The rarity and generally poor preservation of specimens of this bivalve, in contrast to the abundance and good preservation of the lymnaeid snails, suggests the snails are autochthonous.

In the upper stratigraphic levels, the permanent-water snail *Physella virgata* shares dominance with the lymnaeids. Specimens of *P. virgata* are well-preserved and appear to have been deposited in situ or after minimal transportation. This suggests a change from ephemeral pond to permanent sluggish-stream conditions through the depositional sequence. Well-preserved snail shells of taxa representing both mud bank and terrestrial associations (four and five) occur in roughly equal numbers throughout the sequence, indicating no significant change in their preferred environments during deposition.

References Cited

Hibbard, C.W., and D.W. Taylor 1960 Two Late Pleistocene Faunas from Southwestern Kansas. *University of Michigan Museum of Paleontology Contributions* 16:1-223.

Jefferson, G.T., and S.M. Cox 1986 New Articulated Vertebrate Remains from Rancho La Brea. *Current Research in the Pleistocene* 3:70-71.

Taylor, D.W. 1981 Freshwater Mollusks of California: A Distributional Checklist. *California Fish and Game* 67:140-163.

Biostratigraphy and Paleoecology of Ostracodes from Pleistocene Lake Manix, Central Mojave Desert, California

James J. Steinmetz and George T. Jefferson

Analyses of ostracode assemblages from lacustrine sediments exposed near the center of Lake Manix basin 32 km east of Barstow, California provide a data base for the interpretation of regional late Pleistocene climates (Jefferson and Steinmetz 1986). A preliminary examination of assemblage composition shows that the relative abundance of individual ostracode species fluctuates with a periodicity that apparently parallels a 23,000-year Milankovitch cycle.

The 24-meter-thick lacustrine sequence consists primarily of clays, silts, and fine-grained sands. Based on direct stratigraphic correlation with the dated type section of the Manix Formation, the top of the sampled section is about 50,000 yr B.P. and the base approaches 400,000 yr B.P. (Jefferson 1985). Seventy-two 2 kg sediment samples were excavated at 0.3 m intervals from eroded exposures along the Mojave River (Jefferson and Steinmetz 1986). Each sample was processed by standard paleontological washing and screening techniques. Over 12,800 specimens have been identified representing three extant and one extinct species of limnic ostracodes. Relative abundance of individual ostracode species for each sample was determined by a standardized density measurement (Forester 1977). Random samples were tested for coherence by generating performance curves and secondarily by inferential statistical analysis.

Two major biostratigraphic zones have been defined on the basis of the dominant ostracode taxon in each sample. The lower 3 m of the lacustrine sequence are dominated by *Limnocythere platyforma*. *L. robusta* (extinct) appears in moderate abundance intermittently throughout this lower zone. Ostracode assemblages from the top 3-24 m of the section are dominated by *L. ceriotuberosa*. Although *L. platyforma* and *L. ceriotuberosa* may prove to be conspecific (ecophenotypic variants), ecological replacement of *L. platyforma* by *L. ceriotuberosa* records a major climatic and depositional event that has been tentatively correlated with the 7/8 oxygen isotope stage boundry (Jefferson 1985).

Limnocythere platyforma is currently found in cold freshwater ponds and lakes of northwestern Canada and Alaska. The presence of this taxon implies that Lake Manix supported a relatively shallow, cool freshwater ecosystem. Two periods of

James J. Steinmetz, Department of Biology, California State Polytechnic University at Pomona, 3801 West Temple Avenue, Pomona, CA 91768.

George T. Jefferson, George C. Page Museum, 5801 Wilshire Boulevard, Los Angeles, CA 90036.

high ostracode productivity are represented in the lower (0-3 m) zone. The great numbers of *L. platyforma* and *L. robusta* in these intervals may represent high lake stands associated with two pluvial maxima. Following these events, the abundance of *L. platyforma* is low and relatively stable, indicating warmer conditions. At the top of the lower zone, the frequency of *L. platyforma* increases and the assemblage is co-dominated by *Heterocypris* sp., suggesting a rise in lake level. At the 3 m horizon, *L. platyforma* is replaced by *L. ceriotuberosa.*

The abundance of *Limnocythere ceriotuberosa* is initially low above the 3 m level and reaches high frequencies within the superjacent 0.3 m stratigraphic interval. Based on the ecology and biogeographic distribution of extant *L. ceriotuberosa* (Delorme 1971; Forester 1986), dominance of this taxon in the upper biostratigraphic zone (3-24 m) suggests that Lake Manix shifted from a cool, highly freshwater system to a warmer, moderately alkaline lake. Variations in salinity, trophic state, and temperature are documented by cyclic changes in the relative abundance of the taxon through time. Six intervals of high productivity are recognized in the upper zone; four pre-date the 6/7 oxygen isotope stage boundry (13 m above the base of the section), one occurs early in stage 6, and one interval follows the 4/5 oxygen isotope stage boundry (20 m above the base of the section) (Jefferson 1985).

Oxygen isotope stage 5 is represented by numerous barren intervals that occur 18-20 m above the base of the stratigraphic section. Here, sediments consist of dense, fissile claystones and poorly sorted, silty sandstones. Very low numbers of *Limnocythere ceriotuberosa* occur at the 19.3 m horizon and suggest that the lake may have been ephemeral. The increased abundance of *L. ceriotuberosa* in the top 4 m of the lacustrine sequence (20-24 m above the base of the section) indicates a return to perennial lake conditions with two high lake stands (20-19 m above the base of the section).

Given the effects of sedimentation rates and other taphonomic biases on the content of ostracode assemblages, fluctuations in the relative abundances of ecologically sensitive lacustrine ostracode taxa evidently reflect changes in regional paleoclimatic conditions. An observed periodicity in the appearance of peak ostracode populations warrants further investigation of possible Milankovitch-timed oxygen isotope stages in continental lacustrine depositional systems.

This research is one phase of an interdisciplinary study promoted through the Mojave Desert Quaternary Research Center of the San Bernardino County Museum.

References Cited

Delorme, L.D. 1971 Freshwater Ostracodes of Canada. Part V. Families Limnocytheridae, Loxoconchidae. *Canadian Journal of Zoology* 49:43-64.

Forester, R.M. 1977 Abundance Coefficients, a New Method for Measuring Microorganism Relative Abundance. *Mathematical Geology* 9:619-633.

Forester, R.M. 1986 Determination of the Dissolved Anion Composition of Ancient Lakes from Fossil Ostracodes. *Geology* 14:796-798.

Jefferson, G.T. 1985 Stratigraphy and Geologic History of the Pleistocene Manix Formation, Central Mojave Desert, California. In *Cajon Pass to Manix Lake Geologic Investigations Along Interstate 15*, edited and compiled by R.E. Reynolds, pp. 157-169. San Bernardino County Museum, Redlands, California.

Jefferson, G.T., and J.J. Steinmetz 1986 Ostracode Biostratigraphy and Paleoecology of the Late Pleistocene Manix Formation. *Current Research in the Pleistocene* 3:55-56.

Paleoenvironments: Vertebrates

Guanaco Indexes: Their Implications for the Study of Other Ungulates

Luis Alberto Borrero

A study of the economic anatomy of the guanaco (*Lama glama guanicoe*) was performed after butchering an adult individual. Both Selk'nam (Ona) and "objective" meat-bone units were successively butchered and weighed. Then the dry bone weights were registered, and a meat utility index for guanaco was developed (Borrero 1986). The index, which was constructed having in mind comparability with Binford's caribou (*Rangifer tarandus*) and sheep (*Ovis aries*) index (Binford 1978), is a model of the relative importance of guanaco meat attached to the different parts of the skeleton. A correlation coefficient for the values of the guanaco and the caribou models was calculated, which was significant at the 0.05 level. It appears, then, that even the caribou model has some explanatory power in archaeological situations involving guanaco bones.

Several archaeologists have already used the caribou/sheep models in attempts to shed light on archaeological assemblages in which other ungulates were involved, such as bison (*Bison,* Speth 1983) and bighorn sheep (*Ovis canadensis,* Thomas and Mayer 1983). Researchers like Will (1985) were even able to make intelligent use of available information on muskox (*Ovibos*), supplemented with caribou-derived data, to construct indexes that permitted a more objective evaluation of archaeological facts. For these reasons, it was deemed important to see how relevant the original models were when compared with those derived for different animals. In fact, it has been argued that the potential for such use was relatively small due to the small sample size in Binford's original analysis (Gould 1979; Spiess 1982), a critique that was certainly pertinent. Now my findings with the guanaco study support the uses made by Speth or Thomas and Mayer. It also provides some support to the suggestion that the study of single individuals from different species is a fruitful research program (Binford 1984). Variations should be investigated when sexual dimorphism is important (which is not the case for guanacos). On the other side, guanaco, caribou, and sheep have similar profiles, which in turn deviate from those characteristic of bison or muskox. For this reason, I believe that it would be

Luis Alberto Borrero, Programa de Estudios Prehistoricos, Bartolome Mitre 1970 - Piso 5, 1039 Buenos Aires, Argentina.

instructive to have indexes directly derived for those latter animals. Butchering decisions may also intrude in the relative values of an index for different bones, since slight changes in the cutting spot could result in gross differences in the weight of meat attached to bone units. This is probably the reason behind the differences observed between ribs and sternum in the three models (Binford 1978; Borrero 1986). Certainly, the values attached to those bones are expected to co-vary with butchering techniques, which are sensitive to size differences (sheep versus caribou-guanaco), or decision-making (Nunamiut versus Selk'nam versus Navajo). It may well be that the study of the economic anatomy of *Ovibos* or *Bison* will give us new knowledge. I believe that as general scales of the economical value attached to ungulate bones, and having in mind the need for future refinements—which must surely take into account site formation processes—these models should be of use for archaeological analysis. Archaeologists need only be cautious about the meaning of the models, which is heavily dependent on the cultural context (Binford 1987).

References Cited

Binford, L.R. 1978 *Nunamiut Ethnoarcheology.* Academic Press, New York.

Binford, L.R. 1984 *Faunal Remains from Klasies River Mouth.* Academic Press, New York.

Binford, L.R. 1987 Researching Ambiguity: Frames of Reference and Site Structure. In *Method and Theory for Activity Area Research: An Ethnoarchaeological Approach,* edited by S. Kent, pp. 449-512. Columbia University Press, New York.

Borrero, L.A. 1986 Bone Assemblages and Butchering Variability in Fuego-Patagonia: The Case of the Guanaco. *Communal Land Mammal Butchering and Hunting.* Pre-circulated papers of the Symposium by L.B. Davis, N. Noe-Nygaard and B.O.K. Reeves, World Archaeological Congress (Southampton), D:1-49, Allen & Unwin, London.

Gould, R.A. 1979 Caribou hunters. *Science* 204:737-739.

Speth, J.D. 1983 *Bison Kills and Bone Counts. Decision Making by Ancient Hunters.* The University of Chicago Press, Chicago.

Spiess, A.E. 1982 Review of *Nunamiut Ethnoarchaeology,* by L.R. Binford. *American Anthropologist* 82:631-632.

Thomas, D.H. and D. Mayer 1983 Behavioral Faunal Analysis of Selected Horizons. In *The Archaeology of Monitor Valley 2 Gatecliff Shelter,* by D.H. Thomas. Anthropological Papers of the American Museum of Natural History 59:353-391.

Will, R.T. 1985 *Nineteenth Century Copper Inuit Subsistence Practices on Banks Island, N.W.T.* Unpublished Ph.D. dissertation, University of Alberta, Edmonton.

Illinoian Age Fossil Birds of Eastern Nebraska

Robert M. Chandler and Larry D. Martin

During the summers of 1967-1969, the University of Nebraska State Museum conducted excavations at the Bartek Brothers Farm in Saunders County, Nebraska (UNSM Collection Locality Sd-15: NE 1/2, Sec. 12, T. 14N, R. 5E). The Bartek Brothers Farm locality has produced a rich Illinoian age flora and fauna (Frankel

Robert M. Chandler and Larry D. Martin, Museum of Natural History, Department of Systematics and Ecology, University of Kansas, Lawrence, KS 66045.

1963; Schultz and Tanner 1957), which includes several taxa of birds. Bird taxa identified are: prairie-chicken *(Tympanuchus* sp.*)*, American bittern (*Botaurus lentiginosus*), sandpiper (*Caldris* sp.), horned lark (*Eremophila alpestris*), pipit (*Anthus* sp.), meadowlark (*Sturnella* sp.), red-winged blackbird (*Agelaius phoeniceus*), and perching bird (Passeriformes). These are the first Pleistocene records for the American bittern, and red-winged blackbird in Nebraska.

The fossil material for each taxon includes, for the prairie-chicken: right humerus (UNSM 33368), left ulna (UNSM 33118), right tibiotarsus (UNSM 33367); American bittern: right coracoid (UNSM 33119); sandpiper: left scapula (UNSM 47705); horned lark: right ulna (UNSM 33120); pipit: right ulna (UNSM 47706); meadowlark: right femur (UNSM 47707); red-winged blackbird: right ulna (UNSM 47708); perching bird: right carpometacarpus (UNSM 33121). Identifications of the fossils were made with a comparative osteological collection. Identifications to the species level were made if the fossil was identical to a recent taxon.

The occurrence of the American bittern, sandpiper, pipit, and red-winged blackbird in the fauna suggests the presence of a marsh habitat. The prairie-chicken, horned lark, meadowlark, and a perching bird would require nearby prairie or bushland. Most of the bird fossils were recovered from a lens of sand just above a glacial till and below or included with a peat lens containing abundant large plant fossils. Above the peat is a thick section including the Loveland loess, Sangamon paleosol, and the Peorian loess. The mammals recovered from the sand lenses or associated with the peat include shrew (*Sorex cinereus*), shrew (*Sorex* sp.), short-tailed shrew (*Blarina brevicauda*), ground sloth (*Paramylodon* sp.), cottontail rabbit (*Sylvilagus* sp.), thirteen-line ground squirrel (*Spermophilus* cf. *tridecemlineatus*), pocket gopher (*Geomys* sp.), deer mouse (*Peromyscus* sp.), muskrat (*Ondatra nebracensis*), meadow vole (*Microtus pennsylvanicus*), meadow vole (*Microtus* sp.), red-backed vole (*Cleithrionomys* sp.), southern bog lemming (*Synaptomys (Mictomys)* sp.), peccary (*Platygonus* sp.), camel (*Camelops* sp.), bison (*Bison alleni*), and horse (*Equus* sp.) (Kreycik 1969).

We are grateful to C.B. Schultz, R.G Corner, and M. Voorhies for access to the University of Nebraska Fossil Bird Collection. K. (Kreycik) Messenger and L.G. Tanner provided valuable consultation concerning the Bartek Brothers Local Fauna. R.M. Mengel and M.A. Jenkinson made the Charles Dean Bunker Memorial Skeleton Collection available to us for identification purposes.

References Cited

Frankel, L. 1963 The Biota of a Pre-Illinoian Pond in Eastern Nebraska. *Journal of Paleontology* 37:249-253.

Kreycik, K. 1969 *A Medial Pleistocene Faunal Assemblage from Saunders County, Nebraska.* Unpublished Master's thesis, Department of Geology, University of Nebraska, Lincoln.

Schultz, C., and L. Tanner 1957 Medial Pleistocene Fossil Vertebrate Localities in Nebraska. *Bulletin of the University of Nebraska State Museum* 4:59-81.

The First Individual Skeleton of *Smilodon* from Rancho La Brea

Shelley M. Cox and George T. Jefferson

The first nearly complete, semi-articulated *Smilodon* (sabertooth) skeleton, LACMPMS (Los Angeles County Museum Page Museum Salvage) 1-1, has been recovered from a thin tabular asphaltic deposit that was discovered during construction of the George C. Page Museum in Hancock Park, Los Angeles (Jefferson and Cox 1986). This is the most complete individual yet reported from North America, providing new information on relative limb element proportions in this species.

At Rancho La Brea, vertebrate remains commonly occur in large, cone-shaped deposits (Shaw and Quinn 1986; Woodard and Marcus 1973) in which the remains of all species are randomly distributed throughout densely packed masses of disarticulated skeletal elements. These mixed accumulations may span a significant interval of time (Marcus and Berger 1984; Shaw and Quinn 1986). The unique semi-articulated remains described below may represent a short-lived episode of accumulation (Jefferson and Cox 1986).

Seventy-one percent (159 bones) of the skeleton is preserved. All of the metatarsals, the pedal sesamoids, pedal phalanges, and most of the tarsals are missing. Excluding the distal extremities of the hind limbs, the individual is over 90% complete. LACMPMS 1-1 represents a large, mature animal with a well-worn dentition. The skeleton displays a pattern of pathologic features that have been observed on isolated bones recovered previously from Rancho La Brea. Conditions which resulted from chronic stress include deep eburnation of the ventral half of the articular surfaces on the centra of the 4th and 5th cervical vertebrae, minor eburnation of the ventral margin of the articular surfaces on the centra of the 5th and 6th cervical vertebrae, and minor, posteriorly directed lipping of the ventral margin on the centrum of the 11th thoracic vertebra. Healed traumatic injuries are indicated by large, nodose exostoses along the postero-ventral side of left transverse process of the 11th thoracic vertebra, exostoses on the tubercular region of the left 11th rib, non-fusion of fractures in the distal shaft of the left 8th and 9th ribs and proximal shaft of the right 7th rib, and a 30 mm × 12 mm puncture in the postero-dorsal plane of the right scapula.

Since excavations began at Rancho La Brea early in this century, the remains of over 1,000 individual *Smilodon* have been recovered (Marcus 1960). Merriam and Stock (1932) published the first comprehensive description of the genus based on these collections. They reported mean limb bone lengths derived from measurements from a sample of 10 representative specimens of each element (Merriam and Stock 1932). Comparisons with their measurements show that LACMPMS 1-1 is large, within the upper third of the documented size range (Figure 1). The relative proportions of major limb elements in LACMPMS 1-1 are generally consistent with those reported by Merriam and Stock (1932). However, the humerus in this specimen is disproportionally large (Figure 1) with a radius/humerus ratio of 0.72 and a

Shelly M. Cox and George T. Jefferson, George C. Page Museum, Natural History Museum of Los Angeles County, 5801 Wilshire Boulevard, Los Angeles, CA 90036.

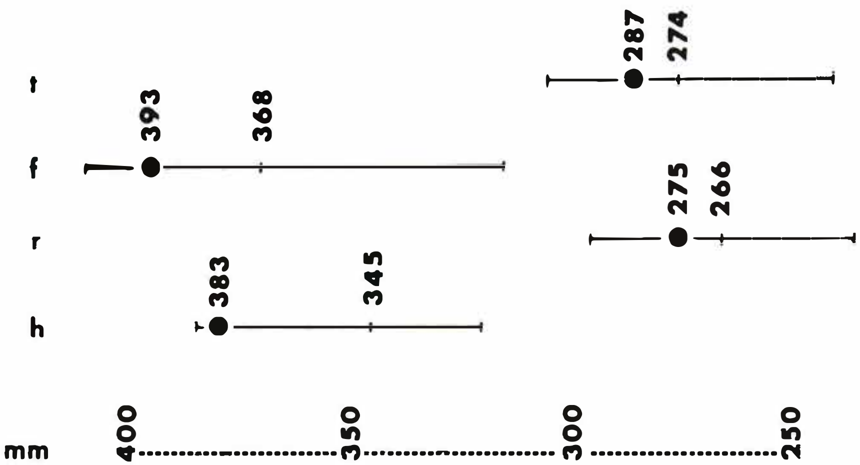


Figure 1. Comparative lengths of major limb elements of *Smilodon* from Rancho La Brea. Size range and mean length are from Merriam and Stock (1932). Abbreviations; h=humerus, f=femur, mm=millimeters, r=radius, t=tibia, solid dot=LACMPMS 1-1.

humerus/femur ratio of 0.97 compared to 0.77 and 0.94, respectively (Merriam and Stock 1932).

In the assembled right manus of LACMPMS 1-1, the terminal phalanges grade in length from 62.5 mm in the first digit to 30.1 mm in the fifth. This condition is in marked contrast to the pattern of nearly equal-sized terminal phalanges found in previous reconstructions and composite mounts.

References Cited

Jefferson, G.T., and S.M. Cox 1986 New Articulated Vertebrate Remains from Rancho La Brea. *Current Research in the Pleistocene* 3:70-71.

Marcus, L.F. 1960 A Census of the Abundant Large Pleistocene Mammals from Rancho La Brea. *Los Angeles County Museum Natural History Contributions in Science* 38:1-11.

Marcus, L.F., and R. Berger 1984 The Significance of Radiocarbon Dates for Rancho La Brea. In *Quaternary Extinctions, A Prehistoric Revolution,* edited by P.S. Martin, and R.G. Klein, pp. 159-183. University of Arizona Press, Tucson.

Merriam, J.C., and C. Stock 1932 The Felidae of Rancho La Brea. *Carneigie Institution of Washington Publication* 422:1-232.

Shaw, C.A., and J.P. Quinn 1986 Rancho La Brea: A Look into Coastal Southern California's Past. *California Geology* 39:123-133.

Woodard, G.D., and L.F. Marcus 1973 Rancho La Brea Fossil Deposits: A Re-evaluation from Stratigraphic and Geological Evidence. *Journal of Paleontology* 47:54-69.

Dental Metrics of *Mammuthus* in the Non-Glacial Regions of North America

Joseph Paine Dudley

A survey investigation of dental characters among mammoths from non-glacial regions of North America has established a broader range of variation in molar metrics than was predicted from the available literature. Intra-individual variation in molar metrics of *Mammuthus* (mammoth) third molars approach levels similar to those expected among different typological species as recorded in the older literature (Osborn 1942). A similar situation among mastodont species was described in a revision of the systematics of gomphotheres (Gomphotheriidae) from the Pleistocene of Brazil by Simpson and Paulo Couto (1957).

The great range of variability in dental metrics within and among regional mammoth populations dictates caution in reliance upon dental metrics alone as a means for identifying relative age and chronospecies taxonomy for North American mammoths. Dental metrics of mammoths from non-glacial latitudes of the United States generally show relatively thicker enamel lamina values (2.0+ mm) than those described for typical Jeffersonian mammoths (*M. columbi jeffersonii:* 1.5-2.0 mm) of periglacial regions (Osborn 1942; Maglio 1973). Lamellar frequency (LF) quotients (number of enamel-dentine places/100 mm) from several southwestern mammoth specimens fall within the range of values assigned to the Jeffersonian mammoth (7.0-9.0). The range of values for enamel thickness (ET) and lamellar frequency presented in Maglio (1973) was found to be in accord with metrical data recorded in this study for two *M. columbi jeffersonii* specimens from Montana (USNM 6017: ET=1.8, LF=6.9; USNM 195: ET=1.8, LF=7.25).

