CURRENT RESEARCH IN THE PLEISTOCENE

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Editor

Jim I. Mead Quaternary Studies Program and Department of Geology Northern Arizona University and the Museum of Northern Arizona Flagstaff

Associate Editor

David J. Meltzer Department of Anthropology Southern Methodist University Dallas

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Regional Index



From the Editor

Current Research in the Pleistocene is maturing, and with any growing process, there are bumps along the way. Most of the time those perturbations are minor and easily handled behind the scenes. But on occasion problems must be aired publicly, hence the letters in the last *CRP* (5:ix-xiv), regarding Harry Tucci's work published in earlier issues of *CRP* and elsewhere. Those letters prompted a response from Dr. Russell Graham, which is printed on the pages that follow. Graham's letter is printed in this issue, not to prolong the Tucci problem, but rather to point out to you that Dr. Graham has had no involvement with Tucci's work, as was implied by Mr. Tucci, as well as to address some important issues regarding *CRP* that Graham raises.

Naturally, with the clear vision of hindsight, I should have contacted Dr. Graham for his input regarding the Tucci matter. Had I contacted him, I would have had to contact some ten additional Tucci "associates". Like Dr. Graham, the Center for the Study of the First Americans and I sincerely regret this entire incident. However, is it the role of *CRP* to undertake a detailed investigation of such a case? I felt that *CRP* was not a court nor were you the reader the jury, but instead believed it necessary to air two points of view in a potentially serious problem.

Now for the future role of *Current Research in the Pleistocene*—some positive growth. How can this situation be avoided in the future? Any answer to this question must bear in mind the special niche *CRP* fills. *CRP* is not *Science, Nature, Quaternary Research* or a newsletter, nor does it claim to be. Unlike those journals, *CRP* offers rapid publication of emerging research results and provides a compact forum for workers in the Quaternary sciences to keep abreast of research within and outside their own fields of inquiry. And unlike the above-mentioned journals, *CRP* offers 40 to 60 short articles in one issue. This is a valuable service which is not fulfilled elsewhere. The task of ensuring accuracy and scholarly integrity while still producing *CRP* in a timely fashion is not an easy one.

To insure the integrity of content, and to respond to the spirit of Dr. Graham's letter, I have enlisted a group of colleagues to help with the editing of *CRP*. My office at Northern Arizona University (Flagstaff) is still the editorial office; all manuscripts submitted to *CRP* will first be reviewed by me and then by at least one peer-reviewer.

Given the dominant role Pleistocene archaeology plays in *CRP*, I have asked Dr. David J. Meltzer (Department of Anthropology, Southern Methodist University, Dallas, TX) to be the Associate Editor. His job is to read all archaeological submissions, and then decide who should peer-review these manuscripts. I have also enlisted the help of Drs. R. Scott Anderson and Larry D. Agenbroad (both at the Quaternary Studies Program, Northern Arizona University) to help select peer-reviewers for the non-archaeological manuscripts. All three began their work with this issue.

With this editorial board, we can offer both tighter quality control and better catch cases of apparent fraud. Although fraudulent manuscripts can slip through the net of reviewers for any journal, with this review process now in place I am not anticipating a repeat of this problem any time soon. Conscious fraud, as Stephen J. Gould points out in *Mismeasure of Man*, is probably rare in science.

Although installation of a peer-review process has increased the editorial workload, I am confident that the benefits derived from these changes will greatly outweigh the inconveniencies. And with the use of BITNET, FAX, and next-day mail, these changes can be accomplished without measurably slowing the production process. To keep the turnaround time to a minimum, however, it is necessary to reiterate the request that contributors to future issues of *CRP* follow the *CRP* style guide. Any manuscript not in this style will be returned immediately to the author. All of this keeps us in a position to continue to serve the growing numbers of subscribers interested in *Current Research in the Pleistocene*.

I appreciate Russ Graham's comments. I do not agree with all of them, but I thank him for taking the time to share his thoughts with us. If you have suggestions you feel would help the production, visibility, or style of *CRP*, please let me know. Russ Graham's comments were immediately put to good use.

Jim I. Mead

Dear Jim:

Since my name recently appeared in a letter from Mark A. McConaughy which was published in *Current Research in the Pleistocene* (5:ix), I feel it is my obligation to state the facts as I know them. McConaughy's statement, "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." is absolutely correct. Furthermore, I have never met, corresponded or had telephone conversations with Harry Tucci. Needless to say, I have never visited Durham Cave or made any type of statement about Tucci's interpretation of Durham Cave #2 as a pre-Clovis occupation.

This situation raises several serious questions about the nature of publications like *Current Research in the Pleistocene* as you state on page vii (Vol. 5). First, I agree with you that collegial trust is an important part of science and publication of scientific data. This is true of peer-reviewed publications as well as those without such review. However, peer-review subjects manuscripts to a greater amount of scrutiny and if questions arise, then verification of data and statements are required before publication.

I believe that your goal for *CRP* to make information on new discoveries, data and interpretations available in an expedient manner is meritorious. However, I do question the format that is used. Specifically, *CRP* now appears as a formal "scientific journal" with short contributions. Although you have made it abundantly clear that these articles are generally not peer-reviewed, they are frequently cited by other investigators as though they are part of the scientific literature.

Currently, *Science, Nature*, and even *Quaternary Research* now publish peer-reviewed short contributions with a modest turnaround time. Therefore, one of your goals is being filled by other scientific journals. I would like to suggest that *CRP* be revised to function as an informal news bulletin for current research in the Quaternary. This would provide a valuable service to the scientific community as well as other interested individuals. For example, the Society of Vertebrate Paleontology has a quarterly news bulletin that keeps its members informed of new research, discoveries, and interpretations. This allows for greater communication between scientists but the information included within the news bulletin is not considered to be published and it is not cited in the scientific literature.

Finally, I an somewhat concerned with the way that this situation has been handled by *CRP*. As you state (p. viii), "the Center for the Study of Early Man is not taking a stand on the contents [of the letters]." If this is the position of *CRP*, how do we know that such a situation will not arise again? This position is customary for articles published in journals in order to avoid favoritism, censorship, or prejudice toward certain ideas. However, once the issue of authenticity of published materials is raised, it is the responsibility of the editor and publisher to fully investigate and report the results.

This was not done in this case. For instance, in fairness to both parties, I feel *CRP* should have independently contacted all individuals involved or mentioned in this situation. These individuals should have then been given the opportunity to provide written comments to be published with the two letters. As it now stands, it is the word of one individual against the other. In order not to jeopardize the reputation of your publication, it is important to lay out all of the facts. I hope *CRP* will have a productive future and I believe that the editor and publisher should give serious

thought to revising the format. I hope this letter will be published in its entirety in the next issue of *CRP*.

Sincerely, Russell W. Graham Curator and Head, Geology, Illinois State Museum

Archaeology

The Shifting Sands Folsom-Midland Site in Texas Daniel S. Amick, Jack L. Hofman, and Richard O. Rose

The Shifting Sands site (41WK21) is located on the southern margin of the Llano Estacado in an active dune field. Thousands of Folsom-Midland artifacts and bison (*Bison*) bone fragments are found in a series of deep blowouts (Amick et al. 1988). Three major stratigraphic units are present. The basal unit is a lacustrine deposit exposed in some blowouts. These old lake beds contain Pleistocene fauna including mammoth (*Mammuthus*). No archaeological evidence has been found in the Pleistocene lake deposits. Overlying the old lake beds is a clay laminated sandy deposit that is a meter thick in some locations. Folsom-Midland artifacts and fragmentary mineralized bison bone are eroding from this deposit. The paleosurface of the laminated deposit may have existed as a series of low dunes. Interdunal ponding probably occurred at the Shifting Sands location during Folsom-Midland times. Overlying the laminated deposit is an active dune field between 5 and 8 m high.

For the past several years, eolian erosion has been monitored at the site. All artifacts and debris are collected from the fresh blowout surfaces. Although we do not assume any direct correlation between the blowouts and prehistoric activities, broad scale spatial patterning is evident at the site which measures about 200 by 270 m.

The assemblage contains a predominance of Folsom (n = 19) and Midland (n = 59) projectile points and several artifact refits have been found both within and between blowouts. Although differential patination is evident in the assemblage, several specimens which exhibit variation in patina are conjoinable. There is an overwhelming degree of homogeneity in the technology and the raw material represented. The lithic techniques and tools in the Shifting Sands collection are similar to those from Hanson (Frison and Bradley 1980) and other Folsom sites. Raw material is almost exclusively nonlocal Edwards Chert, which is available about 150 km to the east.

A total of 413 Folsom stone tools and 4,640 pieces of chipping debris have been collected. The tools include 92 Folsom-Midland points and fragments, 20 preforms,

Daniel S. Amick, Department of Anthropology, University of New Mexico, Albuquerque, NM 87131.

Jack L. Hofman, Oklahoma Archaeological Survey, University of Oklahoma, 1808 Newton Dr., Norman, OK 73019.

Richard O. Rose, Midland Archaeological Society, P.O. Box 4224, Midland, TX 79704.

8 bifaces, 29 endscrapers, 64 miscellaneous scrapers, 22 gravers, 2 perforators, 2 drills, 1 microdrill, 1 spokeshave, 1 denticulate, 1 adze, 135 utilized flakes, 28 utilized channel flake fragments, 3 abraders, 2 quartzite choppers, 1 quartzite hammer, and 1 groundstone fragment. The debitage includes 22 unmodified channel flake fragments and 4,618 other waste flakes. The waste flakes are characteristically small (92% are less than 2 by 2 cm) and noncortical, and most of the flakes are the result of bifacial thinning or tool retouch.

Several large biface thinning flakes are present in the collection which range up to 14 cm long and 7 cm wide. The dorsal side of these flakes commonly exhibits shallow retouch along the margins which could be interpreted as modification for use; therefore these artifacts are classified as scrapers. This retouch, however, might represent blunting of sharp edged tool blanks. These flakes appear to be derived from very large bifacial cores such as the one reported by Stanford and Broilo (1981) from Frank's Folsom Campsite at Blackwater Draw. No cores are found in the Shifing Sands Folsom-Midland collection.

A total of 19 Folsom points (1 refit), 59 Midland points (2 refits), and 14 Folsom or Midland (indeterminate) points are in the collection. The assemblage illustrates a tendency for Folsom points to be complete or if broken to exhibit impact fracture. Midland points exhibit a different pattern with much higher proportions of broken points, especially proximal fragments, and a greater incidence of snap fractures relative to impacts. Several diminutive Folsom-Midland points are present in the collection, one of these was manufactured on a channel flake.

Also of note are several adult human molars which were found as an articulated tooth row in situ. It is likely that these teeth represent the remains of a Folsom-age individual.

Differences among tool/debitage ratios and tool assemblages between the blowout areas indicate spatial patterning at the site. Some artifacts show evidence of burning and tools are burned more frequently than debitage. Hearth-centered activity that involves tool use or rejuvenation is inferred. The bison bone concentration may represent a kill. The bone is associated with a high frequency of broken projectile points, utilized flakes, and choppers which supports this interpretation. The high frequency of scrapers and gravers, bifaces and preforms, debitage, and burned tools found in another blowout about 60 m to the south may reflect short-term habitation including hide working, butchery, tool production, and tool maintenance.

All blowouts show a mixture of both Folsom and Midland points suggesting that these points are operating within the same technological system. The Shifting Sands collection appears to represent a Folsom-Midland assemblage that accumulated over a relatively limited time span; therefore the assemblage has considerably more integrity than Scharbauer (Wendorf et al. 1955), the Midland type site.

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Clovis Occupation at Kincaid Shelter, Texas

Michael B. Collins, Glen L. Evans, Thomas N. Campbell, Melissa C. Winans, and Charles E. Mear

Kincaid Shelter, part of extensive archeological site 41UV2 in the Sabinal Valley in Uvalde County, Texas, consists of stratified deposits beneath a limestone overhang 10 by 10 m in area. Investigations by the Texas Memorial Museum (TMM) in 1948 and by TMM and the University of Texas (UT) Department of Anthropology in 1953 included complete excavation of the shelter. Some looting preceded these excavations. Excavation records and collections are housed at TMM, the Vertebrate Paleontology Laboratory, and the Texas Archeological Research Laboratory at UT. Recent study discerned several chert artifacts with Clovis technological affinities associated with extinct fauna and a substantial, artificial stone pavement.

There are six stratigraphic zones in the shelter. The lowest, Zones 1 and 2, are culturally sterile, fluvial deposits. Zone 3 is a pond deposit of travertine, clay and bones of Pleistocene fauna which filled a shallow depression in Zone 2. While highly plastic, Zone 3 was capped with stones. The deepest looters' pit penetrated this stone pavement into Zone 3 in a small area.

The stone pavement covers more than 10 m² and contains more than two metric tons of allocthonous (introduced) boulders and cobbles. Toward the front of the shelter the pavement was disrupted slightly by erosion. Zone 4 rests directly on the stone pavement over most of the extent of the pavement. Zone 4 is gritty clay that is cemented with travertine near the back wall of the shelter. The vertebrate fauna of Zone 4 includes slider turtle (*Pseudemys* sp.), alligator (*Alligator* sp.), armadillo (*Dasypus novemcinctus*), pocket mouse (*Perognathus hispidus*), badger (*Taxidea taxus*), and raccoon (*Procyon lotor*) all of whose present ranges include or are near the site, a box turtle (*Terrapene carolina*) which is not present in or near the area today, and extinct horse (*Equus* sp.) and mammoth (*Mammuthus* sp.).

Holocene midden Zones 5 and 6 complete the sequence. Cessation of travertine formation and some erosion of Zone 4 preceded the deposition of Zone 5. Several lithics with adhering traces of travertine were found in the lower few centimeters of Zone 5 and in looters' backdirt. Adhering travertine indicates the presence of these specimens in the shelter while the spring was still active during Zone 4 deposition.

From Zone 4, on and just above the stone pavement, were recovered flakes, a blade core, two bifaces broken in early, successive stages of reduction (Figure 1a, b),

Michael B. Collins and Thomas N. Campbell, Department of Anthropology, The University of Texas, Austin, TX 78712.

Glen L. Evans, 9011 Fairway Hill, Austin, TX 78750.

Melissa C. Winans, Vertebrate Paleontology Laboratory, Balcones Research Center, 10100 Burnet Rd., Austin TX 78758.

Charles E. Mear, 6949 Valhalla Road, Ft. Worth, TX 76116.

a preform broken by the first flute (Figure 1c), both pieces of a preform broken during percussion thinning after successful removal of one flute and partial preparation of the platform for removal of the second flute (Figure 1d), a basal fragment of a lanceolate obsidian point (Figure 1e), and three large, retouched flakes. The obsidian is from a source in central Mexico (Hester et al. 1985). A reworked Clovis point (Figure 1f) and several non-diagnostic pieces with adhering travertine recovered from the looters' backdirt almost certainly belong with the Zone 4 specimens.

The bifacial reduction sequence in local chert suggests a Clovis habitation. The stone floor suggests a group sufficiently large and intending to stay for sufficient time to warrant paving a relatively small part of the total floor space in the shelter.

The authors thank Ellen Atha for the drawings used in Figure 1.

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Figure 1. Bifacial artifacts of Clovis affiliation, Kincaid Shelter. a, b, early reductive stage failures; c, fluting failure; d, thinning failure after first fluting; e, obsidian point base; f, resharpened Clovis point.

Preliminary Geoarchaeology of the Lower Yellowstone Badlands: A Paleoindian Site Predictive Model for East-Central Montana

Leslie B. Davis, Stephen A. Aaberg, and William P. Eckerle

Through reinvestigation of Paleoindian sites recorded by pioneer Montana archaeologist Oscar T. Lewis in the 1920s and 1930s and survey of new, largely unknown privately owned land, which have yielded an unusually high density of Paleoindian points, Montana State University evaluated area research potential in May 1987 (Davis and Aaberg 1988). Reconnaissance suggested additional potential for locating in situ Paleoindian sites in the deeply dissected, breaks topography of the Blue Mountain, Dawson County area in east-central Montana.

Three Paleoindian sites with potential for in situ cultural deposits were tested on a small scale in 1988. Only the OTL Ridge site (24DW272) yielded in situ Paleoindian lithic artifacts and minute faunal remains. The artifact collection made by Lewis includes Clovis, Agate Basin, Scottsbluff, and Eden points. OTL Ridge (named after Lewis as discoverer) is a bedrock-underlain, upland erosional remnant (elevation 830 m) in a badland grass setting bordered by dense Rocky Mountain juniper (Juniperus scopulorum) forest on the north. The eroding south slope is steep and sparsely vegetated. Test excavations 3 m below ridge surface revealed three paleosols. The deepest paleosol is locally gleyed, but is everywhere marked by high clay and carbonate content. This earliest paleosol, which varies in depth from 72 to 100 cm below surface, is referred to as the "high surface" soil. Cultural materials recovered below, within, and above this paleosol include chert, porcelanite, and dominantly chalcedony debitage; a chert uniface and several marginally retouched flakes; and the proximal end of a heavily patinated chalcedony projectile point (found in situ at the upper edge of a sandy clay stratum with high carbonate content). This context associates with what appears to the earliest paleosol, although gleying was not apparent at this locus. The point is identified as Goshen (after Irwin 1968) in type (G.R. Clark and S.T. Greiser, pers. comm.) (Figure 1) and resembles points from the Mill Iron site (24CT30) 125 km southeast of OTL Ridge dated ca. 11,300 yr B.P. (Frison 1987). Lithic artifacts found up to 20 cm below the Goshen point at OTL Ridge lack diagnostics.

The OTL Ridge site was formed in an approximate four-meter veneer of loess and reworked loess and slopewash that caps the high surface. Paleosols in the slopewash cap display an Ab-Cb or Ab-Cgb-Cb sequence, both types of which contain secondary illuvial carbonates in all horizons with thick, dark A horizons. Ferric iron mottles predominate in the Bg horizon. A radiocarbon date of $8,990 \pm 100$ yr B.P. (Beta-26395) on bulk carbonaceous sediments in this soil is likely too young because of later carbon additions and younger soil carbonates. These paleosols may reflect moister grassland conditions than today.

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

William P. Eckerle, 862 Jefferson Street, Salt Lake City, UT 84101.

Stratigraphic profiling of the OTL Ridge section, preliminary soil identification, and field observations made throughout the project area serve as the basis for proposing a Paleoindian site location model. Recognition of loess-bearing upland landforms is key to this model. Loess caps occur at relatively high elevations on drainage divides, near drainage heads, and on bedrock-controlled landforms in the Blue Mountain area. Loess is absent from much of the area landscape due to post-depositional erosional processes. These loess deposits often contain a repetitive series of paleosols that offer potential for locating buried Paleoindian occupations.

Environmental conditions may have favored upland occupation by Paleoindians, but supporting data are lacking for such an explanation. However, one working hypothesis is worth considering in the context of geoarchaeological observations available. Massive quantities of lag cobble and plate chalcedony and porcelanite are available locally in stream gravels and in a gravel deposit that caps bedrock underlying many landforms at various elevations. These lithic-rich gravels are likely derived from Tertiary (Hell Creek and Fort Union) formations and were probably deposited during the late Pleistocene, perhaps during the Illinoian-Wisconsin interglacial when the badlands began to form. Engulfment of the area landscape by loess following Wisconsin glaciation would have covered much of these lithic-rich gravels. It is possible that the Blue Mountain area, the highest in Dawson County, projected through the loess cap or was not as deeply buried as lower lying areas. Access to upland lithics may have been better because of shallow burial or faster erosion of steeper scarp faces. Occupation of lithic source access routes in a loessengulfed landscape may explain the occurrence of Paleoindian occupation sites in upland settings around Blue Mountain and Glendive Creek. Extended inventory and mapping of pertinent landforms are essential for testing this hypothesis.

The Blue Mountain Archaeological Project was sponsored by Joe and Ruth Cramer (Denver). We are also grateful to private property owners who granted us access for these investigations.



Figure 1. Goshen complex projectile point from the OTL Ridge site in east-central Montana (illustrated by Sally T. Greiser).

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Montane Paleoindian Occupation of the Barton Gulch Site, Ruby Valley, Southwestern Montana

Leslie B. Davis, Stephen A. Aaberg, William P. Eckerle, John W. Fisher, Jr., and Sally T. Greiser

In 1987, small-scale excavations of two Paleoindian occupations in Locality B at the stratified Barton Gulch site (24MA171), east of Ruby Reservoir, relocated the stratigraphic provenance for large, transverse-parallel flaked lanceolate points removed from context by garnet collectors in 1972 (Davis et al. 1988). Locality B excavations were extended in 1988. Although the Barton Gulch complex occupation floor, dated at 8,780 \pm 260 yr B.P. (RL-1376), was enlarged substantially, only small amounts of widely scattered lithic and bone detritus were recovered. However, the material culture content and structure of the underlying Alder complex cultural stratum, dated previously at 9,410 \pm 140 yr B.P. (Beta-232215), were defined in some detail. An underlying carbonaceous stratum, which dated at 9,800 \pm 120 yr B.P. (Beta-23220; ETH-3525), is not yet known to be cultural.

Barton Gulch is an east-west trending perennial stream valley within the upper Ruby River basin along the west flank of the Greenhorn Range in the Northern Rocky Mountains. The Barton Gulch site (elevation 1,675 m), which has been situated near the margin of a footslope/alluvial fan and a stream channel throughout the Holocene, is enclosed within colluvium, slopewash, and debris flow deposits. More than 8 m of unconsolidated sediments contain several stratified prehistoric occupations. The deepest deposit examined is a fine-bedded fluvial sand and silt unit, one stratum of which dated at 9,800 yr B.P. Overlying is a unit comprised of interbedded slopewash and debris flows that contains the 9,410 yr B.P. occupation; several fluventic A horizons in this unit associate with occupations. Overlying this is well-sorted fluvial sand and gravel, the upper boundary of which is the 8,780 yr B.P. Barton Gulch complex occupation.

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

William P. Eckerle, 862 Jefferson Street, Salt Lake City, UT 84101.

John W. Fisher, Jr., National Museum of Natural History, Department of Anthropology, Smithsonian Institution, Washington, D.C. 20560.