The specimen possessing an enamel thickness value most closely approximating that of these Jeffersonian mammoths (ET=1.7 vs. 1.8) was a massive lower third molar from Oklahoma (USNM 2217) having a lamellar frequency less than half that of the Montana specimens (LF=3.38 vs. LF=6.9 and 7.25). The anomalous dental characters of this specimen (USNM 2217) and an upper third molar with similar characteristics from the same site (USNM 2216) may indicate a divergent ecological radiation among southern mammoth populations. These Oklahoma specimens and a partial lower third molar from Florida (UF 48899) are conditionally referred to the taxon designated in Osborn (1942) as *M. imperator scotti.*

A partial mammoth mandible with two molars of an extremely primitive character has been recovered from an Irvingtonian deposit in New Mexico (Logan 1984; Logan et al. 1984; Sobus and Logan 1984). This specimen is conditionally referred to *M. africanavus* on the basis of dental metrics for this taxon presented in Maglio (1973).

Data on dental metrics of mammoths from Florida shows inconsistent variation in gross dental morphology among early Irvingtonian and late Rancholabrean samples. The practice of assigning early dates to mammoths from non-glacial regions of North America on the basis of plesiomorphic dental characters may be thus untenable without supporting evidence.

Joseph Paine Dudley, 118 Newins-Ziegler Hall, University of Florida, Gainesville, FL 32611.

References Cited

Logan, T.P. 1984 Early Irvingtonian (Early Pleistocene) Mammals from the Upper Part of the Sante Fe Group, Albuquerque-Belen Basin, Central New Mexico. *Geological Society of America, Abstracts* 16:245.

Logan, T.P., S.G. Lucas, and J.C. Sobus 1984 Blancan-Irvingtonian Boundary in the Ceja Member of the Sante Fe Formation, Tijeras Arroyo, Albuquerque Area, New Mexico. *New Mexico Geology* 6:14.

Maglio, V.J. 1973 Origin and Evolution of the Elephantidae. *Transactions of the American Philosophical Society of Philadelphia* 63:1-149.

Osborn, H.F. 1942 *Proboscidea: Vol. II. Stegodontoidea, Elephantoidea.* American Museum Press, New York.

Simpson, G.G., and C. de Paulo Couto 1957 The Mastodonts of Brazil. *Bulletin of the American Museum of Natural History* 112:129-189.

Sobus, J.C., and T.P. Logan 1984 Taphonomy of Mammoth Occurrences-Ceja Member of the Sante Fe Formation, Tijeras Arroyo, Bernalillo County, New Mexico. *New Mexico Geology* 6:14-15.

Bone Litter from an Alaskan Pleistocene Carnivore Den

R. Dale Guthrie

Construction work on the Transalaskan Oil Pipeline unearthed a Pleistocene-aged den in steep loess bluffs overlooking the Tanana River in central Alaska (64° 18′N and 146° 15′W) near the old community of Richardson. Unfortunately, most of the deposit was destroyed before it was noticed. John Cook, the archaeological salvage director, was called in to assess the archaeological significance. Dr. Cook determined the deposit was not of human origin, but recognized it was an interesting paleontological site and notified me. When I reached the site only the terminal meter of the silt-filled loess cave remained undisturbed. The basal portion of this cross section was filled with Pleistocene organic debris and contained many fossil snail shells, the rest of the hole had been filled with reworked silt. Most of the bones which had been in the deposit were strewn about the construction site, a number having already been removed. Only those bones on the surface could be collected, so the sample was very incomplete.

Breakage patterns indicated that virtually all the bones had been broken when fresh or relatively fresh. However there was little evidence of "kennel chewing" on the bones, as one usually finds on bones from wolf dens (Binford 1981; Haynes 1983). Wolves *(Canis lupus)* are the only living Alaskan carnivore that regularly accumulate large mammal bones around their dens. Despite the lack of wolf gnaw patterns on the associated bones, this large loess cave filled with Pleistocene aged silt on a high (50 m+) and steep loess slope was characteristic of a large mammal den.

The large number of snails, in the hundreds, on what was once the floor of the loess cave were identified to the genus *Succinea* (Bobrowsky, pers. comm.). Species of this genus, especially the xerophilic *S. grosvenori*, are commonly found in loess bluffs and feed primarily on mold, and could have been, at times, associated

R. Dale Guthrie, Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99701.

with the damp conditions of a den floor littered with decomposing animal parts (Bobrowsky, pers. comm.).

The collected bones were identifiable as members of the mammoth fauna (Guthrie 1982): steppe bison (*Bison priscus*), horse (*Equus* sp.), woolly mammoth (*Mammuthus primigenius*), and caribou (*Rangifer tarandus*). Radiocarbon dates on the collagen fraction were obtained from two different bones: 26,770+490/-520 yr B.P. (DIC-2124) from an incomplete cervical vertebra of *Mammuthus primigenius;* and 25,750+910/-1040 yr B.P. (DIC-2125) from an incomplete radius of *Bison priscus.*

These dates indicate the den was active in early stages of the last glacial (marine isotope stage 2) when birch (*Betula*), alder (*Alnus*), and spruce (*Picea*) trees were not present in the Alaskan interior, and vegetation was instead an extensive arid steppe (see Hopkins et al. 1982). The den location overlooks braided flats of the Tanana River. From this vantage point, during the treeless glacial, a predator scavenger could have observed the flood plain for many kilometers.

No direct evidence was found to determine which carnivore species accumulated these bones. Indirect evidence of a bison radius-ulna broken by two puncture holes 7 cm apart seems best explained as the work of large canine teeth. In a comparison with widths between upper canines of different carnivores (wolf=4.5 cm, lion=8.5 cm), this measurement best fits the short-faced bear (*Arctodus simus*). It is possible that brown bears (*Ursus arctos*) could have produced the broken bone, but they do not regularly accumulate bones around their dens. Two dates by John Cook (pers. comm.) on brown bear from Alaska, which are even older than those reported here, show that they were present at least as early as the last interstade (marine isotope stage 3). A wolverine (*Gulo gulo*) humerus was also found at this site, and at first I thought the site represented a wolverine den, but the larger broken bones are probably beyond a wolverine's capacity. However, it is likely the den was used by more than one carnivore species—as are most dens in Alaska today. The break on the bison radius-ulna suggests *Arctodus* once occupied the den and could have been responsible for the bone accumulation. Only one date exists for *Arctodus* in Beringia (Harington 1980): approximately 30,000 yr B.P. (I-11037). *Arctodus* bones are present in late Pleistocene sediments, and they are present in well-dated contemporary sites farther south (Agenbroad and Mead 1984).

The interpretation that *Arctodus* accumulated most of the bones in the loess cave is consistent with Voorhies and Corner's (1986) conclusion that *Arctodus* was an important breaker and flaker of late Pleistocene megafaunal remains. It seems unusual to think of canine teeth being used in bone cracking, but they are indeed powerful points of energy transfer. I have a photograph of a truck tailgate made of heavy steel that was completely punctured by the canines of an Alaskan brown bear while under partial sedation. The skull structure of *Arctodus* indicate that they had the potential for an even more powerful bite (Voorhies and Corner 1986).

References Cited

Agenbroad, L.D., and J.I. Mead 1984 Mammoth, Wolf, and Bear from the Hot Springs Mammoth Site, South Dakota. *Current Research* 1:61-62.

Binford, L.R. 1981 *Bones*. Academic Press, New York.

Guthrie, R.D. 1982 Mammals of the Mammoth Steppe as Paleoenvironmental Indicators. In *Paleoecology of Beringia,* edited by D.M. Hopkins, J.V. Matthews, Jr., C.E. Schweger, and S.B. Young, pp. 307-329. Academic Press, New York.

Harington, C.R. 1980 Radiocarbon Dates on Some Quaternary Mammals and Artifacts from Northern North America. *Arctic* 33:815-832.

Haynes, G. 1983 A Guide for Differentiating Mammalian Carnivore Taxa Responsible for Gnaw Damage to Herbivore Limb Bones. *Paleobiology* 9:164-172.

Hopkins, D.M., J.V. Matthews Jr., C.E. Schweger, and S.B. Young (editors) 1982 *Paleoecology of Beringia.* Academic Press, New York.

Voohries, M.R., and R.G. Corner 1986 The Giant Bear *Arctodus* as a Potential Breaker and Flaker of Late Pleistocene Megafaunal Remains. *Current Research in the Pleistocene* 3:49-51.

Bears and Man at Porcupine Cave, Western Uinta Mountains, Utah

Timothy H. Heaton

Porcupine Cave is located at an elevation of 2,800 m in a steep glacier-cut valley in the western Uinta Mountains of Utah. The cave was discovered in 1960 by Dale J. Green and John F. Haman of the National Speleological Society, who cleared rubble from a tight, 12-m-long horizontal crawlway to gain entry. Beyond this crawlway a larger dirt-filled passage called the Bridge Junction (2 m wide × 2 m high) slopes downward into the deeper parts of the cave. In this passage, 25 m inside the cave, Green and Haman collected a juvenile maxilla and adult cranium of black bear (*Ursus americanus;* UUMZ 22360-22361) and found what appear to be bear claw marks on the cave walls. The dirt fill ends 30 m inside the cave, and the passage beyond is littered with earthquake-shattered speleothems. This passage is horizontal and leads to a large room (10 m wide × 14 m high) full of breakdown blocks. In this room Green and Haman found a pair of sub-adult grizzly bear dentaries (*U. arctos;* UUMZ 22362) 65 m inside the cave, and the room was named the Bear's Den. These bones were donated to the University of Utah Museum of Zoology and identified by Stephen D. Durrant. The cave was mapped and described in a private publication (Haman 1963).

In 1986 I collected additional material at the Bridge Junction. The sediments there, which came in from the cave entrance, are composed of fist-sized angular limestone cobbles in a clay and organic matrix partly covered with decaying sticks, roots, and bones. This deposit slopes 20° and appears to be disturbed from slumping. The room was carefully mapped, and bone (now at Brigham Young University) was collected from the upper 0.2 m of deposit. The rest of the juvenile black bear skull was recovered, as was about half of its skeleton (BYUVP 9960). Bones of this animal were disarticulated and widely scattered. At least two adult black bears were represented by two left maxillae, an upper canine, thoracic vertebra, metacarpal, calcaneum, and claw (BYUVP 9961-9967).

In addition to bears, a suite of boreal mammals and birds typical of the Uinta Mountains was found. The 43 bird bones (BYUVP 9855-9897) have not been identified. Of small mammals I recovered 2 jaws of snowshoe rabbit (*Lepus americanus*),

Timothy H. Heaton, Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138.

24 of marmot (*Marmota flaviventris*), 16 of northern pocket gopher (*Thonomys talpoides*), 3 of bush-tailed wood rat (*Neotoma cinerea*), 7 of porcupine (*Erethizon dorsatum*), 2 of pine marten (*Martes americana*), 1 of long-tailed weasel (*Mustela frenata*), and 1 of striped skunk (*Mephitis mephitis;* BYUVP 9898-9959). Of artiodactyls I found 2 phalanges of wapiti (*Cervus elaphus*), 15 bones of mule deer (*Odocoileus hemionus*), and a metacarpal probably of bison (*Bison bison;* BYUVP 9968-9985). The bones were coated with wet clay, and some were heavily gnawed by rodents.

Several artifacts have been recovered from Porcupine Cave. Haman (1963) reported finding a white quartzite arrowhead (3 cm long by 2 cm wide) in the entrance crawlway. I found a tan chert Elko series point (10 cm long by 5 cm wide) at the Bridge Junction. It was on the surface near the bottom of the sediment fill; its broken tip was 1.5 m lower on the slope. Some charred, water-soaked wood was also found in the soil. A femur of the juvenile black bear was ^{14}C dated at 510±75 yr B.P. (GX-13292). This date suggests that this fauna recovered near the cave entrance and its associated artifacts are very recent.

In 1987 I collected additional bones of the grizzly bear in the Bear's Den, including skull fragments and an assortment of postcranial elements. Rock fall appears to have damaged some bones and buried others. Dripping water kept these bones wet and deposited calcite on some, and some are heavily gnawed by rodents. A group of ribs was ^{14}C dated at 10,620±245 yr B.P. (GX-13676). This is an early date for grizzly bear, which immigrated from Asia in the late Wisconsin, but it has been found with similar dates in caves of Wyoming and Idaho (Kurtén and Anderson 1980). This grizzly bear apparently postdates the extinction of the giant short-faced bear (*Arctodus simus*) which is thought to have been out-competed by the grizzly bear and which has been found in Lake Bonneville deposits of northern Utah (Kurtén and Anderson 1980; Nelson and Madsen 1983). The Porcupine Cave specimen represents the first fossil grizzly bear to be recovered from Utah. A few grizzly bears have been seen in the state in historic times, but the species is now extirpated (Durrant 1952, Merriam 1918). There is no evidence that humans were associated with this fossil grizzly.

The cave entrance at present is too small to admit bears, but if the fill was removed the passage would be sufficiently large. From the dated bear skeletons and their context within the cave, the following historical sequence seems likely: 1) large-scale Wisconsin glaciation eroded the valley and intersected the cave; 2) the glacier disappeared by 10,620 yr B.P. leaving the cave with a large entrance, and the grizzly bear entered the cave (possibly as a den) and died; 3) subsequent glacial activity forced debris 30 m into the cave but left the entrance open enough to admit black bears; 4) the cave was free of ice again by 510 yr B.P. and black bears (and possibly humans) entered the cave (probably as a den), leaving their remains on top of the glacial fill; and 5) subsequent glacial or other causes plugged the 15 m entrance passage with additional debris, preventing the entry of large animals.

Thanks are extended to Julia S. Heaton for helping collect and catalog the collection, Dale J. Green for providing information about the cave's discovery, Asa Nielson and Mike Hall for investigating the archaeology, the University of Utah for loaning their material, and the National Speleological Society for funding the ^{14}C dates.

References Cited

Durrant, S.D. 1952 Mammals of Utah: Taxonomy and Distribution. *University of Kansas Publications, Museum of Natural History* 6:1-549.

Haman, J.F. 1963 Porcupine Cave, Summit County, Utah. *Salt Lake Grotto Technical Note* 61:1-9.

Kurtén, B., and E. Anderson 1980 *Pleistocene Mammals of North America*. Columbia University Press, New York.

Merriam, C.H. 1918 Review of the Grizzly and Big Brown Bears of North America. *U.S. Department of Agriculture, Bureau of Biological Survey, North American Fauna* 41:1-136.

Nelson M.E., and J.H. Madsen, Jr. 1983 A Giant Short-Faced Bear (*Arctodus simus*) from the Pleistocene of Northern Utah. *Transactions of the Kansas Academy of Science* 86:1-9.

Ontario Fossil Cervids: Neglected Data and Dating

Lawrence J. Jackson and Heather McKillop

Discoveries over the past three decades in the Northeast support the association of early and late Paleoindian peoples with remains of cervid species. Despite tantalizing clues, we are little closer to understanding interrelationships of early hunting groups and these animals. Focus on tool assemblages has drawn needed attention away from efforts to reconstruct animal habitat and ranging behavior. Identifying how and why hunting groups used particular sites and regions requires understanding of the habits of their prey species, as well as the nature of their toolkits.

The fossil record for southern Ontario, like most Great Lakes states, is dominated by proboscideans between 12,000 and 10,000 yr B.P. (Dreimanis 1968). With close to 100 late glacial mastodon and mammoth, smaller and more fragile fossils such as cervids are overlooked. Cervid remains actually occur on several Ontario proboscidean sites (McAndrews and Jackson 1988). Preliminary search of published sources, together with recent field work, provides 26 records of southern Ontario fossil land mammals other than proboscideans. Twenty-one of these are large gregarious herbivores, 17 of them cervids. Five others belong to the Rodentia and Carnivora. Cervids include three caribou *(Rangifer)*, eight elk *(Cervus)*, one extinct stag-moose *(Cervalces)*, four deer (three *Odocoileus* and one "cervine deer"), and an unidentified cervid.

Scarcity of radiocarbon dates and variable contextual detail introduces uncertainty into calculations of fossil ages. There is good evidence that noted cervids, except for elk, were in Ontario after Port Huron ice retreat and contemporaneous with main Lake Algonquin 11,500 to 10,300 yr B.P. This age overlap with Paleoindian is reinforced by 60% co-occurrence of fossils in geographic regions of fluted point site abundance (Jackson 1983).

One of the most neglected aspects of Ontario cervid fossil investigations is the use of shed antler as a range indicator. Shed male caribou antler is recorded from proglacial Lake Iroquois beach deposits near Toronto, offering strong evidence of a northern range. Male antler is commonly shed between October and December

---

Lawrence J. Jackson and Heather McKillop, Northeastern Archaeological Associates, P.O. Box 493, Port Hope, ON, Canada, L1A 3Z4.

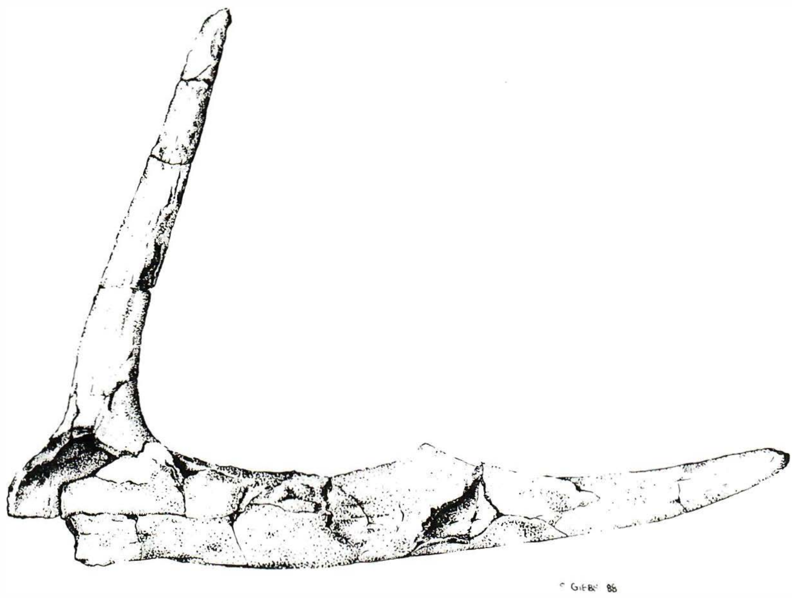


Figure 1. *Odocoileus* cf. *virginianus* antler from a stratified post-Wisconsin deposit in southern Rice Lake region, Ontario (reconstructed main antler beam above snag tine to tip).

during rutting on the route from tundra summer ranges (and calving grounds) to forested winter ranges—today as much as 1,287 km apart (Banfield 1974). Late glacial Ontario caribou, therefore, likely wintered in the northeastern United States.

The geologist who recorded the Lake Iroquois caribou antlers at the turn of this century also wrote (Coleman 1899) of a possible association with Indian artifacts—perhaps the first suggestion of early Amerindian exploitation of this animal. Unfortunately, the artifacts were lost before Coleman's investigations.

In addition to caribou, frequently advanced as the sole resource of northeastern Paleoindians, fossil records of white-tailed deer are common in locations away from proglacial Great Lake strandlines (Figure 1). Deer are increasingly seen as a critical reason for the situation of interior Paleoindian sites where geographically predictable locations offer maximum topographic advantage for the taking of such prey (Jackson and McKillop 1987; McDonald 1984). The white-tailed deer was actually the most ubiquitous food source of Amerindian hunters throughout the Holocene. Although modern analogs suggest that deer did not co-occur with caribou, we have little information on late Pleistocene faunal diversity and range behavior. As spruce and lichen habitat disappeared near the end of the Pleistocene, white-tailed deer may well have moved into former caribou range offering new hunting opportunities to late Paleoindian groups.

Obviously, a great deal of information needs to be uncovered before definitive statements on Paleoindian subsistence and hunting strategies are possible. In the Rice Lake area of south-central Ontario, we have begun a program of intensive archaeological survey and ^{14}C analysis of cervid fossil material in an attempt to reconstruct Pleistocene/Holocene hunting adaptation. We would encourage other archaeologists to carry out similar research, working closely with natural sciences such as mammalogy to establish late glacial ranges and availability of various prey species to Paleoindian hunters.

References Cited

Banfield, A.W.F. 1974 *The Mammals of Canada.* University of Toronto Press, Toronto.

Coleman, A.P. 1899 The Iroquois Beach. *Transactions Of The Canadian Institute* 6:9-44.

Dreimanis, A. 1968 Extinction of Mastodons in Eastern North America: Testing a New Climatic-Environmental Hypothesis. *The Ohio Journal of Science* 68:257-272.

Jackson, L.J. 1983 Geochronology and Settlement Disposition in the Early Paleoindian Occupation of Southern Ontario, Canada. *Quaternary Research* 19:388-399.

Jackson, L.J., and H. McKillop 1987 Early Paleoindian Occupation in Interior South-Central Ontario. *Current Research In The Pleistocene* 4:11-14.

McAndrews, J.H., and L.J. Jackson 1988 Age and Environment of Late Pleistocene Mastodont and Mammoth in Southern Ontario. *Proceedings of the Smith Symposium,* Buffalo Museum of Science, Buffalo.

McDonald, J.N. 1984 The Reordered North American Selection Regime and Late Quaternary Megafaunal Extinctions. In *Quaternary Extinctions: A Prehistoric Revolution,* edited by P.S. Martin, and R.G. Klein, pp. 404-439. University of Arizona Press, Tucson.

The Distribution of *Mammut americanum* (Mastodon) and *Mammuthus* (Mammoth) Occurrences in Kansas

William C. Johnson and Edward J. Kost

It is well known that for aceramic archaeological sites, animal bone is second only to stone in its resistance to degradation over time. Much of what is known about Paleoindian and, to a lesser degree, Archaic cultures is a direct result of the initial discovery of a concentration of large mammal bones. Consequently, a compilation of recorded megafaunal finds provides insight into the potential distribution of early cultures. This is particularly instructive in the central Plains where few direct associations between human and extinct megafaunal remains have been documented.

All published records and museum collections of late Pleistocene and early Holocene megafaunal finds (e.g., mastodon, mammoth, bison, camel, horse) in Kansas have been compiled (Kost 1987). The megafauna reported for Kansas total approximately 650 separate occurrences, an occurrence being defined as the presence of one or more specimens of a faunal type at a distinct location. The data base, consisting of all types of megafauna recorded, undoubtedly includes some records earlier and some later than the late Pleistocene and early Holocene, but, collectively, reflects the approximate megafaunal distributions for this time period. Sufficient numbers of occurrences exist to establish the general patterns for most forms.

William C. Johnson, Department of Anthroplogy, University of Kansas, Lawrence, KS 66045-2121.

Edward J. Kost, Department of Geography, University of Kansas, Lawrence, KS 66045-2121.

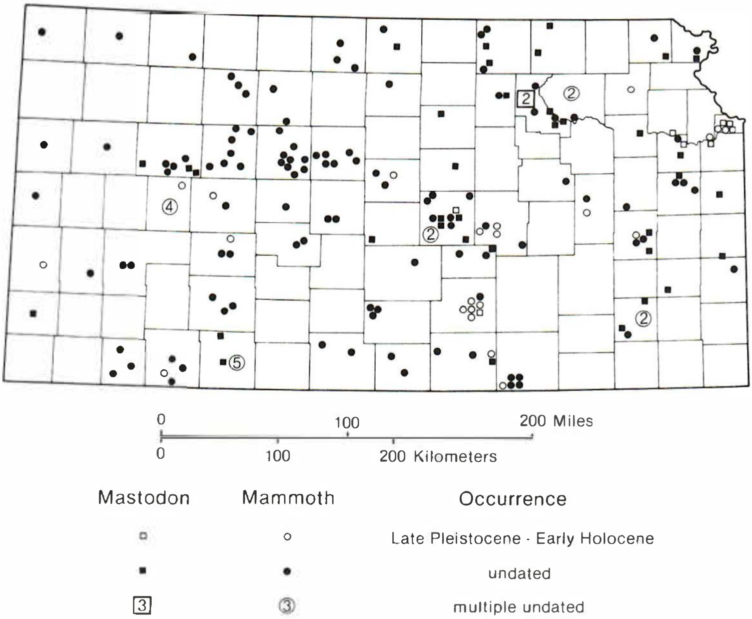


Figure 1. The occurrence of mastodon and mammoth remains recorded in Kansas.

Overall, the two proboscidians (mastodons and mammoths) hold particular potential for understanding ancient cultures because of their proven association with early hunters (e.g., Clovis) and the relatively large numbers of recorded finds. Together they account for 30% of the total number of megafaunal occurrences reported in Kansas. The family Mammutidae (order Proboscidea) is represented in North America by a single species, *Mammut americanum* (American mastodon) while the family Elephantidae is represented by the genus *Mammuthus* (mammoth). Of the four North American species recognized, three are found in Kansas: *Mammuthus columbi* (Columbian mammoth), *M. jeffersonii* (Jefferson's mammoth), *and M. primigenius* (Woolly mammoth).

The record of mastodon material is confined primarily to the eastern half of the state, with the exception of a notable void in the Flint Hills (Figure 1). The western half of the state, in contrast, contains only 15% of the occurrences. There are, however, potential biases in the distribution. Some occurrences may represent early to mid-Pleistocene animals, and misidentification is a possibility where post-cranial elements or tusks were used in the determination. Also, there is some bias introduced by where people have looked, e.g., eastern versus western Kansas. These apparently do not, however, prevent a representative pattern from emerging. The distribution of mastodon finds is consistent with paleobotanical evidence for mixed coniferous and deciduous woodlands in eastern Kansas (Fredlund and Jaumann 1987).

Mammoth occurrences are spread across the state, but not in a uniform distribution (Figure 1). Very few records occur in the High Plains physiographic region which comprises the western one-third of the state. The greatest number of occurrences is located within the Smoky Hills region, north-central Kansas. Further, finds seem to concentrate in the western Smoky Hills region where it contacts the High Plains, reflecting the dissection of the fossil-bearing, late Pleistocene deposits of western Kansas by eastward-flowing stream systems. The distribution of mammoth remains suggests a dominantly grassland environment for the western two thirds of the state, but it does not preclude the existence of extensive populations of boreal, or taiga, tree species (Wells and Stewart 1987).

Given the distribution of these two extinct megafaunal forms, Paleoindian sites should produce a similar pattern. Only two Paleoindian sites have been extensively excavated in Kansas, but they suggest a focal bison subsistence economy in the High Plains region (12 Mile Creek site; Rodgers and Martin 1984) and a more diffuse subsistence economy in the eastern part of the state (Sutter site; Katz 1971). Archaeological confirmation is certainly lacking in large part because many of the faunal occurrences were not carefully investigated for human association. Consequently, the distributions of late Pleistocene and early Holocene megafauna, as illustrated by two types herein, would seem to have potential ramifications for archaeological research.

References Cited

Fredlund, G.G., and P.J. Jaumann 1987 Late Quaternary Palynology and Paleobotanical Records from the Central Great Plains. In *Quaternary Environments of Kansas,* edited by W.C. Johnson, pp. 167-178. Kansas Geological Survey Guidebook Series 5, Lawrence, Kansas.

Katz, P.R. 1971 Archaeology of the Sutter Site in Northeastern Kansas. *Plains Anthropologist* 16:1-19.

Kost, E.J. 1987 Distributions of Pleistocene and Holocene Megafauna in Kansas. In *Kansas Prehistoric Archaeological Preservation Plan,* edited by K.L. Brown and A.H. Simmons, pp. Dl-D20. Office of Archaeological Research and Center for Public Affairs, University of Kansas, Lawrence.

Rodgers, R.A., and L.D. Martin 1984 The 12 Mile Creek Site—A Reinvestigation. *American Antiquity* 49:757-764.

Wells, P.V., and J.D. Stewart 1987 Cordilleran-Boreal Taiga and Fauna on the Central Great Plains of North America, 14,000-18,000 Years Ago. *The American Midland Naturalist* 118:94-106.

A New Cavity Biota From Northeastern Utah

Michael E. Nelson

During the summer field season of 1987, a Fort Hays State University field crew conducted a reconaissance paleontological survey in the northern Wasatch Mountains of Utah. The objective of this search was to locate prospective cave sites which might produce fossil vertebrates, especially mammals. The survey noted a fossiliferous high altitude cave that had been recently opened by road construction crews.

The unnamed small shelter is located in Summit County on the northern flank of the Uinta Mountains at an approximate elevation of 2,125 m. The cave, which formed in the early Cenozoic Wasatch Formation, has an opening that is approximately 4 m in height by 8 m in width. The depth of the cave is unknown, since it appears to

Michael E. Nelson, Department of Earth Sciences, Fort Hays State University, Hays, KS 67601-4099.

be entirely filled with sediments. Likewise, the total size of the original cave is unknown since construction workers broke open the cave during a road building exercise. Trenches have not been excavated, and therefore the stratigraphy of the site has not been fully determined.

There are at least three charcoal or burn layers present in the sediments, and bones appear to be scattered throughout the section. A preliminary analysis indicates that burned packrat *(Neotoma* sp.*)* middens probably contributed to the charcoal layers.

Fossils exposed in the upper 0.3 m of the sediment package were collected during the short 1987 survey. The majority of the biota is comprised of mammals, although birds, reptiles, and plants are present. The mammals are represented by a canid (*Canis lupus* or *C. latrans*), a jackrabbit (*Lepus* sp.), and several rodents, including the cricetine, *Neotoma* sp. One or two birds were collected, including a grouse (family Tetraonidae). Reptiles include vertebrae of an unidentified rattlesnake, *Crotalus* sp. Numerous juniper *(Juniperus* sp.) seeds and branches were noted, and other plant material awaits identification.

The discovery of fossil vertebrates in the Wasatch Mountains represents only the third significant Quaternary fauna in northern Utah, and is one of less than a dozen in the entire state of Utah. The two closest faunas are the Silver Creek l.f. (local fauna) (>40 ka) (Miller 1976) and the Bonneville l.f. (approximately 14 ka) (Nelson and Madsen 1987 and references therein). I anticipate the age of this biota will occupy a segment of time that straddles the Pleistocene-Holocene boundary, a time span that is under represented or previously unstudied in Utah. Future plans call for additional excavation and analysis during 1988.

References Cited

Miller, W.E. 1976 Late Pleistocene Vertebrates of the Silver Creek Local Fauna from North Central Utah. *Great Basin Naturalist* 36:387-424.

Nelson, M.E., and J.H. Madsen, Jr. 1987 A Review of Lake Bonneville Shoreline Faunas (Late Pleistocene) of Northern Utah. In *Cenozoic Geology of Western Utah,* edited by R.S. Kopp and R.E. Cohenour, pp. 315-333. Utah Geological Association Publication 16, in press.

Late Irvingtonian *Ondatra* in Nebraska: The Identity of the Hay Springs Muskrat

M.R. Voorhies and R.G. Corner

Since its initial quantification by Semken (1966), the fossil record of the muskrat (*Ondatra:* Arvicolinae) has proven to be one of the most useful tools for biochronological subdivision of the North American Pleistocene. The broad framework of muskrat evolution, from *Ondatra idahoensis* in the late Blancan through *O. annectens* (early

M.R. Voorhies and R.G Corner, Division of Vertebrate Paleontology, University of Nebraska State Museum, Lincoln, NE 68588-0514.

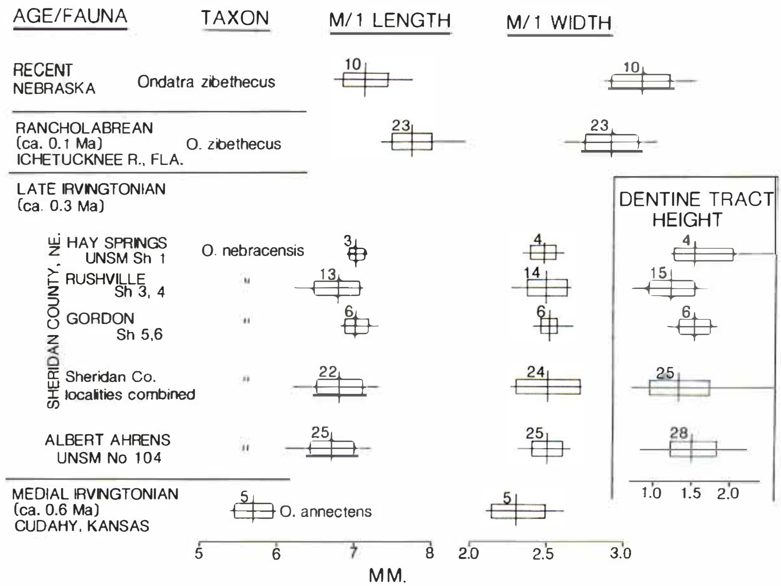


Figure 1. Modified Dice-Leraas diagram showing variation in size and dentine tract development in lower first molars of fossil and Recent muskrats. Length and width measurements are maxima and dentine tract height was measured on the fifth alternating triangle (see Eshelman 1975:39 for details). Data on Cudahy, Ichetucknee River, and Recent Nebraska samples are from Martin and Tedesco (1976). Measurements of late Irvingtonian specimens from Nebraska are original. Number with each diagram equals sample size.

Irvingtonian) and *O. nebracensis* (late Irvingtonian) to *O. zibethicus* in the Rancholabrean and Recent, is now well documented (Chaline 1987). Trends toward larger size, increasing crown cementum, and taller dentine tracts on the molar teeth characterize the lineage. So far as is known, the genus is monophyletic, with the named species grading imperceptibly into one another along a chronocline. Occurrences formerly regarded as indicating departures from monophyly (e.g. the Borchers and Gilliland samples) are now known to have been initially misdated or misidentified (Hibbard and Dalquest 1973).

Perhaps the most significant remaining obstacle to regarding the *Ondatra* lineage as a unified chronocline is the report that both primitive (*O. annectens*) and advanced (*O. nebracensis*) species coexist at the type locality of the latter species, Hay Springs, Sheridan County, northwestern Nebraska (Kurtén and Anderson 1980; Schultz and Martin 1970). Nelson and Semken (1970) also detected bimodality in the small Hay Springs sample studied by them. We analyzed the considerably larger collection of *Ondatra* dentitions from the Hay Springs and two nearby correlative local faunas (Rushville and Gordon) now available in the University of Nebraska State Museum (UNSM) to determine the range of morphological variation present in the lower first molar, the tooth most extensively studied by previous workers.

Standard measurements (method of Semken 1966) of all available Hay Springs-Rushville-Gordon M/1s are presented in Figure 1 and compared with other fossil and Recent samples. Note that the composite Sheridan County sample, although derived from five different excavations (Schultz and Tanner 1957), displays no more variability in the parameters measured than does the single-quarry sample from the Albert Ahrens site (new) collected by us in 1986-87 from a thin lens of fluvial sand near the base of Loveland(?) loess exposures in Nuckolls County, south-central Nebraska.

We conclude that: 1) no evidence for more than one muskrat taxon is present in the UNSM Hay Springs sample, whether analyzed individually or in conjunction with other Sheridan County samples; 2) the Hay Springs muskrat, most appropriately named *Ondatra nebracensis,* is essentially a smaller-sized version of *O. zibethicus* with shorter dentine tracts on the molars as shown by previous workers; 3) a late Irvingtonian age, considerably post-dating the 0.6 million yr B.P. Cudahy fauna, is assigned to all of the Sheridan County assemblages studied; 4) differences among the Sheridan County samples are small and probably attributable to random effects; pending evaluation of the *Microtus* from the various sites, we cannot now falsify the proposition that all are the same age.

References Cited

Chaline, J. 1987 Arvicolid Data (Arvicolidae, Rodentia) and Evolutionary Concepts. *Evolutionary Biology* 21:237-310.

Eshelman, R.E. 1975 Geology and Paleontology of the Early Pleistocene (Late Blancan) White Rock Fauna from North-Central Kansas. *Museum of Paleontology, University of Michigan Papers on Paleontology* 13 (Claude W. Hibbard Memorial Volume 4):1-60.

Hibbard, C.W., and W.W. Dalquest 1973 *Proneofiber,* a New Genus of Vole *(Cricetidae: Rodentia)* from the Pleistocene Seymour Formation of Texas, and its Evolutionary and Stratigraphic Significance. *Quaternary Research* 3:269-274.

Kurtén, B., and E. Anderson 1980 *Pleistocene Mammals of North America.* Columbia University Press, New York.

Martin, R.A., and R. Tedesco 1976 *Ondatra annectens* (Mammalia: Rodentia) from the Pleistocene Java Local Fauna of South Dakota. *Journal of Paleontology* 50:846-850.

Nelson, R.S., and H.A. Semken 1970 Paleoecological and $Stratigraphic Significance of the Muskrat in Pleistocene Deposits. *Geological Society of America Bulletin* 81:3733-3738.

Schultz, C.B., and L.D. Martin 1970 Quaternary Mammalian Sequence in the Central Great Plains. In *Pleistocene and Recent Environments of the Central Great Plains,* edited by W. Dort, Jr. and J.K. Jones, Jr., Department of Geology University of Kansas Special Publication 3:341-353.

Schultz, C.B., and L.G. Tanner 1957 Medial Pleistocene Fossil Vertebrate Localities in Nebraska. *Bulletin of the University of Nebraska State Museum* 4:59-81.

Semken, H.A. 1966 Stratigraphy and Paleontology of the McPherson *Equus* Beds (Sandahl Local Fauna), McPherson County, Kansas. *Contributions from the Museum of Paleontology, University of Michigan* 20:121-178.

Paleoenvironments: Geosciences

Discrepancy in Termination of Pinedale Glaciation, Wind River Mountains, Wyoming

Dennis E. Dahms

Field and laboratory analyses of soils developed on piedmont and alpine moraines suggest a temporal discrepancy exists in the termination of Pinedale (>10,000 yr B.P.) glaciation from the northern to the southern region of the Wind River Range of Wyoming. Two radiocarbon dates reported from separate regions of the mountains support the soils relationships, and indicate ice retreated from the southern piedmont approximately 3,000 years earlier than ice retreat is recorded in the north. Together, the differences in soil development and the range of reported dates suggest the southern moraines are older, and reflect an unequal distribution of glacial ice in the mountains during the terminal Pinedale.

Soils developed on Pinedale piedmont moraines of the Wind River Range differ from the north to the south. From New Fork Lakes to Soda Lake (Figure 1), soils exhibit cambic B-horizons, based on color and weakly developed structure (A-Bw 2BC-2C). South of Soda Lake, profiles more often exhibit A-Bt-2BC-2C profiles, with sufficient clay increase in B-horizons to qualify them as argillic (Soil Survey Staff 1975). Most of the clay increase is in the $<0.5\mu$ (fine) fraction, indicating an illuvial, rather than an authigenic origin. Differences in B-horizon development within an area of similar climate, vegetation, and parent material are generally thought to be due to the time available for soil development (Birkeland 1984).

In the northern part of the range, Sorenson and Richmond obtained a radiocarbon date of 9,305±75 yr B.P. (SI-5700) on bog-bottom peat between Fremont and Soda Lakes (Sorenson 1987). In the south, Davis and Zielinski concluded a valley glacier had retreated into the upper Big Sandy Creek drainage by 11,770±110 yr B.P. (GX-11772) based on a radiocarbon assay of gyttja from Rapid Lake (Zielinski, pers. comm. 1987). These ages suggest that ice in the northern reach of the mountains persisted outside the mountain front to a later date and a lower elevation than ice only 60 km to the south. A major question is, then, what is responsible for such a disparity in the timing of glacial retreat, and how might this have occurred?

Two ancient peneplains (erosion surfaces) occur adjacent to the high peaks of the mountains. The highest lies at ca. 3,450 m (AMSL), and forms a bench-like area that

Dennis E. Dahms, Department of Geography, University of Kansas, Lawrence, KS 66045-2121.

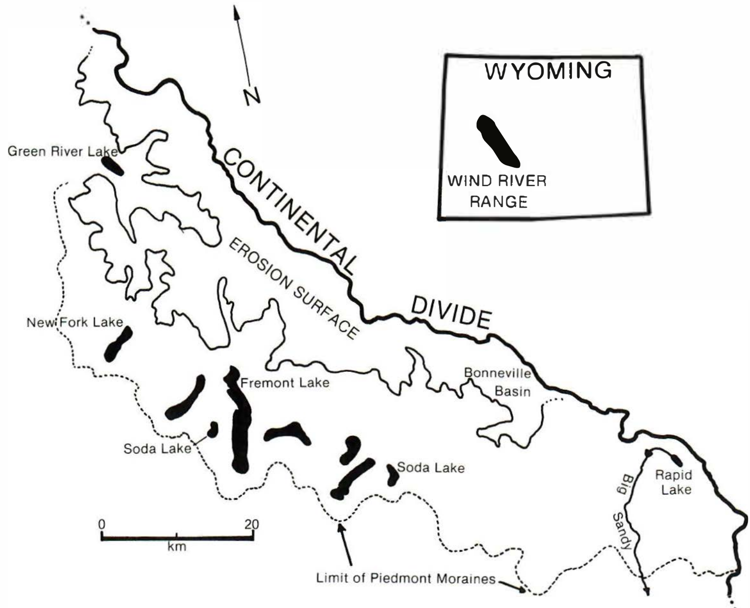


Figure 1. Location of the Wind River Range in Wyoming, and localities on the west side of the Continental Divide discussed in the text.

separates the high peaks from a second, lower erosion surface. The lower erosion surface ("pre-Pleistocene" (Love 1960)) has the largest area, and is thought to mark the maximum depth under which the mountains were buried during Tertiary deposition within the Green River Basin. The pre-Pleistocene surface occupies most of the sub-alpine zone above 3,000 m, and is the most obvious physiographic feature of the mountains, outside the high peaks. Below 3,000 m, large canyons drain the erosion surface; above 3,000 m, alpine valleys channel drainage onto the surface. The area of pre-Pleistocene surface above 3,000 m is largest in the north. To the south, the surface has been heavily dissected, and the area is limited. The key to the problem is thought to be the large surface area in the north. This area may have affected the glacial dynamics enough to cause the differences seen in the radiocarbon dates and soils data.

Alpine ice from valley glaciers may have coalesced onto the erosion surface to form an ice cap in the north. The ice cap would feed the lower valley and piedmont glaciers, and perhaps act as a separate area of snow accumulation. Piedmont glaciers would be most directly influenced by the ice on the erosion surface. South of Bonneville Basin, the erosion surface above 3,000 m nearly disappears. The effect of this portion of the erosion surface as an area for ice accumulation area would be minimal. Therefore, glaciers flowing out of the mountains in the south would respond most directly to ice in cirques and alpine valley glaciers. With the onset of ablation, glaciers in the south probably retreated more quickly, also due to a buffering effect by ice built up on the erosion surface. By 12,000 yr B.P., glaciers had retreated from the piedmont and lower valleys to the south, but ice still existed as piedmont glaciers around Fremont Lake.

Cores are being collected from bogs along the erosion surface between Fremont Lake and the Big Sandy Creek valley. Dates from peat above till may provide information about the timing of ice retreat from each location. Thus, dates obtained by this study should indicate whether differential ice retreat occurred in the Wind River Range, and if the erosion surface was an effective geomorphic factor in this process.

References Cited

Birkeland, P.W. 1984 *Soils and Geomorphology.* Oxford University Press, New York.

Love, J.D. 1960 Cenozoic Sedimentation and Crustal Movement in Wyoming. *American Journal of Science, Bradley Volume* 258-A:204-214.

Soil Survey Staff 1975 *Soil Taxonomy.* USDA Handbook No. 436. U.S. Department of Agriculture, Washington, D.C.

Sorenson, C.J. 1987 *Soils Map of the Fremont Lake South Quadrangle, Sublette County, Wyoming.* U.S.G.S. Miscellaneous Investigation Series, I-1800. United States Geological Survey.

Late Glacial Loess Stratigraphy and Archaeology in the Nenana Valley, Central Alaska

John F. Hoffecker, Christopher F. Waythomas, and W. Roger Powers

Field research continues in the northern foothills of the Alaska Range, where late glacial loess deposits have produced a rich and complex archaeological record. In recent years, most investigations have been focused on the Nenana Valley, approximately 100 km southwest of Fairbanks. Four multi-component sites here contain one or more occupation levels radiocarbon-dated to the 12,000-10,000 yr B.P. interval; aeolian stratigraphic correlation suggests that several other sites in the valley also contain late glacial occupations. Two distinct archaeological complexes appear to be present: a microblade industry dated to ca. 10,600-7,000 yr B.P., and an industry lacking microblade technology dated to ca. 11,800-11,000 yr B.P. The relatively deep loess deposits of the Nenana Valley provide a stratigraphic context of unusually high resolution for sites in this time range in central Alaska.