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

The 1988 excavations were conducted within a 420 m² area stripped of overburden by dragline. An additional 116 m² of the Barton Gulch complex living floor was investigated, which total of 156 m² includes 40 m² from 1987. A 124 m² area of the Alder complex floor recognized and lightly sampled in 1987 was excavated. Large quantities of lithic detritus and formed flaked stone artifacts (bifacial preforms, lanceolate projectile points, knives, marginally retouched flake scraping and cutting tools, and end scrapers), an andesitic tuff abrading stone, numerous sub-floor features, and remains of utilized animal species were recorded and recovered for the Alder complex. The 10 Ruby Valley points diagnostic for this complex are obliquely flaked, medium to small lanceolates with narrow, square basal edges and basal and marginal grinding (Figure 1). Only two points approximate their original form, the others having been extensively modified after breakage, some reshaped significantly by resharpening. Evidence of oblique flaking was removed during reworking and resharpening straightened the convex body edges to form long, narrow, straight-sided artifacts. Extreme resharpening after breakage produced lozenge-shaped implements with a drill-like tip. The Ruby Valley points are not a recognized Plains Paleoindian type nor is the prominent selection of quartzite a Plains trait. Morphologically similar points are rather widely distributed in the Rocky Mountain West. A closely similar series where quartzite selection was also prominent is known from an inundated, deflated occupation site (24BW1009) 135 km northwest of Barton Gulch at the southwest end of Canyon Ferry Reservoir on the Missouri River (Greiser 1986). Ruby Valley points are technologically and morphologically similar to later Paleoindian points from occupation sites in the Transmontane area of southwestern Montana, in east-central Idaho, and in north-central and northwestern Wyoming.

Four task-differentiated domestic and perhaps domiciliary activity loci were recorded within the Alder complex living floor. Four discrete feature aggregates, consisting of 37 features, are nearly identical in construction and morphology. They are spaced uniformly 4 m apart and each incorporates a central, shallowly



Figure 1. Alder complex Ruby Valley Paleoindian projectile points from the Barton Gulch site (illustrated by Sally T. Greiser).

excavated, unlined, heavily oxidized basin. One or two 40 cm diameter, 30 cm deep, unlined, charcoal-filled features occur around the periphery of each basin. Two aggregates include two deep, charcoal-filled pits, while a third has only one; the fourth is not yet entirely exposed. Forming what appears to be a 2 m diameter circle or semicircle around each oxidized basin is a series of circular, 20 to 23 cm diameter, 10 cm deep features. These small, shallow features are unlined and infilled with carbonaceous sediments that mark this living floor. These feature aggregates are unique in the regional Paleoindian record, although the larger features are evidently hearths.

Utilized taxa present in the Alder complex faunal assemblage include cottontail rabbit (*Sylvilagus* sp.) (MNI = 2), indeterminate rabbit (Leoporidae), mink (*Mustela vison*) (MNI = 1), and deer (*Odocoileus* sp.) (MNI = 2). Human utilization is evidenced by intensively reduced bone, probable hammerstone impact scars, and stone tool cut marks on deer-sized long bone shaft fragments. Numerous calcined bone fragments reflect food preparation and detrital discard.

The stratified Barton Gulch Paleoindian occupations reflect a settlement pattern keyed on the seasonal subsistence exploitation of medium and small game species, and possibly the gathering of economic plants, and selection of locally abundant surficial cobbles as toolmaking raw materials. The Alder complex is a regionally distributed montane Paleoindian adaptation, while the succeeding Barton Gulch complex montane Paleoindian manifestation is more localized in distribution.

Barton Gulch site investigations were sponsored by Joe and Ruth Cramer (Denver), with support by the Museum of the Rockies, the SPIN Foundation, and International Research Expeditions. We also continue to be grateful to Harold Kelly of Alder for permitting access to his property.

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The Aubrey Clovis Site: A Paleoindian Locality in the Upper Trinity River Basin, Texas

C. Reid Ferring

The Aubrey Clovis Site (41DN479) was discovered by the author in a deep alluvial exposure along the Elm Fork Trinity River in Denton County, Texas in December, 1988. An initial program of geologic-paleoecologic study and archaeological testing is in progress. This report provides preliminary descriptions of the locality, its geologic context, and the recovered faunal and artifact assemblages.

C. Reid Ferring, Department of Geography/Anthropology and Institute of Applied Sciences, University of North Texas, Denton, TX 76203.

The Aubrey Clovis site is situated on the western edge of the Elm Fork Trinity River flood plain. Above the flood plain are Pleistocene terraces. A 5 m terrace is part of the Denton Creek terrace complex; above that at 13 m is the Hickory Creek Terrace (formerly the Lewisville terrace of Crook and Harris (1958)). Revised terrace nomenclature, alluvial stratigraphy and the predicted position of Paleoindian sites in this region are discussed in Ferring (1986, 1987, 1989).

Archaeological and faunal materials at the Aubrey site are stratified in late Pleistocene sediments, between 7 to 8 m below the flood plain. Near this locality, boreholes show the alluvial fill below the flood plain to be ca. 16 m thick. The lower 6 m of this fill is sand and gravel associated with late Pleistocene channels that were incised into bedrock sometime after ca. 20,000 years ago (Ferring 1986). The surface of the fining upward sands had stabilized prior to Clovis time, and was the occupation surface in the camp area, described below. The remainder of the exposed late Pleistocene sediments are inset between this sand unit and the bedrock wall of the valley, ca. 110 m to the west. Against the bedrock valley wall are thick spring deposits. Travertine is cemented to the bedrock valley wall. Travertine, tufas, peats, and marls are interstratified in the spring area. These deposits grade, away from the spring, into facies including lacustrine silts, marls, tufas, and laminated humic marls. All of these deposits have rich molluscan faunas and plant fragments, and represent a spring-fed pond that predates the Clovis occupation. Immediately above these sediments is a pond deposit that includes a very dark gray clay stratified between two thin marls. This is the youngest lacustrine deposit exposed. Lithic artifacts and bison (Bison) bones with cut marks indicate the dark gray clay unit is of Clovis age. Radiocarbon samples from the entire late Pleistocene section are currently being processed at the Radiocarbon Laboratory, Southern Methodist University.

Archaeological testing is in progress in two settings: the pond sediments and the camp area on the sand remnant that stands approximately one meter above the dark gray pond clays. Thus far, five contiguous 1 m^2 pits have been excavated in the camp area. Lithic artifacts occur in a discrete horizon at the transition from the soil at the top of the sands to the massive clays that overly the entire late Pleistocene section. Well over 1,000 lithic artifacts have been recovered from the test area. Most of the artifacts are from a partially excavated 1 to 2 m^2 cluster that contains hundreds of chips, flakes, biface thinning flakes, core trimming elements, and a fragment of a large preform. At the edge of this cluster (in situ, but eroding from the channel cut) was a Clovis point fragment. Near the lithic reduction area was a cluster of unifacial tools (one burned) and fragments of burned large mammal bone. New test pits are now being excavated away from the contiguous squares to determine the size of the camp area.

The Clovis point is made of a gray chalcedony-cemented quartzite; the base is missing, but flute scars are present on both faces, and both margins are ground just above the break. Unifacial tools from the camp area include two end scrapers, one end-side scraper, and three heavily retouched and utilized blades. The majority of the raw materials are non-local quartzites; one Edwards chert blade, and also non-local, unidentified cherts and chalcedony are present.

Eight test units have been dug in the pond area near a concentration of *Bison* sp. bones. Three quartzite resharpening chips found in fine screen matrix, and cut marks on one bone indicate at least partial processing at this location. More *Bison* sp. bones and one large retouched-utilized flake have been found in the same geologic

unit, but have not been tested yet. Faunal materials from the ponded clay unit thus far include: *Bison* sp., deer (*Odocoileus*), two rabbit species (*Sylvilagus*), pocket gopher (*Thomomys*), three species of vole (*Microtus*), squirrel, birds, turtle, and non-poisonous snake. Detailed analyses of the faunas will be completed by Ernest Lundelius and Bonnie Yates. Preliminary examination of sediments by Steve Hall indicate excellent to good preservation of pollen in all Clovis and pre-Clovis strata; his analysis of pollen and the molluscan faunas is in progress.

The Aubrey site joins a very small group of in situ Clovis sites in the Southern Plains; on a much larger scale, it is also a rare example of a Clovis camp in North America. Analysis of archaeological materials from the camp area will provide important new information concerning Clovis lithic procurement, lithic reduction and tool maintenance technology. Spatial patterning in the camp area is excellent and will provide evidence for activity segregation as well as occupation intensity and/or periodicity. The well-preserved faunas will shed light on Clovis subsistence in a setting quite far from sites on the High Plains, where known Clovis sites in this region are concentrated (Meltzer 1987). Also, the Aubrey site has an excellent geologic and paleontologic record of late Pleistocene environments—the first to be found in the eastern portion of the Southern Plains. Clearly, this site will provide significant new information about Clovis adaptive strategies and their late Pleistocene environmental context.

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Paleoindian Occupation at Cerro El Sombrero Locality, Buenos Aires Province, Argentina Nora Flegenheimer and Marcelo Zárate

During the last decade there has been a renewed interest in archaeological investigations in Buenos Aires province. Present research in the Tandilia Range, where several sites are being investigated, is centered on Cerro El Sombrero locality. Here a high density and great variety of Paleoindian lithic artifacts have been found. The large collection recovered and the existence of several sites within the locality provide a unique opportunity for both the study of a South American Paleoindian lithic assemblage and the analysis of intersite variability.



Figure 1. A, Discoidal stone with central graving, No. S12/105/2; B, Fell's Cave Stemmed point with fluting on both faces, No. S12/105/1. Dots represent grinding; C, Small Fell's Cave Stemmed point, No. S12/301/1; D, Modified Fell's Cave Stemmed point, No. S12/204/2.

Nora Flegenheimer, CONICET, C.C. 275, 7630 Necochea, Pcia Buenos Aires, Argentina.

Marcelo Zárate, Centro de Geología de Costas y Cuaternario, Universidad Nacional de Mar del Plata, C.C. 722 Correo Central, 7600 Mar del Plata, Pcia Buenos Aires, Argentina.

Cerro El Sombrero is an elongated tabular hill, with its major axis in a north-south direction. Its height above the surrounding plain is about 250 m with a maximum elevation of 429 m above sea level. The far-reaching view from the hilltop conveys a panorama of the neighbouring ranges and boundless Pampas. The geology of this butte is conformed by a Low Paleozoic quartzite cover up to 60 m thick which unconformably overlies a Precambrian granitic bedrock (Teruggi and Kilmurray 1980). The hillsides formed by loess, reworked loess and colluvial deposits are currently under study.

Surface materials have been collected from most of the 12,000 m² summit where Paleoindian remains have been reported on several occasions (Flegenheimer 1987). In January 1987 new finds from a 16 m² excavation included: 454 flaked tools, 1 core, about 2,500 flakes and 4 ground stone tools. Nearly all these artifacts (94%) are on fine-grained quartzite which has been located 30 and 60 km westwards. The local coarse-grained quartzite is barely represented. There is a small quantity of local quartz (3%) and other raw materials (opal, chalcedony, igneous rocks). Side scrapers are the predominant tool type. Eighteen tools are Fell's Cave Stemmed points or stems of different sizes; modification of broken points is a common feature (Figure 1). Ground stone tools are represented by a fragment of a small sphere, a discoidal stone with a graving (Figure 1) and 2 fragments, possibly corresponding to the same type already identified in other South American sites in association with Fell's Cave Stemmed points (Bird 1970).