The northern foothills of the Alaska Range, primarily composed of poorly consolidated Tertiary formations, extend up to 30 km beyond the mountain front. The Nenana River is one of many streams that flow northward out of the range into the Tanana Basin, incising a deep valley through the soft bedrock. Alternating phases of riverine aggradation and downcutting, combined with a series of late

John F. Hoffecker, Energy and Environmental Systems Division, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

Christopher F. Waythomas, Institute of Arctic and Alpine Research, University of Colorado at Boulder, Campus Box 450, Boulder, CO 80309.

W. Roger Powers, Department of Anthropology, University of Alaska at Fairbanks, Fairbanks, AK 99701.

Cenozoic tectonic events and glaciations, have created an intricate sequence of terraces in the valley (Wahrhaftig 1958).

Traces of ancient (pre-middle Pleistocene) glaciation are confined to isolated patches of till and erratics, but more recent advances are represented by extensive moraine and outwash systems. The Healy moraine, deposited in the upper valley and linked to both a depositional and erosional terrace level, apparently represents a late middle-Pleistocene or early late-Pleistocene advance (Ritter 1982). Late Wisconsin moraines (locally termed Riley Creek) do not extend into the foothills, but are associated with a sequence of down-valley terraces reflecting three successive advances ((?)25,000-17,000 yr B.P., 15,000-13,500 yr B.P., and (?)12,800-(?)11,800 yr B.P.); a final advance is dated to (?)10,500-9,500 yr B.P., but is not represented by a separate terrace level (Ten Brink 1983; Ten Brink and Waythomas 1985).

Loess and aeolian sand deposits mantle surfaces throughout the Nenana Valley, achieving a thickness of 2 m or more in places. Buried soils of varying character have been identified at many localities, and are likely to be useful for correlation among archaeological sites. The sequence begins with a series of organic A-horizons dating to the 12,000-10,000 yr B.P. range. Above these soils lies a highly diagnostic soil complex of early Holocene age composed of alternating organic horizons and light-gray and yellowish-brown bands; this buried soil complex may constitute a stratigraphic marker for the Pleistocene/Holocene boundary throughout the valley. The later Holocene is represented by paleosols with well developed B horizons that resemble the modern forest soil profiles of the region (Thorson and Hamilton 1977). Radiocarbon dates from soil organics and charcoal suggest that the aeolian deposits do not antedate the third late Wisconsin glacial advance (ca. 13,000-12,000 yr B.P.) (Powers and Hoffecker 1988; Thorson and Hamilton 1977). Older loess appears to be absent in the valley, and may have been removed by deflation (Hoffecker 1985a; Thorson and Bender 1985).

Pollen data (collected from several lake cores in the foothill zone) indicate that shrub tundra vegetation, comprising dwarf birch, willows, ericads, and herbaceous plants (sedges, grasses, and various forbs), began to invade the foothills after 13,500 yr B.P (Ager 1980). However, "corridors of herbaceous tundra" (with abundant sedge, grass, and *Artemisia*) are thought to have survived for several millennia along the river valleys (Ager 1975, 1980). Late glacial faunal remains, recovered from both the Nenana Valley and the neighboring Teklanika Valley, include woolly mammoth (*Mammuthus primigenius*), steppe bison (*Bison priscus*), and wapiti (*Cervus canadensis*) (Powers et al. 1988; Ten Brink and Waythomas 1985).

Archaeological sites of late glacial age are invariably located along the outer margin of the terraces, adjacent to side-valley streams. The most important sites discovered to date include the following: Dry Creek (HEA-005), located on the west side of the river at the upper end of the valley on a Healy outwash terrace (Powers and Hamilton 1978; Powers et al. 1988) Panguingue Creek (HEA-037) and Little Panguingue Creek (HEA-038), also located on the west side of the valley on Healy terraces several kilometers downstream from Dry Creek (Powers and Hoffecker 1988; Powers and Maxwell 1986); Walker Road (HEA-130), situated farther down-valley on the east side of the river on a Healy terrace (Powers and Hoffecker 1988; and Moose Creek (FAI-206), located on a high terrace of probable Tertiary age in the central part of the valley on the east side of the river (Hoffecker 1985b).

The earliest occupation horizons lie at or near the base of the loess sequence. The artifact assemblages contain lanceolate and triangular bifacial points, but lack evidence of microblade technology; two of these assemblages are rich in endscrapers. Associated faunal remains at Dry Creek comprise wapiti and Dall sheep (*Ovis dalli*) (Powers et al. 1988). The early horizons have been tentatively grouped together under the designation Nenana complex (Powers and Hoffecker 1988). They have yielded radiocarbon dates (charcoal) of 11,010±230 yr B.P. (AA-1683), 11,170±180 yr B.P. (AA-1681), 11,300±120 yr B.P. (AA-2264), and 11,820±200 yr B.P. (Beta-11254) at Walker Road; and 11,120±85 yr B.P. (SI-2880) at Dry Creek (Powers and Hoffecker 1988). The lowermost horizon at Moose Creek lies within and below a buried soil complex which has produced four dates (soil organics) ranging between 11,730-8,100 yr B.P. (Hoffecker 1985b).

An artifact assemblage assigned to the Denali complex (see West 1967, 1975) overlies a Nenana complex horizon at Dry Creek. The former contains wedge-shaped microblade cores, microblades, burins, bifacial points, bifacial "knives," and other items, and has yielded a radiocarbon date (charcoal) of 10,690±250 yr B.P. (SI-1561) associated faunal remains consist of steppe bison and Dall sheep (Powers et al. 1988). An early Holocene Denali assemblage (containing both wedge-shaped and conical microblade cores) has been recovered from Panguingue Creek and has produced a series of dates (charcoal) between 8,600-7,130 yr B.P. (Powers and Hoffecker 1988; Powers and Maxwell 1986).

Current research in the Nenana Valley is focused on study of the loess stratigraphy, with particular attention to paleopedology and dating; additional excavation work is planned at Walker Road and Moose Creek. During August 1987, sediment samples were collected from Dry Creek, Little Panguingue Creek, Walker Road, Moose Creek, and site FAI-205 (located at the lower end of the valley) for analysis of magnetic susceptibility and TL dating. Preliminary results from the magnetic susceptibility study indicate high mass susceptibility readings associated with buried B-horizons, which may facilitate future correlation. TL dates are not yet available, but preliminary analyses indicate that basal loess samples exhibit consistent and measurable TL, and should be datable. Samples of suspected volcanic tephra were collected from Dry Creek and Moose Creek, but the results of their analysis have been negative.

References Cited

Ager, T.A. 1975 *Late Quaternary Environmental History of the Tanana Valley.* Report No. 54. Institute of Polar Studies, Ohio State University, Columbus.

Ager, T.A. 1980 An Outline of the Quaternary History of Vegetation in the North Alaska Range. In *North Alaska Range Project Final Report on 1978-1982 Geoarchaeological Studies,* edited by N.W. Ten Brink. Unpublished report to the National Geographic Society and the National Park Service.

Hoffecker, J.F. 1985a Archaeological Field Research 1980. *National Geographic Society Research Reports* 19:48-59.

Hoffecker, J.F. 1985b The Moose Creek Site. *National Geographic Society Research Reports* 19:33-48.

Powers, W.R., and T.D. Hamilton 1978 Dry Creek: A Late Pleistocene Human Occupation in Central Alaska. In *Early Man in America from a Circum-Pacific Perspective,* edited by A.L. Bryan, pp. 72-77. Department of Anthropology Occasional Papers No. 1, University of Alberta, Edmonton.

Powers, W.R., and J.F. Hoffecker 1988 Late Pleistocene Settlement in the Nenana Valley, Central Alaska. *American Antiquity,* in press.

Powers, W.R., and H.E. Maxwell 1986 Lithic Remains from Panguingue Creek, an Early Holocene Site in the Northern Foothills and the Alaska Range. *Alaska Historical Commission Studies in History* 189.

Powers, W.R., R.D. Guthrie, and J.F. Hoffecker 1988 *Dry Creek: Archaeology and Paleoecology of a Late Pleistocene Alaska Hunting Camp.* Aurora Series, Alaska Anthropolgical Association, in press.

Ritter, D.F. 1982 Complex River Terrace Development in the Nenana Valley near Healy, Alaska. *Geological Society of America Bulletin* 93:346-356.

Ten Brink, N.W. 1983 Glaciation at the Northern Alaska Range. In *Glaciation in Alaska: Extended Abstracts from a Workshop,* edited by R.M. Thorson and J.D. Hamilton, pp. 82-91. Alaskan Quaternary Center, University of Alaska Museum, Occasional Paper No. 2, Fairbanks.

Ten Brink, N.W., and C.F. Waythomas 1985 Late Wisconsin Glacial Chronology of the North-Central Alaska Range: A Regional Synthesis and Its Implications for Early Human Settlement. *National Geographic Society Research Reports* 19:15-32.

Thorson, R.M., and T.D. Hamilton 1977 Geology of the Dry Creek Site; A Stratified Early Man Site in Interior Alaska. *Quaternary Research* 7:149-176.

Thorson, R.M., and G. Bender 1985 Eolian Deflation by Ancient Katabatic Winds: A Late Quaternary Example from the North Alaska Range. *Geological Society of America Bulletin* 96:702-709.

Wahrhaftig, C. 1958 *Quaternary Geology of the Nenana River Valley and Adjacent Parts of the Alaska Range.* U.S. Geological Survey Professional Paper, Contract No. 293-A.

West, F.H. 1967 The Donnelly Ridge Site and the Definition of an Early Core and Blade Complex in Central Alaska. *American Antiquity* 32:360-382.

West, F.H. 1975 Dating the Denali Complex. *Arctic Anthropology* 12:76-81.

Dating the Lower Member of the Domebo Formation in Western Oklahoma

Jack L. Hofman

Research 25 years ago at the Domebo mammoth kill site in southern Caddo County, western Oklahoma, provided the first substantive study of late Pleistocene ecology in the area (Leonhardy 1966). The lower member of the Domebo Formation was first mapped and defined by Albritton (1966) in Domebo Canyon, a perennial tributary of the Washita River. The Domebo study remains the primary basis for interpretation of the terminal Pleistocene and early Holocene in the southern prairie Plains region. The only additional work in the vicinity on the period between 12,000 to 8,000 yr B.P. ago was a brief geomorphological study in a similar canyon tributary of the Washita River located in Washita County, 40 km to the west (Nials 1977). Nials documented the presence of a formation in Cedar Creek very similar in composition to the lower member of the Domebo Formation and which produced two radiocarbon dates on charcoal of 9,645±110 yr B.P. (UGa-1728) and 9,335±125 yr B.P. (UGa-1732).

Stafford et al. (1987) dated additional bone samples from the Domebo mammoth producing encouraging results for future accurate dating of bone samples using the TAMS method. An elm stump from the lower member at Domebo was also dated by

Jack L. Hofman, Oklahoma Archeological Survey, University of Oklahoma, 1808 Newton Drive, Norman, OK 73019.

Stafford et al. (1987) to 11,490±450 yr B.P. (AA-823). This date compares well with two previous dates on preserved stumps from the Domebo site: 11,045±647 yr B.P. (SMU-695) and 10,123±280 yr B.P. (SMU-610) (Albritton 1966).

Slumping recently exposed a stump about 50 m downstream from the Domebo type section and the specimen was sampled and dated. This stump was rooted in the lower member of the formation but the top was in contact with the upper member, similar to the previously dated elm stump from Domebo. This date (10,980±70 yr B.P. (Beta-24212) is in close accord with the previous stump dates from the site.

The question of whether the lower member of the Domebo Formation represents a widespread stratigraphic unit in canyons throughout the Caddo County area, or is simply an anomalous situation at the Domebo site has not been adequately addressed. Recent work in several canyons in both the Washita and Canadian river systems suggests that this unit may be widespread and of significance for studying the Pleistocene/Holocene transition in the region (Hofman 1987). Unit 2 of the lower member was described by Albritton (1966) as a dark gray, clayey silt paludal paleosol. The lower member of the Domebo Formation is found at the base of canyons overlying Permian-age Rush Springs sandstone. Tree stumps from such deeply buried deposits in several canyons have now been radiocarbon dated documenting the widespread occurrence of the lower Domebo member. A stump from Cedar Creek in Washita County has been dated to 9,220±120 yr B.P. (Beta-22427) and compares well to charcoal dates reported from this deposit by Nials (1977).

A canyon 65 km north of Domebo in the Canadian River drainage, yielded a number of stumps in the lower Domebo member of which three have been dated (9580±100 yr B.P. (Beta-20948), 9,780±90 yr B.P. (Beta-22428), 9,490±80 yr B.P. (Beta-24211)). A fourth date was run on a small charcoal sample found in a similar deposit containing bison bones. The Talkington bone bed (34Cd311), some 650 m upstream from the closest dated stump, produced a TAMS date of 8,400±360 yr B.P. (Beta-22430, ETH-3226). This younger age is unexpected given the stump dates from the "same" unit in the canyon. No cultural materials have yet been found with the bison bone, but numerous late Paleoindian projectile points have been documented in gravels downstream from the deposit (Hofman 1987).

Except for the "late" charcoal date from the bone bed, these northern Caddo County dates from the Canadian River drainage compare well to those from the Cedar Creek locality and to a sediment date from the Domebo type locality (9,400±300 yr B.P. (OX-56)). The latter was possibly contaminated by humic acids and might be considered as minimum date for the lower member at the Domebo type exposure.

In sum, preliminary study of stratified alluvial deposits in several canyons in western Oklahoma along the Washita and Canadian rivers gives evidence for the relatively widespread occurrence of the lower member of the Domebo Formation. All canyons in which this unit has been identified have produced Paleoindian projectile points, and the available dates support a time interval from 12,000 to 9,000 yr B.P. for various exposures of the lower Domebo. This situation suggests that a refined understanding of the Pleistocene/Holocene transition in the region can be reached through continued study of various aspects of these deposits.

Assistance in these studies has been provided by Roy Patterson, Ivan Stout, Lindel Thomason, Terrell Nowka, Dean Gamel, Bob Brakenridge, Fran King, Pete Mehringer, Don Wyckoff, Brian Carter, Lois Albert, Cecil Talkington, Tom Springfield, and Harry Nowka.

References Cited

Albritton, C.C., Jr. 1966 Stratigraphy of the Domebo Site. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains,* edited by F.C. Leonhardy, pp. 10-13. Contributions of the Museum of the Great Plains 1, Lawton.

Hofman, J.L. 1987 Recent Studies of Late Pleistocene and Early Holocene Sites in Western Oklahoma. Paper Presented at the 45th Plains Anthropological Conference, Columbia, Missouri

Leonhardy, F.C. (editor) 1966 *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains.* Contributions of the Museum of the Great Plains 1, Lawton.

Nials, F.L. 1977 *Geology of Reservoir Area, Cowden Laterals Watershed Site Number 8.* Report on file at the Oklahoma Conservation Commission.

Stafford, T.W., Jr., A.J.T. Jull, K. Brendel, R.C. Duhamel, and D. Donahue 1987 Study of Bone Radiocarbon Dating Accuracy at the University of Arizona NSF Accelerator Facility for Radioisotope Analysis. *Radiocarbon* 29:24-44.

A Rhythmite Sequence from Glacial Lake Upham, Northeast Minnesota

James K. Huber, John Ballantyne, and Dianne Dorland

Recent investigations of Glacial Lake Upham have led to the location of an approximately 8 m section of rhythmites that may be varve deposits. The rhythmite section is exposed in a tributary stream cut of the Whiteface River approximately 55 km northwest of Duluth, Minnesota (92° 40′N, 47° 6′ 30″W). The lower contact of the rhythmite section is not exposed and the total thickness is unknown at this time.

Glacial Lake Upham has undergone two stages of development. The first stage occurred during the Automba-Vermilion phase of the Superior and Rainy lobes when Glacial Lake Upham I was formed. Glacial Lake Upham II formed as the St. Louis sublobe retreated during the Alborn phase (Wright 1972). Hobbs (1983) suggests that Glacial Lake Upham II was at a fairly stable level approximately 9,000 to 10,000 yr B.P. and later drained via the St. Louis River. If the rhythmites are determined to be yearly varves, the section will yield a minimum time span for the duration Glacial Lake Upham was in existence.

A 20-cm-thick sample of rhythmites was extracted from the lower 2 m of the exposed section for preliminary analysis. The rhythmites are composed of alternating bands of dark olive-gray clay (5Y 3/2) and a gray silty clay (5Y 5/1). Both layers are carbonate rich. The olive-gray clay layers range from 3.8-6.9 mm, averaging 5.2±0.8 mm in thickness, and the silty clay layers range from 1.0-8.0 mm, averaging 4.2±2.3 mm. Sets of layers average 9.9±2.1 mm. Based on pipette analysis, the rhythmites have a bulk composition of 34% silt and 66% clay.

James K. Huber, Archaeometry Laboratory, University of Minnesota-Duluth, Duluth, MN 55812.

John Ballantyne, Department of Geology, University of Minnesota-Duluth, Duluth, MN 55812.

Dianne Dorland, Department of Materials Processing Engineering, University of Minnesota-Duluth, Duluth, MN 55812.

Preliminary analysis of eight rhythmites yielded the following pollen types: *Picea* (spruce), *Pinus* (pine), *Betula* (birch), *Salix* (willow), *Quercus* (oak), *Corylus* (hazel), *Cornus* (dogwood), *Ulmus* (elm), *Artemisia* (wormwood), Chenopodiaceae/Amaranthaceae (goosefoot/amaranth), *Ambrosia* (ragweed), Gramineae (grass), and Cyperaceae (sedge). Spores of *Pteridium*-type (bracken fern), and *Sphagnum* (sphagnum) were also found. In addition, *Pediastrum simplex, P. boryanum,* and *Scenedesmus,* all Chlorophycophyta algae, were also found. The pollen types found are consistent with those reported by Baker (1964) for Spider Creek, an early postglacial peat deposit in a drainageway of Glacial Lake Upham. A few fragments of plant material were observed, however, they were not large enough to be identified.

After more detailed field observations are undertaken of the rhythmite section, more complete analyses are planned for pollen, diatoms, and grain-size distribution. These analyses should provide a more complete history of Glacial Lake Upham.

References Cited

Baker, R.G. 1964 *Late-Wisconsin Glacial Geology and Vegetational History of the Alborn Area, St. Louis County, Minnesota.* Unpublished Masters's thesis, University of Minnesota, Minneapolis.

Hobbs, H.C. 1983 Drainage Relationships of Glacial Lakes Aitkin and Upham and Early Lake Agassiz in Northeast Minnesota. In *Glacial Lake Agassiz,* edited by J.T. Teller and C. Clayton, pp. 245-259. Geological Association of Canada Special Paper 26.

Wright, H.E., Jr. 1972 Quaternary History of Minnesota. In *Geology of Minnesota: A Centennial Volume,* edited by P.K. Sims, and G.B. Morey, pp. 515-547. Minnesota Geological Survey.

Dating Late Quaternary Deposits in the Alpine of Western Wyoming by Soil Stratigraphy

William C. Mahaney

Over the last 15 years approximately 100 sites of neoglacial age have been excavated, described, and sampled in the alpine zone of the Wind River and Teton ranges of western Wyoming. While no artifacts were recovered from these sites, it is probably only a matter of time before one or more workers find temporary prehistoric occupation sites on or near neoglacial deposits in some of the high valleys. The purpose of this report is to point out that it is possible to use soil stratigraphy to derive relative ages for deposits in neoglacial successions.

In Upper Titcomb Basin (43° 07′N, 109° 37′W) a sequence of glacial deposits (Figure 1), spanning the last ±10,000 years, are prominently displayed on the valley floor (see Mahaney, 1978 for details of the geomorphology, soil chemistry and mineralogy). Deposits in this chronosequence can be assigned ages by relative dating methods (Mahaney et al. 1984a) which include topographic position, weathering characteristics (including stone frequency, weathering ratios, weathering rinds, and

William C. Mahaney, Geography Department, Atkinson College, York University, 4700 Keele Street, North York, ON, Canada M3J 1P3.

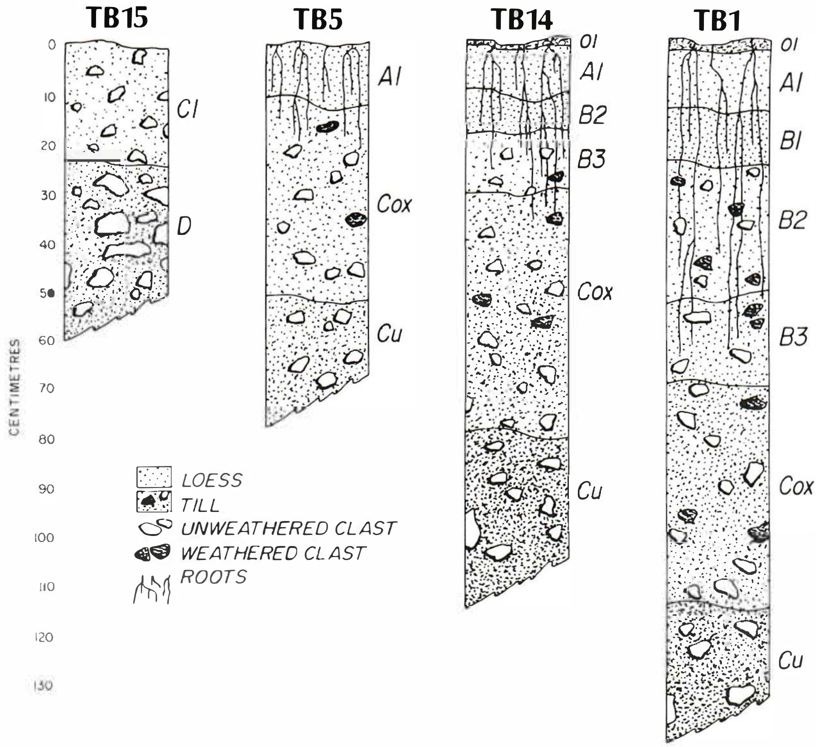


Figure 1. Soil profiles discussed in text.

pitting on stone surfaces), and lichenometry. Another method which reveals the relative ages of individual deposits involves soil stratigraphy, or the degree of weathering that occurred in substrates following deposition. These deposits carry distinctive soil profiles representative of the age of each individual stratigraphic unit. Deposits may be differentiated largely by changes in field morphology and degree of soil genesis. In addition, detailed analyses of the organic and textural profiles, mineralogy of the clay fraction (<2 mm), and selected soil chemical parameters yield additional data useful in relative age determination (Mahaney 1978, 1981, 1984; Mahaney and Spence 1984; Mahaney et al., 1984b; Miller and Birkeland 1974).