Several rockshelters with archaeological remains have been discovered; they are scattered along the quartzite escarpment surrounding the top. In March 1988, during excavations covering 6 m² at site Abrigo 1 (Shelter 1), an occupation level including Fell's Cave Stemmed points was exposed. Only flaked artifacts (12 tools, 4 cores and 205 flakes) and ochre (10 pieces) were recovered. Represented raw materials are: exotic quartzite (50%), local quartzite (4%), local quartz (41%) and others (5%).

There still is no absolute dating for the locality. However, an occupation with similar artifacts has been dated at 10,700 yr B.P. in Cerro La China, 15 km southwards (Flegenheimer 1987).

Fieldwork was possible thanks to collaboration from the Museo de Historia y Ciencias Naturales of Lobería and from Campos family at Estancia San Verán. Funds were provided through CONICET grant PID 3910803/85 directed by A. Aguerre to whom we are sincerely grateful.

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A Re-evaluation of Ryan's Site: A Disturbed Plainview Cache on the Southern High Plains of Texas

W. T. Hartwell, Eileen Johnson, Vance T. Holliday, Ronald W. Ralph, and Sonny Lupton

Initial, limited data obtained for Ryan's site suggested the presence of an undisturbed, single-component campsite of Plainview occupation, with retooling being the major activity represented (Johnson et al. 1987). Subsequent controlled excavations and further analysis of materials recovered indicates, however, that Ryan's site represents instead a disturbed, single-event caching of a lithic assemblage that initially was produced and retooled elsewhere.

Ryan's site occurs at the edge of an agricultural field next to a county road, on the upland surface of the Southern High Plains, near Shallowater, Texas. In 1985, two lithic bifaces were discovered by Sonny and Ryan Lupton. The bifaces were exposed in an erosional gully that cuts into the site. Two potholes (approximately 1 m² each and < 1 m apart) subsequently produced a lithic assemblage of 101 artifacts consisting of 9 projectile points, 37 incomplete to intact bifaces, several blades, and numerous utilized and waste flakes.

Of the nine points recovered from the potholes, eight exhibit a technology comparable to that of the Plainview collection (Knudson 1983). The remaining point is fluted, and very likely represents the secondary use of a Clovis point. All but one of the points are complete, and all seem to exhibit signs of having been reworked. The tips, in many instances, are fairly short relative to their corresponding bases.

Although the site was initially believed to have existed outside of the plow-zone, controlled excavations carried out in July of 1987 and July of 1988 revealed several distinct plow scars running in a north-south line through the site. Several artifacts were found embedded directly in the plow scars, and a few had been shattered in place. The scars cut well into the organic-rich playa lake sediments in which the assemblage was believed to have existed in situ. Furthermore, controlled excavations could not conclusively demonstrate that in situ deposits still existed within the playa sediments.

The controlled excavations produced five more Plainview points in addition to the missing tip of the point base previously recovered from the original potholes. Ten more incomplete to intact bifaces, as well as numerous additional utilized flakes and blades, were obtained. The great majority of the bifaces recovered from the potholes and subsequent excavations have sustained a complete breakage across their midsections, and much of the remaining material exhibits recent nicks and other damage. Most of this breakage is typical of that described by Mallouf (1981) in his discussion of plow damage to chert artifacts. The high concentration of materials obtained from the potholes and from the immediate area of the potholes would

W.T. Hartwell and Eileen Johnson, Museum of Texas Tech University, Lubbock, TX 79409.

Vance T. Holliday, Department of Geography, University of Wisconsin, Madison, WI 53706.

Ronald W. Ralph, Texas Parks and Wildlife Department, 4200 Smith School Road, Austin, TX 78744. Sonny Lupton, P.O. Box 550, Shallowater, TX 79363. suggest that this area is, in fact, the original location of the cache. As one would expect, artifacts were transported several meters north and south of this position (in the direction of plow movement), while only deviating up to 1 m east or west of this line.

Several factors contribute to the hypothesis that Ryan's site is, in fact, a cache and not an occupation. First of all, no significant amount of debitage occurs of the size that one would expect from the production and/or retouching of such a large number of implements. All sediments from excavations were washed through nested fine-mesh screens. This process yielded very little debitage, and such waste flakes as were obtained can be attributed to spalling as a result of plow impact. Secondly, the presence of non-lithic resources that might indicate an occupation or killsite (e.g., bone, charcoal, burned rock) is lacking. Last of all, the presence of so great a number of valuable implements within such a limited area seems to bear out the probability of a cache. Ryan's site has obvious potential for greatly expanding the existing data base regarding Plainview lithic technology. It also promises to be instrumental in supplementing studies such as those carried out by Mallouf (1981), and studies regarding the spatial integrity of sites within the plow zone (Roper 1976; Ammerman 1985; Lyman and O'Brien 1987; Odell and Cowan 1987).

Ryan's site was discovered by Sonny and Ryan Lupton and named for Ryan. We appreciate Ryan's continued interest in the site and his willingness to have it investigated professionally and to protect it. This investigation is part of the continuing research of the Lubbock Lake Project into the cultural and ecological changes on the Southern High Plains, and field work was funded through The Museum of Texas Tech University.

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Further Investigation of the Folsom Bison Kill at Lipscomb, Texas

Jack L. Hofman, Lawrence C. Todd, and C. Bertrand Schultz

The Lipscomb site, located in the northeastern corner of the Texas Panhandle, was first investigated by the University of Nebraska State Museum in 1939 (Schultz 1943). Limited fieldwork was also done at the site in 1946. Lipscomb continues to figure prominently in discussions of Folsom hunting tactics, but diverse and often conflicting interpretations have been offered concerning the circumstances of this kill (Hofman et al. 1988). Limited fieldwork in 1988 and continuing study of the



Figure 1. Map of Lipscomb bonebed Block 12, excavated in 1939.

J.L. Hofman, Oklahoma Archaeological Survey, 1808 Newton Drive, University of Oklahoma, Norman, OK 73019.

L.C. Todd, Department of Archaeology, Boston University, 675 Commonwealth Ave., Boston University, Boston, MA 02215.

C.B. Schultz, Nebraska Academy of Sciences, Morrill Hall, University of Nebraska-Lincoln, Lincoln, NE 68588.

collections provide new information about the site and should help rectify some common misconceptions. Lipscomb is now known to be the largest Folsom bison kill on record, and has a well preserved Folsom bison (*Bison*) assemblage.

The original fieldwork at Lipscomb was primarily a paleontological venture, with importance derived from good preservation and numerous articulated bison skeletons of known terminal Pleistocene age. Schultz (1943) reported 14 partially articulated skeletons and 9 additional skulls from the site. These materials formed part of a study on High Plains bison variability (Hillerud 1970), and continuing analysis has established several important facts about the Lipscomb bison fauna (Todd et al. 1988).

The kill involved at least 55 bison (MNI based on left astragali), more than twice the number documented for other known Folsom kill sites. This calls into question common interpretations about the size and organization of Folsom hunting groups, which are usually thought to have hunted single animals or small herds (Bonnichsen et al. 1987).

Study of tooth eruption and wear on the Lipscomb bison mandibles documents that the kill occurred during the late summer or early fall (Todd et al. 1988). This contrasts with a recognized pattern for Paleoindian bison kills to occur during the late fall and winter (Frison 1982). Both the size of the kill and season have implications for re-evaluating views on the organization and mobility patterns of early Paleoindian groups (Kelly and Todd 1988).

The presence of camp and processing activities adjacent to Folsom kills is a recurrent pattern (e.g., Frison and Stanford 1982), and we believe that such activities were originally conducted at Lipscomb near the kill. During the early work at Lipscomb, excavation ceased at the margin of the dense bonebed (Figure 1), or when preservation was too poor for expedient recovery. The absolute limits of the bonebed were not defined, nor was there exploration for associated processing or camp areas.

In 1988, limited excavation at Lipscomb documented part of the 1939 excavation area. And, intact deposits adjacent to the original excavations were found to contain bison bone (Hofman et al. 1988). Field notes from the original excavations and information from the 1988 testing, demonstrate that chipped-stone artifacts and bison bones occur away from the dense bonebed. This suggests that an associated camp or processing area may be present at the site.

Better definition of the margins of the original excavations will be critical for integrating modern studies with the original samples. Documenting the stratigraphy and soils at the site is planned in concert with collection of samples for study of snails, pollen, and phytoliths.

Charcoal was commonly encountered during the 1939 fieldwork, but that was prior to radiocarbon dating and samples were not collected. Very small samples collected in 1988 are now being processed for possible dating. It should eventually be possible to analyze a series of samples so the Lipscomb kill can be accurately dated. Refining our interpretation of Lipscomb is important to developing accurate perceptions of Folsom lifeways, hunting tactics, and group organization.

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New Dates for the Paleoindian Societies of South America

Hugo G. Nami

In the southern part of South America, Paleoindian sites are very scarce. Between the 1930s and 1950, Dr. Junius Bird of the National Museum of Natural History (New York) reported on discoveries at the Fell and Pali Aike caves in the southern part of the Republic of Chile (Bird 1938, 1946). These sites provide the primary stratigraphic record for southern Chile occupation.

During the winter of 1985, Dr. Mateo Martinic B., Department of History and Geography of the Instituto de la Patagonia, invited me to excavate the Cueva del Medio, District of Ultima Esperanza, Republic of Chile. My purpose in conducting excavations at this site was to find the first evidence of early man in southern South America.

Cueva del Medio is approximately 90 m long, 40 m wide and 6 m high. The cave is located approximately 1 km east of the famous Mylodon Cave, extinct fauna—ground sloth (*Mylodon* sp.), horse (*Hippidium* sp.), sabertooth (*Smilodon* sp.), among others—have been found since 1893. The cave was looted during the "Mylodon Rush," and cave deposits have been disturbed by uncontrolled excavations. Three intact stratigraphic zones were located. During spring and summer of 1986 and the summer of 1987, three archaeological excavations were carried out. The new project is being sponsored by the Instituto de la Patagonia and

Hugo G. Nami, CONICET, Bartolome Mitre 1970, Buenos Aires 1039, Argentina.

the University of Magallanes, Punta Arenas, Chile, with support from the Bird Foundation and the Sigma Xi Scientific Research Society.

Approximately 40 m² were removed by the new excavations. Four layers were exposed, and layers 3 and 4 contain cultural material. The cultural components have been identified as Fell, Magallanes or Bird I and Bird III. Both layers contain cultural remains associated with extinct horse, ground sloth (*Mylodon listai*), extinct llama (*Lama*) and other faunal remains (Nami 1987, 1988).

Four radiocarbon dates from charcoal from the Fell I component date the association between extinct fauna with bone and stone tools in context. The four radiocarbon dates from three hearths are: $10,550 \pm 120$ yr B.P. (Gr N-14911), 10,310 yr B.P. (Gr N-14912), $12,390 \pm 180$ yr B.P. (PITT-0343), and $9,595 \pm 115$ yr B.P. (PITT-0344).

In sum, Cueva del Medio provides important new evidence for Paleoindian period of Patagonia.