The data shown in Figure 1 illustrate the morphologic differences between soils in the chronosequence. At site TB15 a young Entisol of post-Gannett Peak age (<100 yr), weathered to a depth of ±20 cm, is found over 10% of the youngest neoglacial moraines. Brownish gray (10YR 6/1) soil colors and loamy sands textures dominate in this profile, which is structureless and pebbly throughout. Roots are not present in these young neoglacial soils owing to insufficient time for plant colonization.

The next oldest soil in the sequence of post-Audubon age (±1,000 yr B.P.) is represented by profile TB5 (Cryorthent), which is typical of soils formed in older neoglacial moraines and mass wasted deposits. Because of greater elapsed time since deposition, roots have developed in the A1 and upper Cox horizons. Colors range from brownish black (10YR 3/2) in the A1 horizon, to dull yellow orange (10YR 6/3) in the Cox and grayish yellow (2.5Y 7/2) in the parent material (Cu). Pebbles dominate throughout the Cox/Cu horizons tapering off in the A1 horizon where some airfall (loessic) sediments are located. Weathered clasts in the Cox horizon are not as plentiful as in the older profiles in the sequence.

With increasing time, profiles of post-Indian Basin age (e.g. TB14) develop different characteristics in sediments of glacial and mass wasted origins. An 01 horizon appears for the first time as residual organic matter accumulates on the surface. Color differences become more pronounced with brownish black (10YR 2/3) hues in the A1, brown (10YR 4/4) in the B2, dull yellowish brown (10YR 5/4) in the Cox, changing to olive (5Y 5/3) in the parent material. The loess thickness increases slightly with greater time, and horizon differentiation gives rose to a Cryochrept (Soil Survey Staff 1975) with an A/B/C horizon complex. Depth of weathering increases to ±80 cm, and greater textural differentiation is possible between A, B, and C horizons. In general, it requires nearly 3,000 years to develop Inceptisols (Cryochrepts) like TB14 (Mahaney 1978; Mahaney and Spence 1984).

The oldest profile (TB1) of post-late Pinedale age developed in a deposit emplaced during recessional stillstand of alpine valley glaciers at approximately 8,000-10,000 yr B.P. (Mahaney 1978; Mahaney and Spence 1984). These soils, (Mahaney 1978) represented by profile TB1, have 01 horizons and relatively well developed root systems that penetrate through the soil solum (A and B horizons). Loess thickness is greater than in the younger profiles, and the B2 (cambic) horizon is thicker, a sign of somewhat greater weathering and oxide formation. A greater frequency of weathered clasts is encountered in the B and C horizons and colors indicate advanced weathering—dull yellowish brown (10YR 5/4) and dull yellow orange (10YR 7/3) hues in the B2 horizon. These colors change to grayish yellow (2.5Y 7/2) in the unweathered till (Cu horizon). Overall, depth of weathering increases to ±100 cm.

The data in this soil chronosequence show that overall depth of weathering, clast weathering, soil color, degree of horizonation, loess thickness, soil structure, and texture, provide useful criteria for age differentiation. Soil system characteristics appear dependent on elapsed time since deposition and are useful in recognizing deposits in late Quaternary alpine sequences.

References Cited

Mahaney, W.C. 1978 Late-Quaternary Stratigraphy and Soils in the Wind River Mountains. In *Quaternary Soils,* edited by W.C. Mahaney, pp. 223-264. Geoabstracts Ltd., Norwich, U.K.

Mahaney, W.C. 1981 Paleoclimate Reconstructed from Paleosols: Evidence from East Africa and The Rocky Mountains. In *Quaternary Paleoclimate,* edited by W.C. Mahaney, pp. 227-247. Geo Books, Norwich, U.K.

Mahaney, W.C. 1984 Indian Basin Advance: New Name for Early Neoglacial Till in Western and North-Central Wyoming. *Northwest Science* 58:94-102.

Mahaney, W.C., and J. Spence 1984 Glacial and Periglacial Sequence and Floristics in Jaw Cirque, Central Teton Range, Western Wyoming. *American Journal of Science* 284:1056-1081.

Mahaney, W.C, D.L. Halvorson, J. Piegat, and K. Sanmugadas. 1984a Evaluation of Dating Methods Used to Differentiate Quaternary Deposits in The Wind River and Teton Ranges, Wyoming. In *Quaternary Dating Methods,* edited by W.C. Mahaney, pp. 355-374. Elsevier, Amsterdam.

Mahaney, W.C., M.G. Boyer, D.L. Halvorson, and K. Sanmugadas 1984b Glacial Chronology of The Rocky Mountains: Some Problems from Observations in Western Wyoming. In *Correlation of Quaternary Chronologies*, edited by W.C. Mahaney, pp. 225-241. Geo Books, Norwich, U.K.

Miller, C.D., and P.W. Birkeland 1974 Probable Pre-Neoglacial Age of the Type Temple Lake Moraine, Wyoming: Discussion and Additional Relative-Age Data. *Arctic and Alpine Research* 6:301-306.

Soil Survey Staff 1975 *Soil Taxonomy*. United States Government Printing Office, Washington, D.C.

Late Quaternary Sedimentation in the Republican River Basin, South-Central Nebraska

Charles W. Martin

The identification of paleosols in upland and lowland deposits in the vicinity of Harlan County Lake has yielded preliminary information on the late Quaternary sedimentation record of the Republican River in south-central Nebraska (Figure 1). Because of its location within the climatic zone that separates the humid eastern and arid western portions of North America, the 80 km reach of the Republican River under study has been particularly sensitive to changes in late Quaternary climate. These changes are reflected in the sedimentation record of the area.

Radiocarbon dating of buried soils in the study area has provided numerical age estimates for upland and lowland deposits. Upland deposits, most of which are comprised of loess, appear to date to the late Pleistocene. Paleosols developed in loess at the Bone Cove and North Cove sites yielded radiocarbon ages of 26,260±680 yr B.P., (Tx-5910); and 16,130±270 yr B.P. (DIC-3358) respectively. A paleosol formed in reworked loess at the Prairie Dog Bay site was radiocarbon dated at 10,360±130 yr B.P. (Tx-5909), a period of surface stability and soil formation also identified by May (1986) in the Loup River basin, Nebraska, and by Johnson and Martin (1987) in the Kansas River basin, Kansas.

While upland deposits in the study area have been radiocarbon dated to the late Pleistocene, lowland deposits in the Republican River valley appear to be Holocene in age. Upriver from Harlan County Lake, an extensive lowland surface that slopes gently to the adjacent upland has been identified. At one site, the Republican River has eroded a 7-m-high cutbank in fill beneath this surface, exposing three paleosols separated by fining-upward sequences of medium sand to silt. Humates from the Ab horizon of the lowermost (4.96-5.02 m below banktop) and uppermost (1.90-1.96 m below banktop) soils were radiocarbon dated at 3,050±60 yr B.P. (Tx-5912) and 2,020±60 yr B.P. (Tx-5911) respectively. The relative youthfulness of these deposits suggests that late Pleistocene and early Holocene material has been eroded from the reach of the Republican River under study here. Further, the late Holocene age of these deposits appears to preclude the possibility of finding in situ, early Archaic cultural material in this reach of the valley.

Whereas the late Quaternary sedimentation record of the Republican River basin was examined in the initial phase of this study, subsequent research will focus

Charles W. Martin, Department of Geography, University of Kansas, Lawrence, KS 66045-2121.

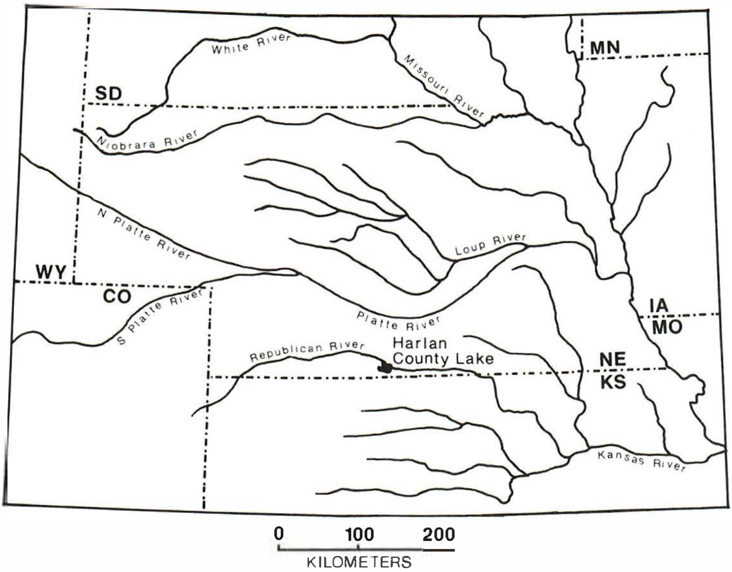


Figure 1. Location of Harlan County Lake and the Republican River basin.

on the abundant floral and faunal material found in the study area. To date, the North Cove site has produced numerous faunal remains indicative of boreal conditions, including yellow-cheeked vole (*Microtus xanthognathus*), snowshoe hare (*Lepus americanus*), and heather vole (*Phenacomys intermedius*) (Stewart, pers. comm. 1987). Results from additional analysis of these and other remains will be used to reconstruct the late Quaternary climatic record of the study area. Integration of this record with the sedimentation record should, in turn, facilitate the development of a model that explains changes in sedimentation activity in the study area in the context of climate fluctuations. This model can then be compared with those discussed by Brakenridge (1981), Wendland (1982), Knox (1983), and May (1986), among others.

References Cited

Brakenridge, G.R. 1981 Late Quaternary Floodplain Sedimentation Along the Pomme de Terre River, Southern Missouri. *Quaternary Research* 15:62-76.

Johnson, W.C., and C.W. Martin 1987 Holocene Alluvial-Stratigraphic Studies from Kansas and Adjoining States of the East-Central Plains. In *Quaternary Environments of Kansas,* edited by W.C. Johnson, pp. 109-122. Kansas Geological Survey Guide Book No. 5, Kansas Geological Survey, Lawrence.

Knox, J.C. 1983 Responses of River Systems to Holocene Climates. In *Late Quaternary Environments of the United States, the Holocene,* edited by H.E. Wright, Jr., pp. 26-41. University of Minnesota Press, Minneapolis.

May, D.W. 1986 *Holocene Alluviation, Soil Genesis, and Erosion in the South Loup Valley, Nebraska.* Unpublished Ph.D. dissertation, Department of Geography, University of Wisconsin, Madison.

Wendland, W.C. 1982 Geomorphic Responses to Climatic Forcing During the Holocene. In *Space and Time in Geomorphology,* edited by C.E. Thorn, pp. 355-371. Allen and Unwin Ltd., London.

The Seaman Reservoir Mammoth Locality (5LR1098), North Fork Cache La Poudre River, Colorado

Michael McFaul, Christian J. Zier, and Elaine Anderson

A single *Mammuthus* sp. (mammoth) tooth was recovered ±1.2 m beneath the land surface at site 5LR1098 (T9N R70W S1/2 SE 1/4 S28). The site lies at 1,667 m elevation on a fill terrace within a steep valley cut into the eastern Precambrian flank of the Colorado Front Range, 15.7 km northwest of Fort Collins. Initially recorded as an archaeological site, 5LR1098 was test excavated to determine the nature, extent, and age of subsurface cultural deposits, and to elucidate the geomorphic characteristics of the terrace on which the site is situated. There is no apparent association of the tooth with the prehistoric cultural remains.

The tooth was encased within a massive, strong brown (7.5YR 4/6 m), alluvial silty sand. This silty sand is part of an upward-fining alluvial sequence that mantles >14 m of cobble/boulder outwash fill. Sequential fining continues to within 4 cm of the surface where the alluvium has been reworked by reservoir wave action, and textures coarsen. The tooth was recovered from the lower portion of fine-grained alluvium between the outwash fill and the reworked surface sediment. The tooth level alluvium is well-sorted and void of colluvial or alluvial clasts >2 mm. The silty sand texture of the tooth matrix alluvium, the absence of clasts >2 mm, and the tooth/matrix size relationship (Behrensmeyer 1975) all suggest that the tooth had not been transported a great distance by the North Fork.

Datable cultural materials are not associated with the bone level. However, geomorphic relationships suggest a late Pleistocene-early Holocene setting for terrace construction. Similar alluvial terraces of this age in northeastern Colorado (Holliday 1987) are named Pleasant Valley or Kersey (Bryan and Ray 1940). *M. columbi* (Columbian mammoth) remains dating 11,200 yr B.P. (Haynes 1964) were recovered in Kersey terrace alluvium at the Dent site on the South Platte River. At the Seaman Reservoir locality three factors indicate a favorable correlation with the geomorphic characteristics of the Kersey terrace (Holliday 1987). These are: a) height of the outwash fill above the river floodplain (Bryan and Ray 1940); b) the glacial origin of the fill (Bryan and Ray 1940); and c) ridge-swale terrain developed on the outwash.

Terrace abandonment and approximately 15 m of subsequent stream incision have exposed the following fill sequence:

1) The North Fork Cache la Poudre River cuts the Precambrian rock to form the valley (Pleistocene);
2) Greater than 14 m of Pleasant Valley outwash deposited in the valley (late Pleistocene);
3) Outwash deposition ends (earliest Holocene);
4) Fine-grained alluvium mantles the fill (earliest Holocene to >9,000 yr B.P.). The tooth was buried >40 cm above the outwash in a channel swale;
5) Terrace abandonment (>9,000 yr B.P.; Holliday 1987)
   a) incision by the North Fork to the modern floodplain interrupted by the formation of an inset terrace and a floodplain step (>9,000 yr B.P. to present);

Michael McFaul, LaRamie Soils Service, P.O. Box 255, Laramie, WY 82070.

Christian J. Zier, Centennial Archaeology, Inc., 2400 Hawthorne Ct., Ft. Collins, CO 80524.

Elaine Anderson, 730 Magnolia St., Denver, CO 80020.

b) formation of a Bw/C1/C2 soil on the terrace (9,000 yr B.P. to reservoir construction);
6) Reworking of the terrace surface by wave erosion (since filling of Seaman Reservoir in 1950s);
7) Formation of the modern platy soil A horizon (<30 years).

An A/2Bwb/2Cb1/(tooth level) 2Cb2 soil profile is present within the fine-grained alluvium. The dark organic or strongly gleyed paleosols associated with other late Pleistocene-early Holocene *Mammuthus* localities on the plains of northeastern Colorado (Graham 1980, 1987) are absent. Soil development appears weak for an early Holocene soil. However, soil development across the Kersey terrace is thought dependent upon valley position and parent material (Holliday 1987). Soils having weak Bw/C soil horizonation similar to that of the Seaman Reservoir locality are developed in Kersey alluvium south of the Jurgens site near Kersey, Colorado (Holliday 1987). Soil Description:

A: 0-4 cm, brown (7.5 YR 4/6 m), platy, sandy loam, non-effervescent, vegetation stripped, wave-reworked alluvium.

Disconformity

2Bwb: 4-60 cm, yellowish red (5 YR 4/6 m), structureless, sandy clay loam, non-effervescent, common, thin bridged films between sands, alluvium. The lack of structure in this horizon is the basis for the clay bridges being termed pressure skins.

2Cb1: 60-115 cm, strong brown (7.5 YR 4/6 m), structureless, silty loam, non-effervescent, alluvium.

2Cb2: 115-116 m. strong brown (7.5 YR 4/6 m), structureless, sandy loam, non-effervescent, alluvium. The tooth was in this horizon (118-122 cm).

The Seaman Reservoir *Mammuthus* sp. tooth was found in fine-grained alluvium deposited upon outwash fill. The alluvial sediments at the Seaman locality correlate geomorphically (Bryan and Ray 1940; Holliday 1987) with those of the late Pleistocene-early Holocene Pleasant Valley/Kersey terrace. Although weak development is not uncommon on the Kersey terrace, soil development in the fine-grained alluvium at the Seaman locality is considered weak for an early Holocene age soil. The size and weight of the tooth in relation to the size of its silty sand matrix (Behrensmeyer 1975) suggest that the tooth was not transported a great distance by the alluvial environment prior to burial. Finally, the location of 5LA1098 within the foothills of the Front Range suggests an expansion of *Mammuthus* range from the plains (Graham 1987; Harris 1985) into the foothills of the Rocky Mountains and hints that this range may extend to the mountain parks.

Investigations at site 5LR1098 were conducted by Centennial Archaeology, Inc. under subcontract to Envirosphere Company of Bellevue, Washington. Funding was provided by the Colorado Water Resources and Power Development Authority (CWRPDA). The assistance of Charles M. Prewitt (Envirosphere), Karl Dreher and Gene Schleiger (Northern Colorado Water Conservancy District), and Blaine Dwyer (CWRPDA) is gratefully acknowledged. The manuscript benefited from suggestions by Richard G. Reider, Department of Geography, University of Wyoming, Laramie.

References Cited

Behrensmeyer, A.K. 1975 The Taphonomy and Paleoecology of Plio-Pleistocene Vertebrate Assemblages East of Lake Rudolf, Kenya. *Bulletin of the Museum of Compartment Zoology, Harvard University,* 146:474-578.

Bryan, K., and L.L. Ray 1940 Geologic Antiquity of the Lindenmeier Site in Colorado. *Smithsonian Miscellaneous Collections* 99:1-76.

Graham, R.W. 1980 Preliminary Report on Late Pleistocene Vertebrates From the Selby and Dutton Archaeological Paleontological Sites, Yuma County, Colorado. *University of Wyoming Contributions to Geology* 20:33-56.

Graham, R.W. 1987 Late Quaternary Mammalian Fauna and Paleoenvironments of the Southwestern Plains of the United States. In *Late Quaternary Mammalian Biography and Environments of the Great Plains and Prairies,* edited by R.W. Graham, H.A. Semken, Jr., and M.A. Graham, pp. 24-86. Illinois State Museum Scientific Papers, Springfield.

Harris, A.H. 1985 *Late Pleistocene Vertebrate Paleoecology of the West.* University of Texas Press, Austin.

Haynes, C.V., Jr. 1964 Fluted Projectile Points: Their Age and Dispersion. *Science* 145:1408-1413.

Holliday, V.T. 1987 Geoarchaeology and Late Quaternary Geomorphology of the Middle South Platte River, Northeastern Colorado. *Geoarchaeology* 2:317-329.

A Long Pleistocene Glacial Sequence in Southwestern Montana

Mort D. Turner, Joanne C. Turner, and Robson Bonnichsen

Quaternary geology was carried out in southwestern Montana during 1985, 1986, and 1987 (Turner et al. 1987). The study was part of an investigation of geoarchaeological and environmental geology in conjunction with the archaeological study of a late Pleistocene/Holocene site, the South Everson Creek/Black Canyon Creek Quarry Complexes, by the Center for the Study of Early Man, University of Maine, with partial support by Earthwatch (Bonnichsen et al. 1987). We concentrated on the Horse Prairie Creek Basin, Grasshopper Creek Basin, and the adjacent east slopes of the Beaverhead Mountains, an area of approximately 1,500 km2 that is about 30 km east-west by 60 km north-south, all within Beaverhead County and bounded on the south and west by Idaho. Preliminary evidence indicates at least six pre-Bull Lake age glacial advances from outside the area to the north. Six tills left by these advances contain at least 30 different rock types, including many that do not outcrop in the local area. Thicknesses range from a few meters to >200 m, with erratics >12 m in length. There is also petrologic evidence in the tills that major valley glaciers moved out of the mountains on the east and west sides of the area and merged with the main glacial lobes that advanced from the north. A few of these early tills were previously mapped (Lowell 1965) as part of the lower Cretaceous/early Tertiary Beaverhead conglomerate. However, the presence of Tertiary volcanics in the tills prevent us from classifying them as part of the Cretaceous Beaverhead conglomerate. Some nine glacial advances that are younger than the six early Pleistocene advances from the north originated in the Beaverhead Mountains along the west side of the area. The crest of the Beaverhead Mountains, both north and south of our area is at >3,000 m elevation. These crests, located outside of our area, supported valley and cirque glaciers during Pinedale and Little Ice Age times (Alden 1953). The crest of the Beaverheads in our area rises only to approximately 2,800 m elevation, which was apparently insufficient to support glaciers during the last 50,000 years. The most recent moraines found in our area are from cirque glaciers of Bull Lake age. Earlier valley glaciers moved east of the Beaverheads in this area, some reaching the valley basins, some 10 km below the crestal cirques.

Selected samples from the various tills were studied petrologically. Quartz grains from these samples, studied by us by scanning electron microscope (Electron Microscopy Laboratory, University of Kansas), all show a predominance of surface

Mort D. Turner, and Robson Bonnichsen, Center for the Study of Early Man, University of Maine, 495 College Avenue, Orono, ME 04473.

Joanne C. Turner, JCT Enterprises, 3920 Rickover Road, Silver Spring, MD 20902.

features that have been attributed to glacial environments (Krinsley and Doornkamp 1973). The number of glacial advances, degrees of weathering, degrees of reduction of original surface forms, topographic locations, and weathering patterns within the tills indicate to us that the tills in this area represent glacial advances ranging in age from lower Pliocene/early Pleistocene to late Pleistocene (Bull Lake).

Individual tills attributed to late Pliocene/early Pleistocene time have been identified in widely separated parts of the mountain West (Birkeland et al. 1971; Coash 1980). There is a long sequence of middle to late Pleistocene and Holocene tills in the Lemhi Mountains in western Idaho (Dort and Turner 1964; Dort 1965; Rupple and Hait 1961). There are long till sequences in the central United States (Dort 1987). However we are not aware of any other till sequences in the West that cover such a long period of time. Further field and laboratory research on this project are planned for at least the next three field seasons.

References Cited

Alden, W.C. 1953 Physiography and Glacial Geology of Western Montana and Adjacent Areas. *U.S. Geological Survey Professional Paper* 231.

Birkeland, P.W., D.R. Crandell, and G.M. Richmond 1971 Status of Correlation of Quaternary Stratigraphic Units in the Western Conterminous United States. *Quaternary Research* 1:208-227.

Bonnichsen, R., J. Taylor, and M.D. Turner 1987 Pleistocene Peoples of Southwestern Montana. *Current Research in the Pleistocene* 4:1-3.

Coash, J.R. 1980 *Field Guide* NAGT-FWS Fall Field Conference, Mammoth Lakes, CA, September 27-28, 1980. National Association of Geological Teachers, Far-Western Section.

Dort, W., Jr. 1965 Glaciation in Idaho—A Summary of Present Knowledge. *Tebiwa* 8:29-37.

Dort, W., Jr. 1987 Salient Aspects of the Terminal Zone of Continental Glaciation in Kansas. In *Quaternary Environments of Kansas,* edited by W.C. Johnson, pp. 55-56. Survey, Guidebook Series 5.

Dort, W., Jr., and M.D. Turner 1964 Four-Dimensional Geomorphology of Birch Creek Valley, Idaho. *Geological Society of America Special Paper* 82:48-49.

Krinsley, D.H., and J.C. Doornkamp 1973 *Atlas of Quartz Sand Surface Textures.* The University Press, Cambridge, England.

Lowell, W.R. 1965 Geological Map of the Bannack-Grayling Area, Beaverhead County, Montana. *U.S. Geological Survey, Miscellaneous Geological Investigation Map* I-433.

Ruppel, E.T. and M.H. Hait, Jr. 1961 Pleistocene Geology of the Central Part of the Lemhi Range, Idaho. *U.S. Geological Survey, Professional Paper* 424-B:163-164.

Turner, M.D., J.C. Turner, and R. Bonnichsen 1987 Investigations of the Pleistocene Geological History in the Vicinity of the South Everson Creek and Black Canyon Creek Archaeological Sites, Southwestern Montana. *Current Research in the Pleistocene* 4:137-139.

Implications of the Alluvial Record of the Santa Cruz River to the Discovery of Paleoindian and Early Archaic Sites in the Tucson Basin, Arizona

Michael R. Waters

Alluvial sediments in river valleys preserve the evidence of human activity that correspond with periods of aggradation. If aggradation were a continuous steady process, a complete history of human activity would be preserved in the alluvial sediments of rivers. However, the stratigraphic record of fluvial systems is incomplete because periods of aggradation were interrupted by periods of degradation (erosion) and non-deposition (stability). During periods of channel downcutting and widening, previously deposited portions of the archaeological record can be either entirely or partially removed. During periods of floodplain stability, characterized by intervals of minimal deposition and erosion and potential soil formation, repeated occupations on the floodplain will be compressed onto a stable surface that may later become buried. Together, periods of erosion and stability, alternating with periods of aggradation, create gaps or unconformities in the alluvial sequence that create an incomplete geological record of material units. Correspondingly, these same geological processes will also create an incomplete record of culture history. This is well illustrated in the Santa Cruz River, a deep arroyo that flows through the semi-arid Tucson Basin of Arizona.

Within the alluvial strata of the Santa Cruz River, archaeological remains of the middle and late Archaic, Hohokam, Protohistoric, and Historic periods are found. However, archaeological material dating to the Paleoindian and early Archaic periods are absent from the alluvial record. A cultural explanation or a natural explanation can be invoked to account for the absence of early archaeological remains. On the one hand, the Santa Cruz floodplain may not have been occupied or utilized during the Paleoindian or early Archaic periods. Alternatively, the archaeological remains dating to these periods may have never become buried in the alluvial record or older deposits that once contained them have been removed by erosion. These explanations have different implications to the interpretation of the terminal Pleistocene and early Holocene archaeological record of the Tucson Basin. To understand the nature of the archaeological record, it is necessary to understand the history of late Quaternary alluviation in the Santa Cruz River. Seven major geologic units are defined for the Santa Cruz River. Absolute ages are assigned to the alluvial units based on 61 radiocarbon dates, 8 archeomagnetic dates, and temporally diagnostic artifacts. A brief review of the alluvial history of the Santa Cruz River is presented here and a more detailed discussion of the stratigraphy and geochronology can be found in Haynes and Huckell (1986), and Waters (1987, 1988a, 1988b).

Prior to 8,000 yr B.P., a braided stream flowed through the Santa Cruz Valley over a wide floodplain at a grade 8 m below the modern floodplain of the Santa Cruz River. This was followed by a major period of channel downcutting and widening

Michael R. Waters, Department of Anthropology and Department of Geography, Texas A & M University, College Station, TX 77843.

from 8,000 to 5,500 yr B.P. During this degradational event, most alluvial deposits in the Santa Cruz River older than 5,500 yr B.P. were eroded from the valley. Slopewash deposition from the adjacent bajadas began to fill the channel between 5,500 and 4,500 yr B.P. after widening of the channel ceased. Another period of alluviation occurred between 4,000 and 2,500 yr B.P. within a braided stream that flowed over the wide floodplain left as a result of the middle Holocene erosional event. After 2,500 yr B.P., the regime of the Santa Cruz River changed dramatically. During this period, the floodplain experienced 7 m of vertical aggradation during four cutting and filling episodes. The modern floodplain became entrenched during the late 19th and early 20th centuries.

The geologic history of the Santa Cruz River indicates that the absence of Paleoindian and early Archaic archaeological remains in this area is probably the result of the episode of erosion of older valley fill during the middle Holocene. Late Pleistocene and early Holocene archaeological sites, if originally buried in alluvium, were probably eroded from the Santa Cruz River as the channel cut deeply into its floodplain and extensively widened itself. If early archaeological remains were once buried, they may still be preserved near the margins of the floodplain in areas where remnants of the early Holocene alluvium were protected from the channel widening or where the channel widening was not severe enough to remove all older alluvium.

In conclusion, environmental changes on the floodplain of the Santa Cruz River had major impacts on the preservation of the archaeological record. Periods of erosion have created absence or gaps in the archaeological record, thus limiting our knowledge of early prehistory and human behavior in the Tucson Basin. In general, the limitations imposed by geological processes on the archaeological record must be recognized for proper interpretation of regional prehistory.

References Cited

Haynes, C.V., and B.B. Huckell 1986 *Sedimentary Successions of the Prehistoric Santa Cruz River, Tucson, Arizona.* Arizona Bureau of Mines and Geology Open File Report.

Waters, M.R. 1987 Holocene Alluvial Geology and Geoarchaeology of AZ BB:13:14 and the San Xavier Reach of the Santa Cruz River, Arizona. In *The Archaeology of the San Xavier Bridge Site (AZ BB:13:14), Tucson Basin, Southern Arizona,* edited by J.C. Ravesloot, pp. 39-60. Arizona State Museum Archaeological Series No. 171.

Waters, M.R. 1988a Holocene Alluvial Geology and Geoarchaeology of the San Xavier Reach of the Santa Cruz River, Arizona. *Geological Society of America Bulletin,* in press.

Waters, M.R. 1988b The Impact of Fluvial Processes on Archaeological Sites and Settlement Patterns along the San Xavier Reach of the Santa Cruz River, Arizona. *Geoarchaeology,* in press.

Preliminary Geoarchaeological Studies in Loess of the Lanzhou Area, Gansu Province, People's Republic of China

Michael Clayton Wilson

Deposits of loess in northern China constitute the best example in the world, both in terms of stratigraphic characteristics and in terms of landform development (e.g., Zhao 1986). In the Lanzhou area, Gansu Province, loess up to 330 m thick (Burbank and Li 1985) are extensively dissected to a near-badlands topography. In June/July 1987 the author, assisted by Ian G. Robertson (University of Calgary), conducted a preliminary reconnaissance near Lanzhou and a more detailed examination of a 2 km-long section at Cuijiaai, on the western outskirts of the city. These studies were conducted in cooperation with Prof. Zhang Linyuan (Department of Geography, Lanzhou University) and graduate students from that department, along with Prof. Yugo Ono (Laboratory of Fundamental Research, Hokkaido University, Sapporo, Japan). Additional field studies at this section are planned for the summer of 1988.

The purpose of the overall study is to develop a general geoarchaeological model for archaeological visibility in loess deposits. An interesting realization from the 1987 trip was that Chinese scholars frequently group all fine-grained sedimentary deposits of appropriate textural properties as "loess", regardless of genesis. Most Western and Soviet scholars specify an aeolian genesis; however, Chinese scholars may either group deposits from a variety of sources together, may segregate "loess" (aeolian) from "loess-like" (non-aeolian) deposits, or may discuss in more specific terms aeolian loess, alluvial loess, and colluvial (deluvial) loess, representing wind-laid, water-laid, and slope-related deposits, respectively (Sasajima and Wang 1984; Liu 1987).

The section at Cuijiaai includes aeolian over alluvial loess, and the "aeolian" portion of the section likely includes a colluvial component. It stands on a high terrace (T4) of the Huang He River between Lanzhou and Xigu. The overall section is approximately 100 m high, of which the lower 35 m is composed of steeply dipping Pliocene bedrock and early Quaternary gravels truncated by an angular unconformity of regional extent. As at many loess sections in the area, a basal alluvial gravel showing strong imbrication is overlain by banded alluvial loess, consisting of multiple fining-upward sand to clayey silt cycles. These represent intermittent sedimentation in a point bar to floodplain environment. Uniform reddish weathering of heavy minerals in the basal coarse fractions of these cycles gives the illusion that buried soils are present, but it is likely that all weathered zones here represent synchronous weathering after burial. No paleosols have yet been discerned with confidence at Cuijiaai, though at least 26 paleosols are present in older loess on a higher terrace (T6, highest in the area) at Jiuzhoutai, 2 km to the north (Burbank and Li 1985). The alluvial loess at Cuijiaai grades upward into massive loess of aeolian and possibly colluvial origin. The massive portion of the loess sequence, about 50 m thick, is of a "yellow earth" color (7.5YR 7/4; pink to

Michael Clayton Wilson, Department of Geography, University of Lethbridge, 4401 University Drive, Lethbridge, AB, Canada T1K 3M4.

reddish yellow) typical of the late Pleistocene Malan loess, as opposed to the more reddish colors of earlier loess units. Relationships with other terraces and deposits in the area suggest an age within the past 150,000 years. Loess on T6 dates back as far as about 1.3 million yr B.P. (Burbank and Li 1985). An important structural feature at Cuijiaai is a small-scale thrust fault that displaces the basal alluvial gravels above the unconformity and reflects late Quaternary tectonic activity; Lanzhou is a relatively active earthquake area (Ai et al. 1981).

A spirally fractured ungulate long bone fragment was collected from near the base of the alluvial loess; about 3.5 m higher, a piece of lithic debitage was collected from the base of the massive loess section. The massive loess was rich in land snail shells. Studies of this material and of sediment samples are in progress and attempts will be made to date the section more precisely; additional samples will be collected in 1988.

With the aid of Zhang Hu Cai (graduate student, Department of Geography, Lanzhou University) we translated portions of several Chinese papers concerning paleontological and paleolithic archaeological sites in the Gansu loesses (e.g. Xie 1982, 1983). Several of these sites appear to be in alluvial "loess" inset into the more widespread aeolian loess sheets, rather than resting within the aeolian deposits themselves: examples include Liujiacha, Gengjiagou, and Heituliang. Of course, there are significant known examples in which finds have been made in the aeolian loess sheets (e.g. the Lantian site, near Xian, 500 km ESE of Lanzhou; An et al. 1987). However, it is clear that a comprehensive geoarchaeological model of site distribution and visibility in the loesses must give a prominent place to alluvial as well as to aeolian processes and settings, and that the idealized "layer cake" so easily envisioned from afar and often outlined in general textbooks is in fact repeatedly interrupted by cut-and-fill alluvial cycles.

The 1987 field work was supported in part by the Social Sciences and Humanities Research Council of Canada (Canada Research Fellowship) and in part by the University of Lethbridge Research Fund. The author is also sincerely grateful for the guidance and assistance provided by Professor Zhang Linyuan and Vice-president Ai Nanshan of Lanzhou University and graduate students Zhang Hu Cai and Zhao Dongzhi; by Dr. Xie Jun Yi of the Gansu Provincial Museum, Lanzhou; by Dr. Xian Min of the Museum of Lanzhou City; and by Prof. Yugo Ono of Hokkaido University, Sapporo. Ian G. Robertson, graduate student in the Department of Archaeology, University of Calgary, proved indispensable as field assistant.

References Cited

Ai, N.-S., Y.-L. Li, A.E. Scheidegger, and S.-Y. Xu. 1981 The Neotectonic Stress Field in the Regions of Shaanxi, Gansu, Ningxia and Qinghai (China). *Rock Mechanics* 14:167-185.

An, Z., T. Liu, X. Kan, J. Sun, J. Wang, W. Kao, Y. Zhu, and M. Wei 1987 Loess-Paleosol Sequences and Chronology at Lantian Man Localities. In *Aspects of Loess Research,* edited by T. Liu, pp 192-203. China Ocean Press, Beijing.

Burbank, D.W., and J. Li 1985 Age and Palaeoclimatic Significance of the Loess at Lanzhou, North China. *Nature* 316:429-431.

Liu, T. (editor) 1987 *Aspects of Loess Research.* China Ocean Press, Beijing.

Sasajima, S., and Y. Wang (editors) 1984 *The Recent Research of Loess in China.* Kyoto University, Japan, and Northwest University, China.

Xie, J.Y. 1982 The Paleolithic Site at Liujiacha, Huanxian County, Gansu Province. *Journal of Archaeology (Kao Gu Xue Bao)* 1:35-48 (in Chinese).

Xie, J.Y. 1983 Vertebrate Animal Fossils in Early Pleistocene Loess Strata at Gengjiagou, Huanxian County, Gansu. *Vertebrata PalAsiatica* 21:357-358 (in Chinese).

Zhao, S. 1986 *Physical Geography of China.* Science Press, John Wiley & Sons, New York.

Special Focus: Bone Modification

Aspects of Bone Modification Applied to Time Resolution in the Fossil Record—An Example From the Miocene of Western Nebraska

Anthony R. Fiorillo

An understanding of the length of time represented at a fossil site has numerous implications for aspects of evolutionary biology and paleoecology. Indeed, the Third North American Paleontological Convention devoted a half-day symposium to the problem of time resolution in the fossil record (see Behrensmeyer and Schindel 1983, for review). This symposium focused on time resolution and underscored the need for attempts at determining the time scales represented by fossil sites. One specific question raised was, "What are the practical and theoretical limits for resolving short time intervals in single samples, given that these must contain enough fossil material to be of analytical value?" (Behrensmeyer and Schindel 1983). The purpose of the present discussion is to address this question by estimating the minimum and maximum limits on the duration of time for the formation of a major mid-Miocene (Barstovian) fossil vertebrate bone bed dominated by ungulate remains, known as the Hazard Homestead Quarry, in southwest Nebraska (Fiorillo 1984, 1987, 1988a, 1988b) (Figure 1).

The problem of time resolution at Hazard Homestead Quarry can be addressed by using estimates of the rates of development of two features of the bone bed, bone weathering and pedogenesis. Behrensmeyer's (1978) study of bone weathering categorized six descriptive stages of bone weathering based on factors such as grease content and the patterns of cracking due to desiccation on the bones of large mammals (greater than 5 kg) scattered about in a semi-arid, grassland environment in southern Kenya. For each of these stages, she attempted to bracket the possible number of years of subaerial exposure represented. The relationship between weathering stage and exposure time that Behrensmeyer documented for modern bones in East Africa closely corresponds to the relationship of weathering and exposure time for a sample of modern bones in the semi-arid plains of western Nebraska (Fiorillo 1988b). This point suggests that there is a degree of universality

Anthony R. Fiorillo, Department of Geology, University of Pennsylvania, Philadelphia, PA 19104, and Department of Vertebrate Biology, The Academy of Natural Sciences of Philadelphia, 19th and the Parkway, Philadelphia, PA 19103.

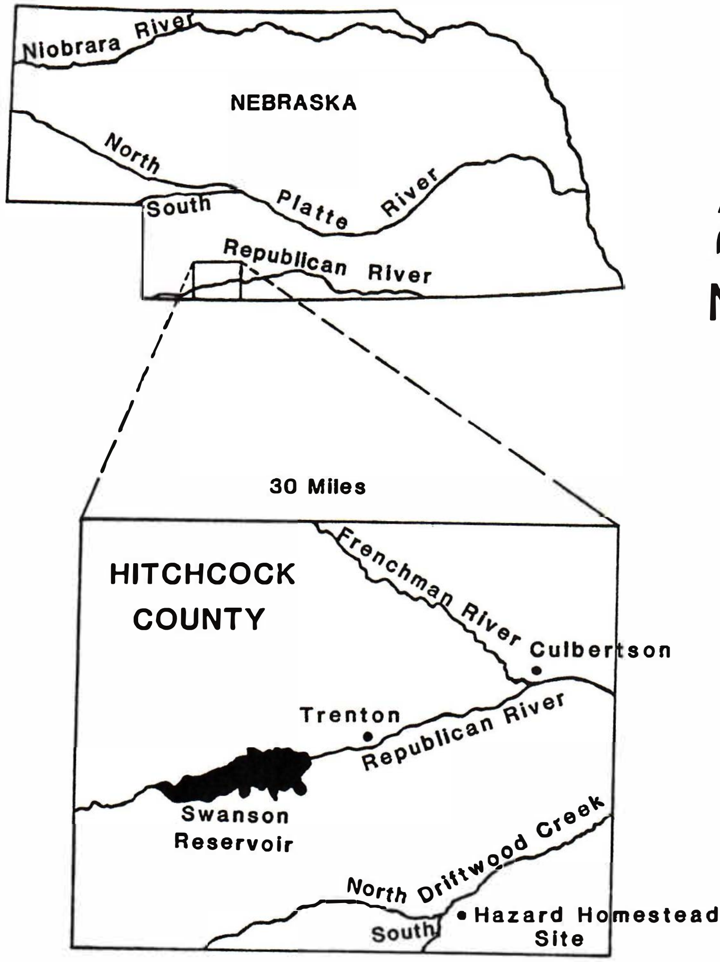


Figure 1. Location of Hazard Homestead site, Hitchcock County, Nebraska.

of this relationship within similar environments. Direct application of Behrensmeyer's weathering stages to a fossil assemblage is not readily possible since definition of some stages includes items like grease content. Slight modification of these stages outlined by Behrensmeyer (1978) permits the application of her weathering stages to a fossil site (Fiorillo 1987, 1988a).

Behrensmeyer points out that her weathering stages, and their subsequent exposure times, are somewhat habitat-dependent (1978). In fact, she points out that the weathering process affecting bones can be sensitive enough to be stopped with a minimal amount of cover, be it sedimentological or biological (e.g., dried skin). Clearly then, in order to apply these semi-arid weathering stages, and perhaps more importantly, their sub-aerial exposure times, to a fossil assemblage one must first find some independent paleoenvironmental indicator that shows the fossil assemblage to have formed under semi-arid conditions.

At Hazard Homestead there are several such indicators. The first indicator is the hypsodont dentitions of nearly all of the ungulates in the fauna, suggesting a grassland vegetation. Abundant grass seeds at the site directly indicates that a grassland environment prevailed there. Another, though indirect, indicator is the presence of caliche horizons in close stratigraphic proximity above the Hazard Homestead bone bed level. These horizons probably indicate a "warm and semi-arid climate" (Retallack 1981). The general paleoenvironment of Hazard Homestead, then, was probably similar to the present High Plains environment. Within this inferred semi-arid grassland paleoenvironment, it is possible to use the exposure times provided by Behrensmeyer's East African study and the experimental modern assemblage from western Nebraska (Fiorillo 1987, 1988b) as "clocks" to measure the length of time the fossil bones lay exposed on the surface.

The rates of soil formation, however, are not as simply applied. There is the initial problem of recognition of the fossil soil type. Soils can be exceedingly varied and are dependent on many factors such as climate, vegetation, topography, bedrock, and time. Criteria for recognizing soils and soil types in the rock record have been adequately summarized by Retallack (1981, 1983), Bown and Kraus (1981), and Van Houten (1982).

The length of time needed for the formation of a soil is related to the maturity of the soil profile within a given environment. Buol et al. (1973) and Bown and Kraus (1981), for example, discuss rates of the magnitude of 10^3 years for the formation of a mature soil profile, while others have noted pedogenic development within tens of years or less (e.g., Mohr and Van Baren 1954; Whiteman 1971; Young 1976). As a general rule, the rates of soil formation increase with increased precipitation. The application of an appropriate soil forming rate to a particular paleosol is dependent on an ability to recognize characters of the paleosol, or the associated fauna, which provide clues to the paleoenvironment.

The Hazard Homestead Bone Bed. The Hazard Homestead Quarry bone bed consists of largely disarticulated vertebrate remains concentrated in a layer 40-50 cm thick (Fiorillo 1987, 1988a). This bone bed can be traced laterally for at least 150 m and has produced bones at densities of up to 8 bones/m^2. The quarry has yielded well in excess of 1,000 specimens.

There are a number of givens provided by the bone bed which allow one to estimate the minimum and maximum amounts of time for the formation of the bone bed. First is that the sediment within the bone bed is of a fluvial origin. Second is that the average thickness of the bone bed itself is 45 cm. A third point is that the bone bed is homogeneous in that there are no faunal, anatomical, or taphonomic distinctions within it. A randomly picked sample of bones from the bone bed (N=196) provided the basis for most of the discussions of bone modification features observed at the site. This sample showed that almost 97% of the bones at the quarry were in weathering stages 0 and 1 indicating very short subaerial exposure (Fiorillo 1987, 1988a), while approximately 3% of the sample were in weathering stage 2. One bone observed in the sample was in the lower limits of weathering stage 3 and is considered as part of the stage 2 sample. Of all the bones collected from this site (aside from the single bone mentioned above), the most advanced weathering stage identified on any specimen was weathering stage 2 which has a subaerial exposure time of 2-6 years (Behrensmeyer 1978; Fiorillo 1988b). In addition to the presence of weathering stages, other indicators which

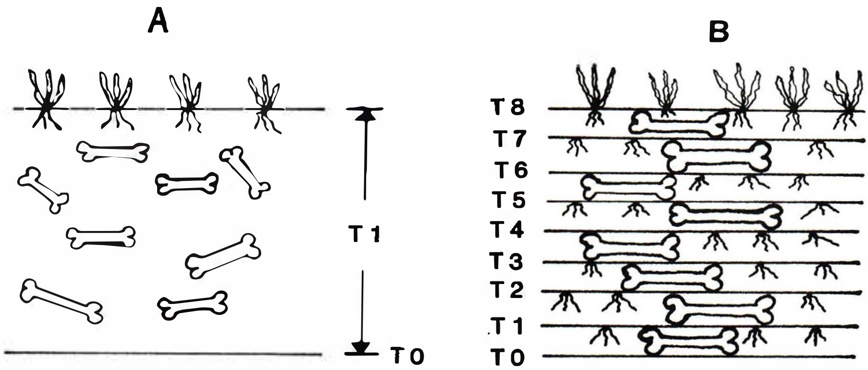


Figure 2. Models for the sequences of events for the formation of the Hazard Homestead Quarry bone bed. Model A shows a single depositional event (T1) after the bones achieved the appropriate weathering stage. Model B shows a cycling of depositional events (T1-T8) occurring. One cycle consists of a bone weathering, being, buried and grass cover developing.

show that the bones experienced subaerial exposure are the gnaw marks and trample marks so common to the sample collected (38% and 41%, respectively; Fiorillo 1987, 1988a). Still a sixth point is that nearly all of the bones show no sign of abrasion. Approximately 10% of the sample showed any signs of abrasion, all of which was minimal. Also, numerous bones were broken apart but the pieces were still adjacent to each other. The last point is that although petrographic examination of the bone bed sediment showed the unreworked fossil grass roots and stems to be common, no other paleopedological evidence of soil profile development was observed. This is supported by the lack of field evidence suggesting paleosol development.