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The Paleoindian Archaeological Record in Northeast Texas: Evidence from Avocational Collecting Activities

Timothy K. Perttula

Despite the considerable amount of prehistoric archaeological work in northeast Texas since the 1930s, particularly most recently in a CRM context, the archaeological record relating to the Paleoindian period (ca. 12,000–8,000 yr B.P.) remains poorly known, and no discrete Paleoindian components have been conclusively identified in the region. Archaeological materials of this period typically consist of isolated finds of diagnostic projectile points in surface and/or multicomponent subsurface contexts. The limited documentation of the Paleoindian occupation of northeast Texas appears to be the result of the inability

Timothy K. Perttula, Institute of Applied Sciences, University of North Texas, P.O. Box 13078, Denton, TX 76203.

of professional archaeologists to locate sites of this period, the limited geoarchaeological investigation of depositional contexts where early occupations may be preserved, and possibly a low regional density of Paleoindian populations.

Currently, therefore, the best available information on the Paleoindian archaeological record in northeast Texas derives from the study of large samples of projectile points collected by avocational archaeologists in the Sulphur, Sabine, Trinity, and Neches River valleys (e.g., Carley 1988; Meltzer 1986, 1987; Perttula et al. 1986; Preston 1972, 1974). A preliminary compilation of data on the distribution, styles, and raw material character of Paleoindian points from these river drainages seems to indicate an extensive late Paleoindian presence in the Blackland Prairie portions of the North and South Sulphur River basins and a rather homogeneous distribution throughout the remainder of northeast Texas. However, no Paleoindian materials have yet been recovered in situ in the Sulphur River Basin. A possible exception is the association of late Pleistocene fauna, alluvial deposits dated between 9,000–12,000 yr B.P. (Slaughter and Hoover 1963, 1965), and purported lithic and bone tool remains from Delta County bone quarries 4 and 5 in the North Sulphur River drainage (Story 1981).

Blackland Prairie Paleoindian assemblages in northeast Texas are dominated by the Plainview, Dalton, Scottsbluff forms, dating from ca. 10,500 to 8,000 yr B.P. Earlier occupations are represented by Clovis and Folsom lanceolates from the North and South Sulphur River alluvial deposits (Carley 1988). San Patrice, a marker point for a local West Gulf Coastal Plain Paleoindian adaptation to early Holocene woodlands (e.g., Ensor 1987) probably contemporaneous with the Dalton horizon (Goodyear 1982), is scarce in the Blackland Prairie. However, in collections from Cedar Creek in the Trinity River basin and Cuthand Creek in the Sulphur River basin, both in the modern Post Oak Savannah, San Patrice points (variety St. Johns) are about as common as Dalton and Plainview types. Over 16 sites with Paleoindian materials have been recorded by avocational archaeologists at Cedar Creek Reservoir (McGregor and Bruseth 1987: figure 18-2), and from at least two of the sites more than 10 Paleoindian projectile points have been collected. San Patrice points are represented at 37.5% of the sites, Plainview at 44%, and Scottsbluff at 37.5% of the sites. On Cuthand Creek, a channelized tributary to the Sulphur River, Dalton and San Patrice forms on local and exotic raw materials are particularly abundant. More limited collections from the Pineywoods of northeast Texas include a wide variety of Paleoindian forms, including Clovis, Folsom, Plainview, Dalton, Angostura, Graham Cave, Brazos Fishtail (Redder 1985), Scottsbluff, and San Patrice. One of the larger assemblages of Paleoindian remains has been recovered by an avocational archaeologist from a site on the Neches River where it has been exposed by Lake Palestine shoreline erosion. Thirty-five Paleoindian lanceolates, primarily Plainview and Scottsbluff forms, projectile point preforms, drills, scrapers, and channel flakes have been found in the deep sand deposits at the site. The overwhelming majority of the tools were manufactured on cherts from the Edwards Plateau of central Texas, but Ouachita Mountains quartzites and cherts are represented along with an Angostura, a Folsom, two channel flakes, and a Folsom preform of Alibates agatized dolomite.

The high frequency of non-local chert raw materials from the Edwards Plateau, the Ouachita Mountains and Arbuckle Mountains of southern Oklahoma, and Alibates agatized dolomite from the Llano Estacado suggests that these Paleoindian groups were highly mobile and wide-ranging foragers. The only Paleoindian projectile point form represented in any frequency by local raw materials is the San Patrice (Ensor 1987).

There is no clear evidence in northeast Texas for the association of Paleoindian components with the remains of extinct late Pleistocene megafauna such as mammoth (*Mammuthus*), mastodon (*Mammut*), horse (*Equus*), and bison (*Bison*) that have been found in the Sulphur River basin. Instead, it is more likely, given the paleoenvironmental setting in northeast Texas at the time (Bryant and Holloway 1985), that the Paleoindian groups were characterized by a generalized forest-based hunting and gathering strategy comparable to Southeastern North American Paleoindian populations (e.g., Meltzer and Smith 1986). Whether the cooler and drier grasslands to the north and west supported similar groups, or more specialized megafaunal hunting societies, has yet to be determined.

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Kessell Side-notched Point: First Record from Michigan

Jeheskel Shoshani, Arnold R. Pilling, and Henry T. Wright

Excavations at 20-OK-394, the Shelton Mastodon site, were carried out during the summers of 1983–1987, following standard field techniques (Joukowsky 1980). This site is located in Brandon Township, Oakland County, about 90 km north of Detroit, at an elevation of 317 m above sea level. Findings include remains of these species: at least 15 vertebrate, 10 insect, 14 molluscan, 16 plant, 91 diatom, and 3 archaeological objects (Shoshani 1989; Shoshani et al. 1989a).

A typical cross-section at the site reveals three distinctive units above the lower glacial deposits: Unit I, the bottom-most, is clay; Unit II, the middle, is sandy with wood and rocks at its base; Unit III, the top-most, is black muck. Twelve radiocarbon dates were obtained: two for the Holocene (Unit III), and 10 for the Pleistocene strata (nine for Unit II, and one for Unit I). A wood sample associated with the Kessell point at the base of Unit III gave a ¹⁴C date of 9,640 ±120 yr B.P. (Beta-10302). Dates for the lower portion of the bone-bearing Unit II correlate with the



Figure 1. The Kessell Side-Notched projectile point (A17/421), estimated age of 9,900 yr B.P. Views shown are: dorsal (or face), edge (or blade), ventral, and cross-section at the markers (drawings by H.T. Wright).

Jeheskel Shoshani, Department of Biological Sciences, Wayne State University, Detroit, MI 48202. Arnold R. Pilling, Department of Anthropology, Wayne State University, Detroit, MI 48202. Henry T. Wright, Museum of Anthropology, University of Michigan, Ann Arbor, MI 48019. forest bed of the Two Creekan Substage at the type locality in Wisconsin (Morgan and Morgan 1979). The mastodon (*Mammut americanum*), the Scott's moose (*Cervalces scotti*) and other late Pleistocene fauna were recovered from Unit II. Faunistic and floristic data from this site support a ponded-marginal lacustrine environment at about 11,500 yr B.P., a habitat typical of Michigan's late Wisconsin topography (Dorr and Eschman 1970; Farrand and Eschman 1974).

Two projectile points were found in Unit III near the boundary with Unit II. The larger point (A17/421, Figure 1) was identified as a Kessell side-notched point from the early Archaic period ca. 9,900 yr B.P., following the descriptions in Broyles (1971). According to Justice (1987), Kessell projectile points are rare finds in the Eastern United States and have not been previously reported from Michigan (they were found in West Virginia [where the type was defined (Broyles 1971)], southern Indiana and Ohio, northern Kentucky and western New York). Specimen A17/421 was probably made from Kettle Point chert from near Sarnia, Ontario. The general color of this artifact is gray with faint bands of lighter material including several minute crystals and fossil remains. In its present condition, this point measures 50.5 mm long, 27.6 mm wide, 8.0 mm thick, and weighs 9.3 grams. Detailed descriptions of this and other artifacts (a reworked LeCroy Bifurcate Base point and a large minimally modified flake) found at this site are given by Shoshani et al. (1989b).

The artifacts found at 20-OK-394 are of greater significance than many other specimens from Michigan (Fitting 1975; Wahla 1981), for they have been recovered from contexts well-documented both stratigraphically and radiometrically. The known distribution of Kessell points in the USA is extended with the finding of one in Michigan. Bones of rabbit (*Sylvilagus*), muskrat (*Ondatra*), and deer (*Odocoileus*) which were collected at the level of the projectile points could be evidence of suitable targets for hunters.

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Accelerator Dates and Chronology at the Packard Site, Oklahoma

Don G. Wyckoff

In 1962 and 1963, archaeological excavations at northeastern Oklahoma's Packard site (34My-66) revealed a long sequence of human occupations within a first terrace bordering the Grand (Neosho) River. Of special interest were two deeply stratified components. One is represented by artifacts of the Dalton complex (Morse and Morse 1983); these were found between 152 and 244 cm below the surface. Under this component was nearly 140 cm of gleyed silt loam that yielded flakes and artifacts of what is now recognized (Wyckoff 1985) as the Packard complex. This assemblage was recovered mainly at 290 cm below the surface and within 4.0 m of a small, shallow, circular unlined hearth. Diagnostic tools found here include three lanceolate spearpoints (Figure 1) stylistically like the Agate Basin type and one



Figure 1. The three Agate Basin-like points and the side-notched point/knife found around the dated hearth at the Packard site (34My-66), Mayes County, Oklahoma.

Don G. Wyckoff, Oklahoma Archeological Survey, 1808 Newton Drive-Room 116, Norman, OK 73019.

side-notched point/knife (Figure 1) like those called Simonsen. A radiocarbon date of $9,416 \pm 193$ yr B.P. (NZ-478) was obtained on charcoal-stained soil from this hearth.

The Packard site's findings are important for documenting late Pleistocene-early Holocene people's adaptations along the Ozarks-Prairie Peninsula border. In particular, this site's component of the Dalton complex, a Southeastern Woodlands Paleoindian manifestation believed (Goodyear 1982; McMillan and Klippel 1981) to be 10,500 to 9,900 years old, is underlain by a component with ties to the High Plains Paleoindian tradition. Moreover, the Dalton component is above, and thus later than, a hearth dated 9,400 years ago. While this date compares well with those from the latest Agate Basin sites on the High Plains (Bonnichsen et al. 1987), it makes the Packard site's Dalton component more recent than the age attributed to the Dalton complex.

Because Packard's single date raises questions about the age of the Dalton complex and the timing of different Paleoindian occupations in an ecologically sensitive region, more dates on this site were merited. The remaining small charcoal samples were most appropriate for accelerator dating. Three minute charcoal pieces from the hearth fill were so dated. All appeared to be of woody bark, but they could not be speciated. They yielded the following results: 9,880 \pm 90 yr B.P. (AA-3116); 9,830 \pm 70 yr B.P. (AA-3117); and 9,770 \pm 80 yr B.P. (AA-3118). These are corrected results wherein delta ¹³C equals -25%. These results are 350 to 400 years older than the original date from the hearth.

Also dated was a single charcoal lump identified as being *Cornus* (dogwood), a tree species still common to hill slopes east of the site. This sample is from a depth of 259 cm (in square 0-Left 1), which is the lower part of the deposit yielding Dalton materials. While not from a habitation feature, this sample was dated to obtain some idea of the Dalton-bearing deposit's age. It yielded a result of 9,630 \pm 100 yr B.P. (AA-3119).

The newly derived radiocarbon dates do help establish the age of the Packard site's earliest occupation more precisely than before. The three accelerator dates on the hearth overlap well at 9,800 years ago, a time near the middle of the age ascribed to Agate Basin (Bonnichsen et al. 1987). These dates are some 400 years older than that obtained in 1963; the difference may be due to humate contaminants in the soil sample processed by the New Zealand Geological Survey lab.

The sample from 259 cm provides a minimum date for the period when the site was visited by people using Dalton points. This was at least a few centuries after the site was first occupied.

Accelerator dating of the Packard samples was made possible by a grant from the University of Oklahoma Research Council and by the cooperation of the University of Arizona NSF Accelerator Facility for Isotope Dating. For their support and interest, C. Vance Haynes, Doug Donahue, Owen Davis, Peggy Flynn, Lee Johnson, and Jack Hofman merit special thanks. The Oklahoma Museum of Natural History graciously made the Packard charcoal samples available for analysis.

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A Cache of Blades with Clovis Affinities from Northeastern Texas

Bill Young and Michael B. Collins

In September, 1988, Keven Davis, a surveyor, discovered three fragmentary prismatic chert blades, similar in every respect to those from the Clovis site (Green 1963), exposed by earth-moving equipment near a small tributary of the Trinity River in Navarro County, Texas. Davis and Young documented the site and conducted sufficient excavation to recover buried specimens, determine that the blades had been closely spaced, and conclude that probably no other artifacts or features are present.

The site (4 1NV659) is on the south side of Cedar Creek valley in an area of rolling hills, sandy loam soil and clay-rich subsoil. Borrowing of sand exposed the blades at and near the top of the clay. The blades were scattered by machinery over an area 1.0 by 1.5 m; the plastic and vertisolic properties of the clay had evidently moved them somewhat from their original placement prior to this disturbance. No pit or other evidence of the original containment of the pieces was observed, but their greatest concentration in an area roughly 30 cm in diameter and 20 cm in depth is suggestive of the original cache dimensions.

The 23 recovered specimens, thought to be most, if not all, that were originally cached, include 10 refits which form 9 essentially complete and 4 incomplete blades; minimally, 13 blades and blade segments were cached. Fresh breakage is not easily distinguished from original surfaces, and prior to further study, it is not certain which pieces are intentional segments as distinct from machine damage. A fourteenth specimen, found approximately 140 m to the west, is the proximal fragment of a blade entirely comparable to the 13 found in close proximity.

No chronometric, geologic, culturally diagnostic, nor extinct faunal evidence from 41NV659 corroborates our technologically based inference that these blades are of Clovis affiliation.

The blades (Figure 1) are of two varieties of high quality-chert. Ten of the 13 and the isolated fourteenth fragment are of medium gray, fine-grained material, almost certainly Edwards chert from Central Texas. Three smaller blades are of an unidentified light-brown chert. Two pieces of each variety have areas of unmodified whitish cortex.

Bill Young, 1800 Beverly Drive, East Corsicana, TX 75110.

Michael B. Collins, Department of Anthropology, The University of Texas at Austin, Austin, TX 78712.



Figure 1. Cached prismatic blades from 41NV659, Navarro County, Texas.

The 9 essentially complete blades range in length from 73 mm to 144 mm (\overline{x} 104 mm), in width from 13 mm to 33 mm (\overline{x} 25 mm), and in thickness from 7 mm to 14 mm (\overline{x} 11 mm). The mean length: width ratio is 4.24:1. Longitudinal sections are strongly curved; cross-sections are prismatic. Platforms are small, multiple-faceted, and lightly ground. Bulbs are nearly flat and most lack bulbar scars. The exterior faces exhibit multiple parallel to subparallel facets.

A distinctive characteristic of all 14 blades is flaking emanating from the lateral edges and extending onto both faces. These are small flake scars, isolated as well as contiguous. Nicking of the edges is also common. The overall pattern suggests damage from vigorous use rather than intentional retouch. It appears that edge damage from machinery is minimal.

We have seen similar blades and segments from other sites in Texas, and a technologically comparable polyhedral core has been noted in the Clovis component at Kincaid Shelter, Texas (Collins et al. 1989). These often may be passed over by collectors and could serve as diagnostics where points have been removed.

We thank Keven Davis of Waxahachie, Texas, for access to the collection from 41NV659 and Karim Sadr of Southern Methodist University for the drawings used in Figure 1.

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Lithic Studies

A Preliminary Survey of Paleoindian Sites in Tennessee

John B. Broster

The Tennessee Division of Archaeology has recently undertaken an intensive inventory of existing records of the Paleoindian occupation of the state. An attempt has been made to document known archaeological sites and collections, and to use these data in developing predictive models of site location within Tennessee. In compiling these data, it was learned that Paleoindian sites and isolated materials have been recorded in all the geographic divisions of the state. Starting in the west, the Coastal Plain and the Western valley of the Tennessee River have produced many isolated finds and eroded small camp sites dating from the Clovis to late or Transitional periods (Figure 1). The eastern and western subdivisions of the Highland Rim, which surround the Central Basin, have probably produced more isolated Clovis materials than any other location in Tennessee. Sites are also known in the Central Basin, Cumberland Plateau, and the Ridge and Valley divisions of the eastern part of the state. Additionally, scattered remains have been reported in the mountains on the Tennessee/North Carolina border.

In Tennessee, the Paleoindian occupation has been generally divided into an early and late phase, based upon projectile point morphology. The early phase corresponds to the general fluted point horizon made up of Clovis and Cumberland types. The Clovis material is generally assumed to be older than Cumberland. Dates of 11,500 to 10,000 yr B.P., based on radiocarbon dates from other regions, have been projected for the fluted point period.

The late phase, often termed Terminal or Transitional Paleoindian, has been assigned dates of 10,000 to 9,000 yr B.P. This phase has become rather broad with the inclusion of numerous projectile point types. Types such as Quad, Beaver Lake, Wheller, Plano and possibly Dalton have been placed in this category. At this stage of research, these so-called types may represent differences in regional adaptations, time factors, or in some cases may be related to different components of the same basic tool kit.

Only two Paleoindian sites, the Wells Creek Crater (40Sw74) and the Pierce site (40Cs24), have been extensively excavated (Dragoo 1965, 1967, 1968, and 1973; Broster 1982). Neither of these sites produced undisturbed materials or occupation

John B. Broster, Tennessee Division of Archaeology, Department of Conservation, Nashville, TN 37211.

levels. To date, there are no known single-component Paleoindian sites recorded in the region which have potential for undisturbed deposits.

In researching the state site files, a total of 58 archaeological sites produced two or more Paleoindian artifacts. Some 24 sites were located in the west, 23 in the central region, and 11 were recorded in the east portion of the state. Additionally, 47 sites produced isolated Paleoindian artifacts on multi-component locations. However, one should be very cautious in giving a Paleoindian interpretation to many of these sites. In excavated context, throughout the region, we have found that Paleoindian materials were often curated and modified by later prehistoric populations. At this point only those sites which have produced numerous Paleoindian tools can be truly assigned to the period. This includes only six known sites.

The most numerous recorded Paleoindian artifacts are the hundreds of isolated fluted and non-fluted projectile points. An attempt in the 1960s, by the University of Tennessee, was made to document fluted point surface finds by local collectors. Of particular value from these studies are the photographic records and point measurements. Unfortunately, provenience information was usually limited to the county of origin although occasionally the drainage or more specific information was obtained. This lack of specific information was probably due to the collectors' reluctance to divulge good collecting sites and suspicion of the motives of professional archaeologists. This suspicion still exists and has done much to harm further studies.

The lack of "in situ" sites has done much to discourage Paleoindian studies in Tennessee. The professional community has not shown much research interest in this important period. The majority of our information is still obtained from collectors willing to share their knowledge and allow the recording of their finds. Due to this lack of systematic research, the Tennessee Division of Archaeology has undertaken a long-term study of existing records and is proposing multi-stage surveys of potential areas of heavy occupation. Local amateurs have been very generous with their time and collections, and are helping to fill in important gaps in our knowledge of this very critical time period.

Specific goals of this study are the development of a systematic survey and testing of probable site locations. Unfortunately, several surface sites are known to have been destroyed by stream action, development and unsystematic collecting. Additionally, a thorough mapping and investigation of known occurrences of late Pleistocene fauna will be attempted to see if there are any correlations in distribution of these remains and Paleoindian artifacts. A major short-term goal will be the continuation of the recording of amateur collections, and the analysis and



Figure 1. Distribution of fluted projectile points in Tennessee. Drawn by Mark Norton.

publication of the unrecorded but well-known surface sites. Although lacking in importance as undisturbed sites, these localities provide much useful information on lithic technologies. Research for this period in Tennessee has lagged behind the rest of the country. This is very unfortunate when one becomes aware of the amount of Paleoindian artifacts which have been collected in Tennessee over the past three decades. This information must be better recorded, and toward this end the Tennessee Division of Archaeology will continue its efforts.

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An Update on the Texas Clovis Fluted Point Survey David J. Meltzer

Since my initial reports of a statewide survey of 205 Texas Clovis fluted points (Meltzer 1986, 1987), an additional 72 Clovis points have been recorded. This new information warrants brief comment.

It is still the case that less than half of the state's 254 counties have produced Clovis points. And most of those have produced very few points. Of the 112 counties (up from the previous high of 95 counties) producing isolated fluted points, 89 counties (79%) have 3 or less. Only three counties—Crosby, Gaines (in west Texas) and Jefferson (on the Texas Gulf Coast)—have 10 or more isolates.

It was earlier observed that the distribution by county of isolated Clovis points appeared unrelated to the distribution of later Paleoindian sites. A comparison of the distribution by county of isolates with the distribution of Paleoindian sites (site data from Biesaart et al. 1985) reveals that there is no concordance or correlation between the two (Kendall's W = .0156, p = .187). However, there was nearly complete agreement between the number of Paleoindian sites and the total number of sites by county (Kendall's W = .946, p < .0000).

Granting biases in the collection and reporting of isolates versus Paleoindian sites, I speculated one might attribute the lack of concordance between the two to differential land use on the part of Clovis groups or perhaps to the fact that Clovis groups only rarely participated in the highly structured spatial behavior that produces sites (Meltzer 1986).

David J. Meltzer, Department of Anthropology, Southern Methodist University, Dallas, TX 75275.

Yet this lack of concordance may be more apparent than real. Reanalysis of the new data set using fewer and larger spatial units—environmental and geographic regions (defined by Biesaart et al. 1985)—shows there is a high correlation between the number of Clovis isolates and Paleoindian sites by such regions (r = .853, p = .0004).

These results suggest that my prior speculation about Clovis land use differing from later Paleoindian land use remains an open question, subject to further analysis and not necessarily supported by the data at hand.

The 72 Clovis points added to the survey were distributed among the various regions of the state in proportion to their abundance in the original sample (save in two areas, North Central and the Southern Coastal Plain of Texas, which gained significantly more Clovis records than would have been expected given the original sample). Thus, the frequency distribution (Figure 1) of Clovis isolates across the state for the updated survey (n = 277) is quite similar to the map from the original sample (Meltzer 1986).