For the following estimates of site formation time, some of the bones were excluded from the data set. These bones fall into two categories. One is the sample of bones which were possibly transported into the site. Identification of these bones was based on the abrasion stage of the bone. Trampling was a dominant process during the formation of Hazard Homestead (Fiorillo 1984, 1987, 1988b), so the other set of bones which were excluded were those bones which showed evidence of trampling. Trampling action may have prematurely buried the bones in a soft substrate.

Minimum Time Estimate. The estimate of the minimum time for Hazard Homestead is the more straight forward of the two estimates. First, since a minimum estimate is the goal, it must be assumed that the estimates of exposure times from the weathering stages on the bones represent the same general time interval (i.e., for example the same 2-6 year interval). Since different weathering stages are present on different bones, however, not all bones started and stopped weathering at the exact same time. The first impulse is to estimate the minimum amount of time as essentially instantaneous due to a single flood event, but the weathering stages of the bones preserved provide a limiting control on the time of accumulation. These stages provide an estimate of the amount of time that the bones were exposed at the surface. The maximum weathering stage preserved at Hazard Homestead is stage 2, recognized by the desiccation cracks penetrating through the cortical layer of bone and into the marrow cavity, which requires approximately 2-6 years to develop. Therefore, these bones require a minimum of 2 years at the surface before burial. The sedimentation event which requires the minimum amount of time to bury these bones, after their exposure at the surface is a flood, which can be treated as an instantaneous event. The minimum amount of time needed for the formation of the Hazard Homestead bone bed, then, is 2 years.

Maximum Time Estimate. An estimate of the maximum amount of time for the formation of the Hazard Homestead bone bed is derived from measuring the rate of accumulation of sediment increments within the bone bed. These increments can be determined by taking into account bone thickness and remembering that the weathering rates of bones can be stopped with a minimum amount of cover. Consider, for example, an isolated bone which has a maximum diameter of 4 cm and is in weathering stage 2. This stage has a subaerial exposure time of 2-6 years (Behrensmeyer 1978; Fiorillo 1988b). The slowest rate of sediment accumulation for that 4 cm interval must be 6 years. Any exposure time longer than 6 years would have pushed the bone into weathering stage 3.

The maximum number of intervals within the Hazard Homestead bone bed which can be treated in this manner can be determined by successively adding the diameters of the largest stage 2 bones until the thickness of the bone bed is reached. If the smaller bones were used to determine the sedimentation intervals, the larger bones would show distinct multiple weathering stages, since they would be covered in small increments. Examination of the materials from the bone bed shows that this is not the case.

The largest bones in the Hazard Homestead sample were limb bones from horses and camels. Of these bones, two had a maximum diameter at the distal ends of 8 cm, three measured 6 cm, two more were 5 cm, and one bone was 4 cm in diameter. The cumulative thickness of these eight bones is 48 cm. Since the most advanced weathering stage present is stage 2, which dictates a maximum exposure time of 6 years, the time represented by these bones, if they were treated as stacked intervals, one on top of the other, is 48 years.

The time represented between each of these intervals can be loosely derived by the presence or absence of paleosols. If a stage of soil development can be identified, then the amount of time needed for that stage to be derived is the maximum amount of time possible for that layer to remain exposed before progressing to a new stage of soil formation. In this case no features of paleosols, as described by Retallack (1981, 1983), can be observed at this bone bed, although the presence of unreworked grass roots and stems in thin section suggests sedimentation was periodically stopped and a grass cover developed.

The question then arises, "What is the maximum amount of time it takes for lithologic evidence of soil horizon development to occur?" Grass cover, a criterion sometimes used in the identification of soils, can develop in as short an interval as one season, but what time interval is needed before a detectable soil profile develops? Young (1976) points out that "on unconsolidated materials, appreciable profile development can take place in periods of the order of 100 years or less. Under a rainforest climate in Ecuador, volcanic ash can be transformed into productive soils with a deep, mature profile in as little as 10 years." In Indiana, soil horizon development has been documented to have occurred under pine forest vegetation in only 20 years (Wayne, pers. comm. 1984). This phenomenon is, however, vegetation-specific within the region (Wayne 1955). Since the sediment from Hazard Homestead Quarry is of a fluvial nature and not of volcanic origin, and that the climate at this pedologic site in Indiana is moister than the semi-arid climate inferred for Hazard Homestead, a more reasonable estimate of the time represented by each of the hiatuses between the bone intervals is 100 years. There are seven possible hiatuses within the bone bed, therefore a total of 700 years may be absent from the bone bed. Combining this figure with the one obtained from the bone weathering rates, the estimate for the maximum amount of time it took for the Hazard Homestead bone bed to form is about 750 years. This calculates to an approximate sediment accumulation rate of 0.5 m/1,000 years. Sadler (1981) compiled nearly 25,000 sediment accumulation rates from various sedimentary environments. The maximum accumulation rate calculated for Hazard Homestead corresponds well with the rates compiled by Sadler (1981) for fluvial environments and suggests that the Hazard Homestead maximum accumulation rate is a reasonable one.

Discussion and Conclusion. It is interesting to note the variation between the two estimates given above. Since the presence of unreworked plant material suggests that sedimentation did not take place as one event, the estimate for the minimum amount of time seems unlikely. The estimate for the maximum amount of time also is suspect when one considers that it calls for eight nearly identical cycles of events to occur within a very short section. The probability of this happening is comparable to the probability of someone rolling the same number on a die eight times in a row. The chances of rolling a particular number on the first roll is one in six, but the probability of rolling that same number in a consecutive series diminishes with each roll. The probability of repeating the same set of conditions in each sedimentation cycle, likewise, diminishes as the number of cycles increases.

The most likely scenario is that the Hazard Homestead bone bed formed somewhere between the theoretical minimum of 2 years and the theoretical maximum of 750 years, rather than at one of these extremes. The laws of probability suggest that the actual time of formation of the bone bed was closer to the theoretical minimum rather than the theoretical maximum number of years.

This paper benefitted greatly from various discussions with Drs. Michael Voorhies and Peter Dodson. I am indebted to each of them for their input, but I bear sole responsibility for the conclusions drawn here.

References Cited

Behrensmeyer, A.K. 1978 Taphonomic and Ecologic Information from Bone Weathering. *Paleobiology* 4:150-162.

Behrensmeyer, A.K., and D. Schindel 1983 Resolving Time in Paleobiology. *Paleobiology* 9:1-8.

Bown, T.M., and M.J. Kraus 1981 Lower Eocene Alluvial Paleosols (Willwood Formation, Northwest Wyoming, U.S.A.) and Their Significance for Paleoecology, Paleoclimatology, and Basin Analysis. *Palaeogeography, Palaeoclimatology, Palaeoecology* 34:1-30.

Buol, S.W., F.D. Hole, and P.J. McCracken 1973 *Soil Genesis and Classification.* Iowa University Press, Ames.

Fiorillo, A.R. 1984 An Introduction to the Identification of Trample Marks. *Current Research* 1:47-48.

Fiorillo, A.R. 1987 *Taphonomy of Hazard Homestead Quarry (Ogallala Group), Hitchcock County, Nebraska.* Unpublished Master's thesis, Department of Geology, University of Nebraska, Lincoln.

Fiorillo, A.R. 1988a Taphonomy of Hazard Homestead Quarry (Ogallala Group), Hitchcock County, Nebraska. *University of Wyoming Contributions to Geology,* in press.

Fiorillo, A.R. 1988b An Experimental Study of Trampling: Implications for the Fossil Record. In *Bone Modification,* edited by R. Bonnichsen and M.H. Sorg, Center for the Study of Early Man, Orono, Maine, in press.

Mohr, E.C.J., and F.A. Van Baren 1954 *Tropical Soils.* Interscience, New York.

Retallack, G. 1981 Fossil Soils: Indicators of Ancient Terrestrial Environments. In *Paleobotany, Paleoecology and Evolution,* edited by K.J. Niklas, pp. 55-102. Praeger Publishers, New York.

Retallack, G. 1983 Late Eocene and Oligocene Fossil Soils from Badlands National Park, South Dakota. *Geological Society of America Special Paper* 193.

Sadler, P.M. 1981 Sediment Accumulation Rates and the Completeness of Stratigraphic Sections. *Journal of Geology* 89:569-584.

Van Houten, F.B. 1982 Ancient Soils and Ancient Climates. In *Climate in Earth History,* edited by W.H. Berger and J.C. Crowell, pp. 112-117, National Academy Press, Washington, D.C.

Wayne, W.J. 1955 *Guidebook to Some Interesting Features of the Geology and Soils of Brown County, Indiana.* Geology and Soils Field Trip, Indiana Academy of Science.

Whiteman, A.J. 1971 *The Geology of the Sudan Republic.* Oxford University Press, London.

Young, A. 1976 *Tropical Soils and Soil Survey.* Cambridge University Press, New York.

Saw Marks on Pleistocene Megafaunal Remains from Alaska

R.D. Guthrie and A. Greenwalt

Museum collections of Alaskan Pleistocene bones include several with definite saw marks. Unfortunately, these curious specimens were collected without stratigraphic provenience; most having been washed from banks of frozen silt as miners removed overburden to reach auriferous gravels. Other saw-marked bones were found along creek beds where they were exposed by natural alluviation. Thus, each of these bones must be dated separately to understand their chronological context.

Saw marks on bones were identified by either: 1) long, narrow, parallel-walled incisions, only slightly larger than 1 mm in width, or 2) extremely straight-walled surfaces, or "cut ends" showing even cut-lines. We have made no attempts at an exhaustive census of such marks, but have observed and noted them during other studies.

There are several classes of sawed bones; the bones of the first class were collected by the junior author along the alluvial bars of Goldstream Creek, just north of Fairbanks, Alaska. These are quite darkly stained, more so than many Pleistocene bones from extinct species. Most of these sawed bones appeared to be bison (*Bison*), but because of the saw marks, they were given special scrutiny. Detailed comparisons with Olsen's (1960) *Bison-Bos* monograph showed that the sawed bones were more similar to those of cattle.

As a double check, collagen fraction dates were obtained from two sepcimens: 60±45 yr B.P. (DIC-2126) on a radius, distal end, and 70±45 yr B.P. (DIC-2127) on a femur, distal end. These dates raise the specter that the identification of yaks (*Bos poephagus*) in Alaska may have been identifications of domestic cattle bones mixed in with the Pleistocene bones.

R.D. Guthrie and A. Greenwalt, Institute of Arctic Biology, University of Alaska, Fairbanks, AK 99701.

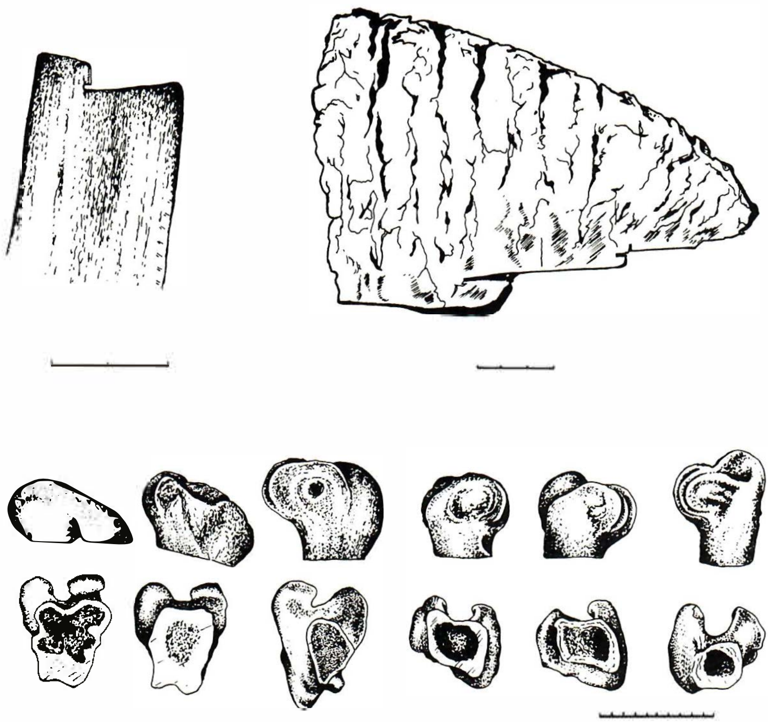


Figure 1. Darkly stained bones from Alaska showing saw marks. (a, above) Six long bone ends, two views of each specimen; the lower view shows the face of the cut surface. (b, lower left) Sawed end of rib; all are from Goldstream Creek. (c, lower right) Mammoth tooth from the Ikpikpuk River showing saw cuts. Scales are in centimeters.

A similarly stained sawed antler of moose (*Alces alces*) was collected by O.W. Geist in 1935 from the "Fairbanks area", now located in the Frick Collections of the American Museum of Natural History. A collagen date of 740±40 yr B.P. (DIC-245) was obtained from this specimen. Although this indicates the specimen dates from the late Holocene, it is unclear whether it is a precise date for early metal moving in from Asia, or whether the date could be distorted to some degree by contamination. The cutmarks are definite saw marks but are just under 2 mm, slightly wider than those of most hacksaws or meat saws. This specimen may represent a second class of saw-marked bones, those which were sawed when fresh prior to European colonization of Alaska.

Both of the two above classes of specimens represent bones which superfically appear to be Pleistocene in age but are really from the late Holocene. Without the diagnostic signature of metal saws and the subsequent radiocarbon dates, they would have been mistakenly identified as Pleistocene in age. We should be aware that other late Holocene specimens are probably present in the large collections of Alaskan Pleistocene bones, teeth, and antlers.

The third class of sawed specimens is from a species not known to occur during the Holocene. There are several woolly mammoth (*Mammuthus primigenius*) teeth in the American Museum of Natural History collections which have their roots sawed off. I collected a similar sawed tooth of mammoth from the Ikpikupk River in northern Alaska; it was dated by the collagen fraction at 32,340+1,070/-1,250 yr B.P. (DIC-2123). Had the marks not been so diagnostic of a modern thin-steel saw, this worked mammoth tooth could have been taken to represent an artifact of mid-Wisconsin age. In fact, we know that Eskimo movements up the Ikpikpuk River were common. The dentine of fossil mammoth teeth is strong and easy to work like ivory, whereas the enamel plates of the crown probably afforded little utility for tools. I think specimens from this third class indicate that fossil raw material was sometimes worked by more recent people. I should note that the penetration of the stain rind on all the specimens discussed in this paper was the same depth in the saw cuts as on the uncut portions.

I do not wish to imply that all cutmarks on Pleistocene bone actually represents recent material which appears old or the use of old bone by recent peoples. Fossil bone with cutmarks made when the bone was fresh do undoubtedly exist (I am reporting on one of these in detail in another publication). The latter can only be judged on the basis of: 1) context, combined with 2) the kinds of cutmarks.

References Cited

Olsen, S.J. 1960 Post-Cranial Skeletal Characters of *Bos* and *Bison*. *Papers of the Peabody Museum of Archaeology and Ethnology*. Harvard University 35:1-12.

Author Index

Aaberg, S.A. 7, 9
Anderson, E. 94
Baker, T.R. 19
Ballantyne, J. 88
Bartone, R.N. 1
Bonnichsen, R. 39, 96
Borrero, L.A. 63
Bozarth, S.R. 45
Casé, A.M. 31
Chandler, R.M. 64
Cinnamon, S.K. 47
Clark, G.A. 3
Corner, R.G. 78
Cox, S.M. 66
Dahms, D.E. 81
Davis, L.B. 7, 9, 25
Dorland, D. 88
Dudley, J.P. 68
Elias, S. 57
Fiorillo, A.R. 103
Greenwalt, A. 109
Greiser, S.T. 9
Guthrie, R.D. 69, 109
Heaton, T.H. 71
Heckenberger, M.J. 19
Hester, T.R. 27
Hevly, R.H. 47
Hoffecker, J.F. 83
Hofman, J.L. 86
Huber, J.K. 48, 88, 52
Jackson, L.J. 73
Jefferson, G.T 59, 61, 66
Jodry, M.A. 11, 21
Johnson, W.C. 75
Johnson, E. 57
Julig, P.J. 29
Keally, C.T. 13
Keller, D.R. 32
Kidd, J.G. 50
Kost, E.J. 75
Lamb, R.V. 59
Lewis, C.R. 15
Liukkonen, B.W. 52
Mahaney, W.C. 89
Mallouf, R.J. 17
Martin, C.W. 92
Martin, L.D. 64
McFaul, M. 94
Mckillop, H. 73
Nami, H.G. 31
Nelson, M.E. 77
Petersen, J.B. 1, 19
Powers, W.R. 83
Putnam, D.E. 1
Rull, V. 54
Ryan, R.M. 32
Schubert, C. 54
Stafford, Jr., T.W. 41
Stanford, D.J. 11, 21
Steinmetz, J.J. 61
Storck, P.L. 23
Tankersley, K.B. 34
Tomenchuk, J. 35
Tratebas, A.M. 37
Turner, M.D. 96
Turner, J.C. 96
Voorhies, M.R. 78
Waters, M.R. 98
Waythomas, C.F. 83
Wilson, M.C. 100
Zier, C.J. 94

Information for Contributors

GENERAL INFORMATION

Categories of notes will be: 1) Archaeology, 2) Physical Anthropology, 3) Lithic Studies, 4) Taphonomy-Bone Modification, 5) Methods, 6) Paleoenvironments (which includes the subsections: Plants, Invertebrates, Vertebrates, and Geosciences), and 7) Special focus. The last category is reserved for a pre-selected topic; articles are submitted by authors at the request of the Center. No more than 65 unsolicited papers for the regular sections and 5 solicited papers for the Special Focus section will be acc senior author. Time being of the essence, the earlier a paper is received, the better its chance of being published. Manuscripts concerned with anyof the above categories should include research dating $\geq$10,000 yr B.P. or have direct implications for research of that time period.

Manuscripts should be of note length, up to 750 words, or 400 words with one figure and caption, plus references. They should be current, original, not be or have been submitted to another journal, and may cover any aspect of the above-mentioned categories. All notes will be published in English. Authors submitting manuscripts in a language other than English may either submit their manuscript also in English or request the editorial staff provide a translation (final decision will be left to the editorial board). In either case, both accepted manuscripts will be published. Manuscripts submitted in a language other than English should be typed double-spaced throughout and be legible. If a manuscript is found to require extensive editing of if a meaning is unclear, the author will be contacted—this could delay the printing of the manuscript.

Manuscripts are first read by the editorial staff to ensure the minimum requirements are met, as outlined above. All manuscripts are edited for style and general grammar. Because one of the practical goals of the journal is to provide quick turnaround time for the printing of manuscripts, authors do not review galley or page proofs. The editorial staff compares the submitted manuscripts with the style-edited page proofs. Thus it is imperative that authors carefully proof their manuscripts for content, journal style, and grammar. It is suggested that all manuscripts be reviewed by a colleague of the author prior to submission. The editorial staff reserves the right to request an outside peer review of any manuscript prior to determining its acceptance for publication.

FORM AND STYLE

Manuscripts should be concise but detailed enough to permit critical appraisal. They must be typewritten and DOUBLE-SPACED THROUGHOUT (i.e., entire manuscript, references, and figure caption) on one side of 22 by 28 cm (8 1/2 by 11 inch) paper with no less than 4 cm (1 1/2 inch) margins.

If a word processor is used, use the following specifications in preparing and printing your manuscript. Use letter quality or near letter quality printing. Align (justify) text to the left margin only. Underline any words that should be italicized in the final typeset galleys. All manuscripts are optically scanned into a computer for typesetting. This process will not 'read' text that extends beyond the margins specified above, that has varying word or letter spacing (what occurs when you justify the right text margin), has italicized or bold face type, or is printed in a type size other than 10 point (standard typewriter size). DO NOT hyphenate words at the right margin. Manuscripts that conform to these specifications will allow us to fully utilize the technology we have available in preparing manuscripts for publication, and to keep the cost of the journal down.

Space will not permit the inclusion of tables. Materials that normally would be placed in a small table should be placed in the text (e.g., "There are five radiocarbon dates from this site (15,000±100 yr B.P. (A-000),...11,000±100 yr B.P. (A-0000))"). One figure is permitted; the caption should be typed on a separate page using all above-mentioned specifications for text preparation. All pages should be numbered consecutively starting with the first page of text. The title page should include an informative title, author(s), affiliation(s), and complete mailing address(es), which must contain your zip code or postal district, when applicable. It would help to include your telephone number on your cover letter, should there be any questions by the editor. Avoid titles with interrogative form, abbreviations, and formulae. Submit two copies of each manuscript and at least one PMT or glossy print of the figure, if one is included. Authors should keep original art.

Standardized words or spellings that do not need to be underlined or described: in situ; et al.; pers. comm.; Paleoindian; archaeology; CRM (for cultural resource management); TL (for thermoluminescence dating); yr B.P. (for years before present); and AMS or TAMS (for accelerator mass spectrometer technique of radiocarbon dating). Do not italicize words in the manuscript, only underline (Ficus not *Ficus*). The use of either Latin of common names is fine, but include the other (common or Latin) name in parentheses following the first time use (e.g., "...recovered the dung of the Shasta ground sloth (*Nothrotheriops shastensis*)"). If technical jargon of abbreviations are to be used, and possibly are not well known to all readers, provide a more common term or explanation in parentheses.