The "empty" spots on the previous map, notably the Lower Plains along the eastern edge of the Llano Estacado and the Trans Pecos region, have still not filled in. Recent geological reports of 2,000-year-old surfaces buried under 7 m of sediment on the Lower Plains (Baumgardner 1986) would seem to corroborate my earlier suggestion that aeolian and fluvial aggradation off the High Plains have deeply buried and thus rendered invisible any late Pleistocene surfaces and associated archaeological records in this region.



Figure 1. Three-dimensional frequency map of Clovis points in the state of Texas. Spikes indicate the number of Clovis points by county. The largest of the spikes—in Gaines County, west Texas—represents 22 Clovis occurrences.

There remains a high frequency of Clovis isolates on the High Plains of west Texas, and the coast of Southeast Texas. That observation is corroborated statistically. Analysis of residuals in a plot of Clovis points by Paleoindian sites indicates there are significantly more isolates in these regions than would be expected. The Clovis isolates from Southeast Texas, nearly all of which occur as surface finds along the Gulf Coast beaches, are presumably being carried on shore from now-submerged localities on the continental shelf (Meltzer 1986). The new discoveries here are the subject of a forthcoming report (Brian Shaffer, personal communication).

I earlier attributed the high number of isolates on the High Plains to archaeological attention and to the high surface visibility of archaeological remains. It is also possible, however, that this area was more intensely occupied by Clovis groups. The environment in late Pleistocene times was wetter and cooler than today. The pluvial lakes that dotted the landscape would have been a prime attraction to human foragers, and many Clovis points are found alongside these now dry features.

Regardless, the conclusion that Clovis groups more intensely occupied this as opposed to other regions of the state will have to remain tentative until such time as those other areas have been as thoroughly searched for Clovis remains as this region.

A note on lithic raw material—most Clovis points from the High Plains are manufactured of exotic Edwards Formation (Cretaceous) cherts that outcrop east and southeast of the region. Fewer Clovis points in the region are manufactured of Alibates dolomite which outcrops on the Panhandle. There are still no reports of Clovis points from the High Plains manufactured of obsidian, the closest outcrops of which occur some 500 km to the west in the northern Rio Grande valley of New Mexico (Hester et al. 1985; Johnson et al. 1985). For that matter, there are very few Clovis points found anywhere in Texas manufactured of obsidian, although Hester (1988) has recently reported one from Calhoun County on the Texas Gulf Coast, but the source of the obsidian is unknown.

What these patterns of stone use might indicate is a Clovis High Plains settlement system that tracked to the north and east of the High Plains, but not to the west. Such a conclusion, however, must be mindful of the fact that the evidence is saying no more than stone sources to the west were not being used—and not that settlement systems failed to extend into those regions.

I would like to thank, collectively, the members of the Texas Archeological Society, who graciously responded to my questionnaires and provided me with invaluable data on points in their possession.

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Early Notched Projectile Points in Texas

Leland W. Patterson

While individual examples of early projectile points with notched bases have been published from time to time, it is not generally realized in the literature that there is a widespread geographic distribution of early notched points throughout the U.S. east of the Great Plains. It is also not generally recognized in the literature that some types of early notched points cover the same time periods as some types of Paleoindian lanceolate points in the same geographic areas, such as Texas. Further, there is seldom published recognition that there is temporal overlap of some types of early notched points with the early Paleoindian fluted point tradition.

Some examples of very early notched points in the eastern U.S. include Hardaway notched points in North Carolina (Peck and Painter 1984), and a "very early Archaic" notched point at the Shawnee Minisink site in Pennsylvania (McNett 1985:fig. 6.8A). Dalton points, some with side-notched bases, overlap the Folsom time period of 11,000 to 10,000 years ago in Missouri (Goodyear 1982). There are now many findings of early notched points in Texas, in the same geographic areas and time periods as Paleoindian lanceolate point types, such as Plainview and Angostura. At the Rex Rogers site in the northern Texas Panhandle, notched points resembling the San Patrice type were found together with lanceolate points having deep basal thinning (Hughes and Willey 1978). This is a late Pleistocene kill site of an extinct species of bison (Bison). At the Horn Shelter No. 2 site in Central Texas, notched points were found slightly later in stratigraphic position than Folsom points, but earlier than Plainview points (Forrester 1985; Redder 1985). Radiocarbon dates on one stratum that contained early notched points range from 9,500 ±200 yr B.P. to 10,310 ±150 ys B.P. (Redder 1985). At the Wilson-Leonard site in Central Texas, some notched point specimens occurred earlier than Plainview points (Weir 1985).

Sellards (1940) found side-notched points well below a Folsom point in excavations at a site in Bee County, South Texas. This overlap in time between notched points and the Folsom fluted point has more recently been given additional credibility with the finding of a side-notched point at the same excavation level as a Folsom point at site 41WH19 in Wharton County, Texas (Patterson and Hudgins 1985), about 60 km east of Sellards' previous investigations. The stratum in question at site 41WH19 has one radiocarbon date of 9,920 ±530 yr B.P.

The morphologies of early notched points found in Texas are quite variable, but most examples have ground stem edges. Except for stem grinding, some specimens

Leland W. Patterson, 418 Wycliffe, Houston, TX 77079.

of early notched points are quite similar to later Archaic period point types. Some specimens of early notched points can be classified as side-notched and other specimens can be classified as corner-notched. Since the wide variety of early notched points from site 41WH19 has been published (Patterson and Hudgins 1985), a number of other sites in Southeast Texas have been identified as having specimens of early notched points. There are now at least 10 sites in Southeast Texas with general varieties of early notched points and well over 20 sites in this region with San Patrice notched points identified with the late Paleoindian period in Texas at about 8,000 to 10,000 years B.P.

It has already been recognized for some time that notched points start as early as 10,000 years ago in the eastern U.S., in what is termed as the early Archaic period for that region (Gardner 1974). More recent examples demonstrate that notched points start at least as early farther west in Texas. Some of the examples given above indicate that notched projectile points start even earlier with a temporal overlap with the early Paleoindian fluted point tradition. Two research questions are raised by these data (although not to be answered here): 1) what is the earliest start of notched points in North America, and is there one or more than one location of development origin?, and 2) what is the relationship of the earliest notched points to early Paleoindian lanceolate points, in terms of technological development sequences and possible differences in lifestyles?

Except for the Great Plains region, where there is a sequence of Paleoindian lanceolate point types, the technological relationship of the Clovis point type to later projectile point technologies is not clear. Additional future data might show multiple technological sequences from Clovis to other point types in different regions. For example, Morse and Morse (1983) seem to imply that there is a relationship between the Dalton point and earlier Clovis technology. There are now sites known in Virginia, Louisiana, Texas, Pennsylvania and Missouri where Clovis seems to be more or less directly succeeded by early notched point technologies, instead of the Folsom technology of the Great Plains. As an alternative, however, the early notched point tradition may be independent of Clovis technology. In any event, it would appear that a wide variety of projectile point styles were being manufactured during the Paleoindian period, instead of starting in the Early Archaic period as is so often assumed.

The finding of early notched points and Paleoindian lanceolate point types at the same sites in Texas seems to represent an interface between two lithic traditions, fluting and notching. It should be noted that technological developments in the early Paleoindian period cannot be fully detailed without considering both lanceolate and non-lanceolate projectile point forms.

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Grinding Stones in Plains Paleoindian Sites: the Case for Pigment Processing

Donna C. Roper

Grinding stone tools (manos, matates, or coarse stone slabs that could have served to reduce raw materials by pulverizing), often considered a hallmark of an Archaic stage lifeway, are found in Paleoindian sites throughout North America. That they may represent plant processing at this time level is a matter which has been debated for several decades and is particularly pertinent now in light of recent arguments for plant utilization by Paleoindians (e.g., Kornfeld 1988). Without denying that Paleoindians may have used plants, the use of grinding stones as a direct indicator of plant processing must be questioned. Such tools are known to have been used for a multitude of purposes at other times (e.g., Adams 1988). The range of uses to which they were put by Paleoindians therefore must be established rather than assumed *a priori*. I here review the evidence that pigment processing was one use to which grinding stones were put by Paleoindians on the Plains. Some of this evidence is direct, some is circumstantial.

Grinding slabs coated with red ochre were found at three Folsom sites in the Northwestern Plains (Roper 1987; for compilation and references) and constitute the best direct evidence of the association. Somewhat less direct is the presence of both a grinding stone and a large block of ochre, among other artifacts, with an adult burial at the Horn Shelter in Texas (Redder and Fox 1988). Interesting scenarios to account for the contents of this cache could be constructed, but would be speculative at best.

More circumstantial is the statistical association of ochre and grinding stones in Plains Paleoindian habitation sites. Nearly a century of reporting of such sites has produced a literature of uneven utility for assemblage comparisons. Some reports are so old that the age and significance of the material reported was not yet recognized. Others focus on specific aspects of an assemblage, and it is not known if

Donna C. Roper, Commonwealth Cultural Resources Group, 102 N. Durand Street, Jackson, MI 49202.

other items were present. Still others report investigations which were limited in scope (test excavation or surface inspection only) or were of sites that were subjected to erosion, deflation, or redeposition. Negative data are ambiguous in such cases. If they are eliminated from the data base for comparative purposes, then 19 sites with 23 components remain (Alberta: Sibbable Creek; Colorado: Cattle Guard, Claypool, Jurgens, Lindenmeier, Wilbur Thomas; Nebraska: Allen, Lime Creek, Red Smoke; Texas: Levi, Scharbauer; and Wyoming: Adobe, Agate Basin, Bottleneck Cave, Carter-Kerr McGee, Hanson, Mangus, Sheaman, Sorenson). Of these 23 components, 1 is Clovis, 6 are Folsom, 14 are within the Plano tradition, and 2 contain Paleoindian components not attributable to a specific complex.

Nearly half the components, 10 of 23, yielded both ochre and ground stone. Another seven components yielded neither ochre nor grinding stones. Of the remaining six components, two had ground stone but no ochre and four yielded ochre but no grinding stones. A chi-square test of the independence of the two variables yields a value of 5.32 which, with one degree of freedom, has a probability of 0.02 of occurring by chance. The phi coefficient is 0.48.

The evidence overall suggests a reasonably strong association between grinding stones and red ochre in Paleoindian sites on the Plains. This association, of course, does not demonstrate the use of any individual specimen, nor does it preclude the use of grinding stones for plant processing or for other purposes. It does, however, not only suggest a potential use for such tools, but also indicates both that analysis of the uses of individual specimens is as necessary for ground stone tools as it is for chipped stone tools and that using ground stone tools as evidence for plant processing by Paleoindians requires assumptions that cannot be considered warranted.

Comments by Bradley T. Lepper both prevented an egregious citation error and improved the manuscript, which otherwise remains my responsibility.