UNITS AND ABBREVIATIONS

Metric units should be used throughout and be abbreviated when appropriate. Examples of the abbreviation style used include: i.e.; e.g.; cf.; cm; m; km; ha; yr B.P.; and sp. Numbers will be written out when they start a sentence or when they are the numbers one through nine (exception: "...20 choppers, 10 burins, and 2 knives were recovered."); numbers greater than nine are written as numerals (e.g., 10, 11, 1,000). All numbers greater than 999, including radiocarbon ages, should use a comma (22,200±1,210 yr B.P.; 1,000 years ago; 12,000 mollusks).

Radiocarbon dates should be expressed in ^{14}C years before present (yr B.P.) and should include the standard error and the laboratory number (e.g., 11,000±140 yr B.P. (A-1026)). International notation should be employed in all cases of chemical notations.

ILLUSTRATIONS

If a figure is used, it must be cited in the text; e.g.,"...as can be seen in Figure 1.","...as is illustrated (Figure 1)." Line drawings ONLY are permitted (no color or continuous tone photographs). Submit at least one glossy photographic or PMT print of the figure, **10 by 12.5 cm** (4 by 5 inch) maximum image size. Photocopies are not acceptable quality for reproduction. Do not send the original artwork.

All lettering MUST be either mechanical or dry transfer (NO HAND LETTERING or TYPEWRITER LETTERING). Authors should check the figure prior to submission to assure that all lines and lettering are clear and legible. The editorial staff and the printers of the journal are not responsible for reduction quality or figure retouching. The senior author's name should be clearly printed on a label and affixed to the back of the figure.

REFERENCES CITED

References cited in the text must adhere to the format printed in *American Antiquity*, 48(2):429-442, 1983; this greatly facilitates the editing for the style used in *Current Research in the Pleistocene*. DOUBLE SPACE ALL REFERENCES. Citing in the text is as follows: "...according to Martin (1974a, 1974b)","...as has been previously stated (Martin 1974; Thompson 1938)." Cross check all references with the original work—this is where most problems occur.

DEADLINE

Manuscripts MUST be postmarked no later than January 31 of each year. It is strongly suggested that manuscripts be submitted prior to the deadline.

Submit manuscripts (two copies) for Volume 6 (1989) to:

Jim I. Mead, editor
CURRENT RESEARCH IN THE PLEISTOCENE
Department of Geology, Box 6030
Northern Arizona University
Flagstaff, Arizona 86011 USA
Telephone 602/523-4561

Manuscripts submitted from outside North America should be sent FIRST CLASS AIR MAIL.

General Index

abrader 12
aeolian 8, 11, 21, 83-84, 100-101
Agelaius phoeniceus 65
Agonum 58
  sp. 57
Alaska 5, 50-51, 61, 69-70, 109-111
Alaska Range 83
Albert Ahrens site 80
Alberta 25
Alces alces 110
Aldan River 4
alder 48, 70
Alibates Dolomite 21
algae 49-50, 52-54, 89
  green 48
alligator 15
Alligator mississippienisis 15
alluvium 4, 8-9, 87, 94-95, 98-101, 109
Alnus 48, 70
amaranth 89
Amaranthaceae 89
Ambrosia 89
Americas 5-6
amphibian 15
Amur River 14
Anodonta californiensis 59-60
antelope 15
antelope brush 47
Anthus sp. 65
Anzick site 22, 25-26
apatite fraction 16
Archaic 1, 2, 6, 33, 75, 92
  early 20, 98-99
  late 20, 98
  middle 20, 98
Arctodus simus 70, 72
Arizona 47, 98
arrowhead 72
Artemisia 84, 89
  spp. 47
artifact 1, 2, 4-5, 7, 13, 15, 19, 21, 23, 27-28, 32, 35, 72, 74, 85, 89, 98
  lithic 13
artiodactyl 72
Arvicolinae 78
Asia 72, 110
  northeast 3
aspen 45-46, 48

Bakerilymnaea
  bulimoides 59-60
  cockerelli 59-60
  cubensis 59
Barstovian 103
Bartek Brothers Farm locality 64
Barton Gulch site 9-10
basalt 26
bear 71
  black 71-72
  brown 70
  grizzly 71-72
  short-faced 70, 72
beaver 20
Beaverhead Mountains 96
beetle 57
  ground 57
Beringia 5-6, 70
Betula 48, 70, 89
  papyrifera 35
biface 9-10, 12, 14, 18, 22, 27-29, 37, 85
birch 48, 70, 89
  dwarf 84
  white 35
bird 20, 64, 71, 78
bison 11-13, 57, 63, 65, 72, 75, 77, 87, 109
  steppe 70, 84, 85
Bison 63-64, 109
  alleni 65
  antiquus 57
  bison 72
  priscus 70, 84
bittern
  American 65
bivalve 59
Blackwater Draw site 21, 27-28
blade 18
Blancan
  late 78
blanks 9-10, 12, 29

Blarina brevicauda 65
Blue Mountain 7
Bone Cove site 92
bone modification 103
Bonnetia roraimae 54
Bonneville local fauna 78
boreal 45-46, 71, 77, 93
Bos 109
  poephagus 109
Botaurus lentiginosus 65
Botryococcus 53
brachen fern 89
Brazil 68
Breameryx sp. 15
Brigham site 2-3
Brockway site 1-2
buffalo-berry 47
Bull Lake glaciation 97
  pre- 96
burial 14, 22, 25
burin 14, 29-30, 37, 84

cactus 47
Caldris sp. 65
California 61
Calosoma porosifrons 57-58
camel 15, 65, 75, 107
Camelops sp. 15, 65
campsite 11-13
Canada
  northwestern 61
canid 78
Canidae 24
Canis
  latrans 15, 78
  lupus 69, 78
caribou 24, 63-64, 70, 73-74
Carnivora 73
carnivore 69-70
caterpillar 57
catfish 15
cattle 109
cave 6, 16, 31, 57, 69-72, 77-78
Celtis 48
Ceramic (Woodland) 1
ceramic sherds 1
Cervalces 73
cervid 73-74
Cervidae 24
Cervus 73
  canadensis 84
  elaphus 72
chalcedony 8, 26, 32
Chenopodiaceae 89
chert 21, 26, 35, 37, 72
  Edwards Plateau 17
Chile 31
Chimantaea 54
China 100
Chloridoideae 45
Chlorophycophyta 89
Chuska Mountains 12
Ciperaceae 54
Cleithrionomys sp. 65
Clovis 5-6, 18, 21, 25, 41-42, 76
  artifact 22
  pre- 6, 25
  workshop 17
Coleoptera 57
collagen 16, 41-42, 70, 109-111
colluvium 4, 8-9, 94, 100
Colorado 11, 94-95
  central 12
  northcentral 21
  southcentral 11
Colorado Plateau 48
  southern 47
conifer 45-46, 49-50, 52-53
Cornus 89
Corylus 89
cottonwood 48
coyote 15
Crotalus sp. 78
cryogenesis 5
cryoturbation 5
Cudahy fauna 80
Cueva del Medio 31
Cummins site 29-30
Cynomys sp. 15
Cyperaceae 89
Cyrilla 54
Debert site 23
debitage 9, 18, 23, 29, 101
deer 9, 73
  mule 72
  white-tailed 24, 74
Dent site 42, 94
Derby site 3
desert 45
diatom 52-53, 89
dicot 45
dogwood 89
Domebo Formation 86-87
Domebo site 86-87
Drake cache 21-22
Dyuktai 3-5
  Cave 4-5
East Africa 103, 105
Ecuador 107
Edwards Plateau 17
eel 20
Elephantidae 76
elk 73
elm 50, 86-87, 89
Equus sp. 15, 65, 70
Eremophila alpestris 65
Erethizon dorsatum 72
Ericaceae 54

ericad 84
erratic 84
Escapule mammoth 41
False Cougar Cave 25-26
feldspar 31
fish 15, 20, 35
Fisher site 35
flakes 17, 36-37
blade 14, 18
lithic 1-2, 12, 14
flint
Knife River 26
Florida 68
Foley site 37
Folsom 5, 11-12, 25
forb 9
Fossaria modicella 59
fox 24
swift 9
Fragilaria spp. 53
Front Range 94-95
Gainey complex 23-24
Gansu Province 100-101
gar 15
geoarchaeology 5, 100-101
geochronology 4, 98
geomorphology 8, 28, 31, 54, 58, 86, 89, 94
Geomys sp. 65
Ghost Cave 7
Glendive Creek 8
gneiss 9
gomphothere 68
Gomphotheriidae 68
goosefoot 89
gopher
pocket 65, 72
Gordon local fauna 79
Goshen complex 25
Gramineae 54, 89
grass 9, 45, 47, 84, 89, 105-107
graver 9, 12
Great Basin 47
Great Lakes 73-74
Green River Basin 82
Greenhorn Range 9
grouse 78
Guayana Shield 54
Gulo gulo 70
ground sloth 15, 65
guanaco 63-64

hackberry 48
Hagen site 7
Hale site 35
hammerstone 12, 17-18, 21-22
Hanson site 38
hardwood 49-50, 52-53
hare 24
snowshoe 71, 93

Hay Springs 78-80
Hazard Homestead Quarry site 103-108
hazel 89
hearth 9, 13
Hell Gap site 29-30
herbivore 73
Heterocypris sp. 61
High Plains 76-77, 105
Historic 98
Hohokam 98
Hokkaido 13-15
Holocene 6, 19, 41-42, 55, 74-75, 78, 87, 92, 96-97, 110
early 11, 20, 47-48, 54, 75, 77, 84-86, 92, 94-95, 98-99
late 92, 110
mid- 50, 99
horned lark 65
horse 15, 65, 70, 75, 107
hunter-gatherer 6, 32
hydrology 8

ice-wedge casts 5, 50-51
Ictalurus sp. 15
Idaho 72, 96
western 97
Ikhine I site 4-5
Ikhine II site 4-5
Ilex 54
Illinoian 64
illuvial 81
Indian Creek site 10, 25-26
Indiana 34-35, 107
insect 57-58
invertebrate 59
Irvingtonian 68
early 79
late 78-80
ivory 21, 111

Japan
northern 13-15
Juglans 48
juniper 32, 78
Rocky Mountain 47
Juniperus
scopulorum 47-48
sp. 78
Jurgens site 11, 95

Kansas 75-77
Kennebec River 2
Kentucky 34-35
Kenya 103
kill site 12
Kincaid Rockshelter 27-28
Kuester site 35

Lake Algonquin 23, 35, 73
Lake Bonneville 72
Lake Iroquois 73-74
Lake Manix 61-62
Lake Minong 29
Lake Upham 88-89
Lama glama guanicoe 63
Lemhi Mountains 97
lemming
  southern bog 65
Lepisosteus sp. 15
Leporidae 24
Lepus
  americanus 71, 93
  sp. 78
Levi site 29-30
lichenometry 90
Limnocythere
  ceriotuberosa 61-62
  platyforma 61
  robusta 61
Lindenmeier site 37-38
Lindsay site 25-26
lion 70
lithic 26, 30
  materials 8, 12, 16
  micro- 14-15
  procurement 11
  scatter 12
  workshop 18
Little Ice Age 96
lizard 15
loess 65, 69-70, 80, 83-85, 91-92, 100-101
Louisiana 28
Lubbock Lake site 27, 57-58
Lymnaeidae 59-60

MacHaffie site 25-26
macrofossil 50-52
Madison River 9
Maine 2, 23
  central 1, 19
mammal 20, 65, 69, 71, 73, 75, 77-78, 103
mammoth 15-16, 42, 68, 70, 73, 75-77, 94, 110-111
  Columbian 76, 94
  Jefferson's 68, 76
  woolly 70, 76, 84, 110
Mammoth Cave 35
Mammut americana 75-76
Mammuthus 68, 75-76, 95
  africanavus 68
  columbi 15, 76, 94
  columbi jeffersonii 68
  imperator scotti 68
  jeffersonii 76
  primigenius 70, 76, 84, 110
  sp. 94-95
Mammutidae 76

mano 16
marble 9
marmot 72
Marmota flaviventris 72
marten
  pine 72
Martes americana 72
mastodon(t) 68, 73, 75-76
meadowlark 65
megafauna 6, 41, 70, 75-77, 109
Melastomataceae 54
Melosira 53
Mephitis mephitis 72
mesquite 58
metate 16
Mexico 28, 58
Michigan 23
microblade 14, 83, 85
microcore 14
Microtus 80
  pennsylvanicus 65
  sp. 65
  xanthognathus 92
Mill Iron site 25-26
mineralogy 89-90
Minnesota 48-49, 52-53
  northeast 88
Miocene 103
Missouri River 10
Mojave Desert 61
mollusk 59-60
Montana 25-26, 33, 68
  southwestern 7, 9, 96
Moorehead complex 2
moose 110
moraine 81, 84, 90, 96
moss 51
mouse
  deer 65
  grasshopper 15
muskrat 20, 65, 78-80
muskox 63
Mustela frenata 72

Nebraska 64, 78-80, 104
  eastern 64
  southcentral 92
  western 103, 105
Nenana Valley 83-85
Neotoma
  cinerea 72
  sp. 15, 78
Nevada 28
New England
  northern 19
New Mexico 27-28, 47, 68
  northwestern 12
New World 4-6-41
Newburgh site 35

North America 6, 33, 42, 45, 66, 68, 76, 78, 92
northeastern 36
North Cove site 92-93
Nova Scotia 23

oak 50, 58, 89
obsidian 26, 28
artifact 27-28
Odocoileus 73
hemionus 72
sp. 9
virginianus 74
Ohio 34-35
Oklahoma 68, 87
western 86
Old World 4, 6
Ondatra 78-79
annectens 78-79
idahoensis 78
nebracensis 65, 79-80
zibethicus 79-80
Ontario 29, 36, 73-74
southcentral 35
southern 23
Onychomys sp. 15
opal phytolith 45-46
Opuntia spp. 47
ostracode 61-62
Obivos 63-64
Ovis
aries 63
candensis 63
dalli 85

packrat 15, 47, 78
Paleoindian 1, 2, 5-6, 8-9, 11, 23, 25, 27-29, 31, 33-35, 73-75, 77, 98, 99
early 7, 25-26, 36
late 9, 11, 73
Paleolithic
early 14
lower 3
middle 6
upper 3, 4, 6
paleosol 8, 84, 87, 92, 95, 100, 105-107
Panicoideae 45
Parkhill site 29
palynology 52, 54
Paramylodon sp. 65
Passeriformes 65
peccary 15, 65
Pediastrum
boryanum 49, 53, 89
integrum 49, 53
simplex 49, 89
pedogenesis 103, 105
Pennsylvania 34
Penobscot River 2
perching bird 65
Permian 47, 87
Peromyscus sp. 65
Petronila Creek 15
Phenacomys intermedius 93
Physella virgata 59-60
Picea 53, 70, 89
glauca 36
mariana 36
Pictograph Cave 7
pine 58, 89, 103
jack 35
pinyon 32, 47-48
Pinedale glaciation 81, 91, 96
Pinus 89
banksiana 35
edulis 47
pipit 65
Pirika site 14
Piscataquis River 1, 3, 20
Plains 86
central 45-46, 75
northwestern 25
Plano 29
Platygonus sp. 15, 65
Pleistocene 6, 9, 13, 17, 42, 45-46, 48, 50, 55, 61, 65, 68-69, 75, 78, 87, 96, 98, 109-111
early 97
late 5, 9, 27, 54, 61, 70, 74-75, 77, 84, 86, 92, 94-97, 99, 101
mid- 9, 76, 84, 97
pre- 82-83
Pliocene 100
lower 97
Podocarpus 54
pollen 47-50, 52-55, 84, 89
Pooideae 45
Populus 48
porcellanite 8, 26
porcupine 72
Porcupine Cave 71-72
prairie-chicken 65
prairie dog 15
Prairie Dog Bag site 92
Precambrian 9, 94
predator 16
preform 9-10, 12, 17-18, 20, 29
Prehistoric 9
Prince Albert National Park 45-46
Proboscidea 76
proboscidean 73, 76
projectile point 13-14, 21
Agate Basin 7-8, 26
Alberta 7-8
bi-beveled 33
Clovis 7-8, 17-18, 21-23, 25-26, 28, 34-35
dart 8, 10
Eden 7-8, 26

Elko series 72
fluted 2, 8, 23, 25-26, 34, 73
Folsom 7-8, 12-13, 25-26, 33, 37-38
Gainey 23
Goshen 8
Hell Gap 7, 10, 26
Jimmy Allen 8
lanceolate 1-2, 9-10, 25, 28, 84
Paleoindian 7-8, 32, 87
Plainview 28, 33
Pryor stemmed 33
San Patrice 28
Scottsbluff 7-8, 26, 28
spear 8, 10
stemmed 2, 14, 20
Tachikawa 14
Protohistoric 98
Pryor Mountains 25
Pteridium 89
Purshia neomexicana 47

quartz 31, 96
pegmatitic 34
quartzite 9-10, 26, 34, 54, 72
Hixton 34-35
Spanish Diggings 10
Quaternary 54, 78, 91, 96
early 100
late 89, 92-93, 98, 101
Quercus 50, 89

rabbit 24
cottontail 65
jack- 78
ragweed 89
Rancho la Brea 59, 66-67
Rancholabrean 79
late 68
Rangifer 73
tarandus 63, 70
rattlesnake 78
Recent 79
red ochre 2, 20-22
red-winged blackbird 65
reptile 78
Republican River 92-93
Rhadine 57
Rhoda site 3
rhythmite 88-89
Rio Grande 11
Rockport site 35
rockshelter 6, 57-58
Rocky Mountains 11-12, 25, 95
rodent 72, 78
Rodentia 73
Ruby River 9
Rushville local fauna 79

sabertooth 66
sagebrush 9, 32, 47
Salix 48, 89
salmonid 20
sandpiper 65
Sandy Springs site 35
Sangre de Cristo Mountains 11
Santa Cruz River 98-99
Sartan glacial 5
Saskatchewan 25, 45-46
Scenedesmus 49, 53, 89
schist 9
scraper 10, 29, 38
end 9, 12, 23, 85
side 9
Seaman Reservoir locality 94-95
Sebec River 1
sedge 84, 89
Seward Peninsula 50-51
shad 20
Sharrow site 2-3, 19-20
sheep 63-64
bighorn 63
Dall 85
Sheperdia rotundifolia 47
shrew 65
short-tailed 65
Siberia
northeast 4-5
Silver Creek local fauna 78
Simon cache 22
sinkhole 16
skunk
striped 72
Smilodon 66-67
snail 60, 69
aquatic 59
land 59, 101
snake 15
sociology 39
soil 9, 45, 81-82, 84-85, 89-92, 95, 98, 105-107
soil heaving 5
Sorex
cinereus 65
sp. 65
South America 31
South Platte River 37, 94
Southwest 33, 47
Spermophilus tridecemlineatus 65
sphagnum 89
Sphagnum 89
spruce 46, 53, 70, 74, 89
black 36
white 36
squirrel
thirteen-line ground 65
St. Louis River 88
stag-moose 73
Stegolepis 54

steppe 45, 70
Stewart's Cattle Guard site 11-13
Sturnella sp. 65
Succinea 69
grosvenori 69
Succineidae 59-60
Sunset Crater 47
Susquehanna tradition 2, 20
Sylvilagus sp. 65
Synaptomys sp. 65

taconite 29
taiga 77
tandem accelerator mass spectrometry 41
taphonomy 39-40, 52, 59, 62, 105
tephra 9, 51, 85
Tertiary 9, 82-84, 96
Teton Range 89
Tetraonidae 78
Texas 12, 15-16, 21, 27-28, 57
northcentral 17
southern 15
western 47
thaw lake 50-52
Thomomys talpoides 72
till 84, 96-97
Tohoku 13-15
tools 20, 35, 37
bone 16
groundstone 20
lithic 1-3, 6, 13-14, 31
Tucson Basin 98-99
tundra 49, 74, 84
turtle 15-16, 20
Tympanuchus sp. 65

Udora site 23-24, 35-36
Uinta Mountains 71, 77
Ulmus 50, 89
ungulate 63-64, 101, 103, 105
uniface 2, 9-10, 12, 22, 28-29
United States 68
central 97
midwestern 34-35
northeastern 74
Ursus
americanus 71
arctos 70-71
use-wear 35-36, 38
Ust'Mil site 4-5

Utah 71
northeastern 77
northern 72, 78
southern 32-33

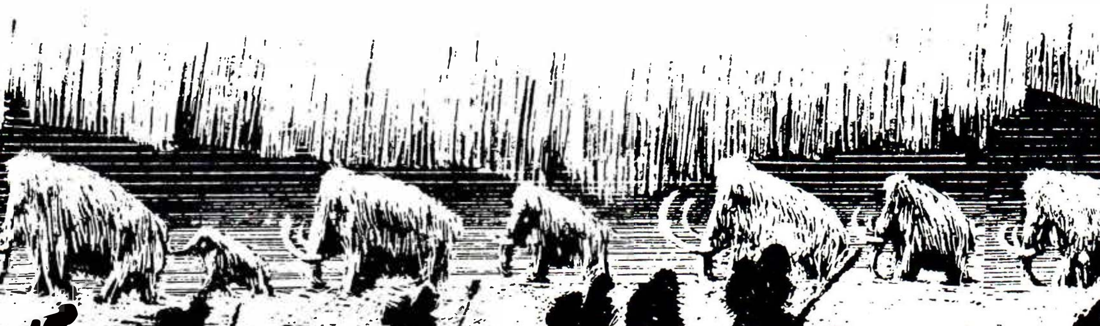
Vail site 23
Valles Caldera 27
varve 88
Venezuela 54
Verkhne-Troitskoe site 4
vertebrate 59, 77, 103, 105
vole
heather 93
meadow 65
red-backed 65
yellow-cheeked 92
Vulpes velox 9

walnut 48
wapiti 72, 84-85
Wasatch Mountains 77-78
weasel
long-tailed 72
Weinmania 54
willow 48, 84, 89
Wind River Mountains 81-83, 89
Wisconsin glacial
late 47, 72, 84
mid- 111
Wisconsin 34-35
wolf 69-70
wolverine 70
wood rat
bushy-tailed 72
Woodland (Ceramic) 1, 20
wormwood 89
Wyoming 25, 33, 37, 72, 81-82
northcentral 39
western 89

x-ray fluorescence 27-28
Xyris 54

yak 109
Yakutsk 4
Yellow Hawk site 17, 21
Yellowstone River 7
Yunosato 4 site 14

Zygnemataceae 54



ISSN 8755–898X