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Patterns in Lithic Exploitation and Human Settlement in the Midwestern United States *Kenneth B. Tankersley*

A survey of the petrographic composition of 708 fluted points and 144 sites, located in a variety of physiographic zones and topographic settings in Indiana, Ohio, and Kentucky, was recently conducted to identify patterns in early Paleoindian lithic exploitation and human settlement. The results of this survey suggest that early Paleoindians were extremely selective in their procurement of lithic raw material. Of the identified lithic raw materials, 64% of the fluted points are manufactured from Upper Mercer, Wyandotte, or Hopkinsville chert. If Flint Ridge, Holland, and Ft. Payne cherts are included (high-quality cherts that co-occur with Upper Mercer, Wyandotte, and Hopkinsville cherts), then 82% of the fluted points sampled are manufactured from lithic raw materials that occur in the Upper Mercer, Wyandotte, or Hopkinsville source areas. Each of these raw materials outcrops as large unflawed masses of high quality chert (Tankersley 1989).

The absence of high-quality lithic material, however, did not prevent early Paleoindians from exploiting game-rich environments. Indeed, the curation of fluted points manufactured from high-quality lithic material (Goodyear 1979), and the expedient use of local poor-quality cherts, permitted early Paleoindians to disregard environmental inconsistencies and maintain a high degree of mobility. Curation is supported by two facts: 97% of the fluted points recovered from



Figure 1. A diagramatic illustration of the early Paleoindian settlement pattern of the midwestern United States. Illustration by Rachael Freyman.

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

"nonlocal" settings are composed of high-quality chert; and, the basal width of the complete fluted points sampled is not a function of point length ($r^2 = 0.403$). The expedient use of poor-quality cherts is also supported by two facts: the frequency of poor-quality lithic use is greater in areas where those materials were locally available (13%), than in areas where they are not (3%); and, the frequency of poor-quality lithic use was greater on glaciated landscapes (12%) than it was on unglaciated landscapes (6%). In the study area, high-quality lithic resources are restricted to the unglaciated region.

The early Paleoindian settlement pattern transcends glaciated and unglaciated landscapes. Approximately 40% of the sites sampled occurred on the floodplain or terrace of a major stream or its tributary, 30% occurred in an area adjacent to a marsh, pond, lake, or spring, and 28% occurred on an overview situation such as a bluff top, ridge edge, knob, moraine, esker, or kame. The remaining 2% of the sites sampled occurred on other topographic settings. In other words, sites are concentrated in areas where game resources could have been procured or monitored (Figure 1). The largest sites and the greatest concentrations of fluted points occurred in areas displaying combinations of these topographic features. Areas frequently used by late Paleoindians and early Archaic peoples, such as upland flats or mountainous terrain were largely avoided by early Paleoindians.

Distribution maps of statistically generated fluted point styles, from this sample, demonstrate that the magnitude of early Paleoindian mobility is better correlated with time than it is space. Fluted points, morphologically and metrically identical to the Clovis points of the western United States, were found to transcend all latitudes of the study area and are manufactured from a wide variety of lithic materials located up to 1,000 km from their findspots. Fluted point styles unique to the eastern United States, however, are manufactured from specific lithic raw materials. The distribution of these styles rarely exceeds 250 km. Assuming that non-Clovis fluted point styles developed after the initial peopling of the Midwest, two temporal trends are apparent—decreased mobility and increased stylistic diversity.

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Bone Modification

Burned Bones in Woodrat Nests from Northwestern Nevada

Bryan Scott Hockett

Burned bones excavated from archaeological sites are sometimes seen as adequate evidence for modification by humans. Despite these assertions, noncultural processes may burn bones in areas once occupied by humans. Natural fire igniting woodrat (*Neotoma*) middens and woodrats carrying burned bones to their nests may account for a portion of the burned bones at archaeological sites.

In this study, bones of mammals other than rodent were collected from 42 desert woodrat (*Neotoma lepida*) nests located in northwestern Nevada. Twenty-six nests that contained bones were located on the western side of Pyramid Lake, Nevada, and 16 nests were located approximately 20 km north of Pyramid Lake on the edge of the Smoke Creek Desert, Nevada. No detailed archaeological excavations have been completed in the immediate vicinity of the Pyramid Lake nests, although a small nearby rockshelter probably contains cultural material. A small cave in the area had been completely destroyed by looters. The Smoke Creek Desert nests are located on the same ridge system as Dryden Cave (Basin Research Associates 1986), a small shelter that contained abundant cultural material and several human burials.

The nests were located in ground-level rockshelters and crevices, as well as in shelters and crevices up to 2.5 m above present ground surface. The top 5 cm of each nest were searched with a trowel for bones from taxa other than rodent. Rodent bones were not recovered because their presence in the deposits could have resulted from woodrat transport to their nests, or from death of the rodents themselves in the nests. Care was taken to preserve the stratified middens for later paleoenvironmental research.

Three hundred and ten bones of rabbit (*Lepus* and *Sylvilagus*), artiodactyl (*Antilocapra, Bos,* and *Ovis*), carnivore (*Canis*), and bird (unidentified) were discovered in the 42 nests. Of this total, 102 bones were discovered in the Pyramid Lake nests. Forty-nine of these 102 Pyramid Lake bones are from ungulates (48.0%); 32 bones are from rabbit (31.4%); 6 are from birds, 1 from a carnivore, and 14 were unidentified. In contrast, 174 of the 208 Smoke Creek Desert nest bones are from

Bryan Scott Hockett, Department of Anthropology, University of Nevada-Reno, Reno, NV 89557.

Bone Modification

rabbit (83.6%); 24 bones are from ungulates (11.5%); 5 are from birds, 2 are from carnivores, and 3 were unidentified.

Fourteen burned bones were found in the Pyramid Lake nests. Eight burned bones are from ungulates, 5 are from rabbit, and 1 is from a carnivore. The burned ungulate bones include 3 cylinder fragments of long bones, 2 phalanges, the distal portion of 1 metapodial, the proximal portion of 1 femur, and the distal portion of 1 tibia. The burned rabbit bones include 2 long bone cylinder fragments, 1 radius, the proximal portion of 1 tibia, and 1 innominate that is extensively damaged.

Two of the burned ungulate cylinder fragments and the burned ungulate femur show signs of carnivore gnawing such as pitting, scoring, and furrowing. The distal one-half of one of the burned ungulate phalanges is fractured longitudinally by an undetermined agent. Modification to the burned rabbit innominate suggests that this bone was damaged by raptors (Hockett 1989a).

The bones could have been incorporated into the woodrat nests before they were charred, and then subsequently burned by natural fire. The bones may also have been burned while located outside the woodrat nests by either human or noncultural processes, and then were later incorporated into the nests by woodrats. Both scenarios are plausible. The 14 burned bones were found in 8 separate nests, 6 of which are entered from ground-level or near ground-level. Natural fire can easily affect bones in these middens. The nest that contained the burned rabbit innominate is located in a rock crevice 1.1 m above present ground surface. Because it is a small nest containing little plant matrial, the innominate was not likely burned in situ in the midden, but was probably collected by the woodrat after the bone had been charred elsewhere.

Grayson (1988) suggested that natural fires igniting woodrat middens had burnt bones at Danger Cave. Aikens (1970) noted that unprepared hearths layed on woodrat middens at Hogup Cave could have burnt bones not directly associated with the hearths. A third indirect noncultural process accounting for the presence of burned bones in rockshelters and caves is offered here. Woodrats will carry burned bones into their middens. All the burned bones found in this study are well within a woodrat's carrying range (Hockett 1989b).

The number of burned bones in woodrat middens may be significant, but appears to be extremely variable. No charred bones have yet been collected from the Smoke Creek Desert nests, but 13.7% of the Pyramid Lake midden bones were burned. A charred proximal femur of coyote was observed in an open-air location near the Smoke Creek Desert middens, and may one day be carried to a rockshelter or crevice by the local woodrats. Ongoing studies of woodrat bone collecting behavior will enhance our knowledge of the burned and unburned faunal remains accumulated in woodrat nests and open-air houses.

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Possible Proboscidean Bone Artifact from the Kansas River

Richard A. Rogers and Larry D. Martin

Sandbars on the Kansas River near Bonner Springs in Wyandotte County, Kansas, have produced numerous fossil bones of extinct Pleistocene animals. These same sandbars have also yielded evidence of lce Age humans including numerous Clovis projectile points (Rogers and Martin 1983).

Among the bones collected from the river is a fragment of a proboscidean long bone, probably from a femur, exhibiting features that seem to indicate human workmanship. Although the possible use of bone tools by Paleoindians is much discussed, only a small variety of bone implements have been figured. It seems worthwhile to report this possible example from the Kansas River in hopes of stimulating discussion and comparison with bone implements from other localities.

The bone object (Figure 1) has been broken into at least five pieces (two of which are missing). The maximum length is 26.5 cm, and the base has a restored width of approximately 10.5 cm. The cortical bone has a maximum thickness of about 3 cm. The bone is heavily impregnated with iron, and the depth of impregnation is approximately equal on all surfaces of the bone except the surfaces of modern breakage. Consequently the suspected worked surfaces relate to the time of original burial and are not the result of recent river activity. One end of the bone (hereafter referred to as the butt) is essentially straight, forming a 90° angle to the long axis. This is an unusual shape in naturally broken bones and is not duplicated in several hundred other broken bones from the river, except for segments of ribs which commonly do have straight terminations. One longitudinal edge is intact, and the cortical bone has been largely abraded away. The intact and reconstructed sides are almost parallel for 15.5 cm at which point they converge toward a tip opposite the butt. The interior table of the bone is beveled toward the tip. Over a centimeter of cortical bone has been ground away to establish the bevel. The beveling resulted from grinding against a flat surface at an angle to the shaft of the bone so that a distinct grinding edge is visible. Such a flat surface would not be expected to be created by natural abrasion in a flowing stream. The maximum length of the bevel is 12.1 cm. The beveling could readily be created by a human agency rubbing the bone against an abrasive flat surface. Some of the narrowing of the beveled tip apparently resulted from the removal of flakes followed by grinding. Both the inner and outer surfaces of the tip of the bone object are polished. Longitudinal striations are observable on the outer surface toward the tip end, and the tip has several large impact scars.

Richard A. Rogers and Larry D. Martin, Museum of Natural History, University of Kansas, Lawrence, KS 66045.

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The function of this object is not known. It may be a digging implement. The more pronounced longitudinal striations on the outer cortex of the object are typical of wear on a spade (Semenov 1964). Shaping of the lateral edges to an ovoid tip and trimming of the butt are reported for some bison (*Bison*) scapulae believed to have been used as digging implements ("diggers") at the Leavenworth site (Krause 1972:60). Both these modifications are present on the proboscidean bone object. The "diggers" from the Leavenworth site are thinner than the proboscidean bone object but generally similar in length and width. The shape and thickness of the butt do not suggest that the probscidean bone object was hafted.

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Figure 1. Putative bone artifact from the Kansas River. The top view shows the wear facet, impact scars on the tip and squared end. The middle view shows the beveling from a lateral view and the bottom view is a cross-section through the tip. The anterior-posterior length is 26.5 cm.

Methods

Digitized Sonic Location and Computer Imaging of Rancho La Brea Specimens from the Page Museum Salvage

George T. Jefferson

The semi-articulated fossil vertebrates that were recovered from a unique, thin tabular asphaltic deposit during construction of the George C. Page Museum (GCPM) (Jefferson and Cox 1986) are presently being prepared and studied (Cox and Jefferson 1988; Lamb and Jefferson 1988). Analyses of these remains may provide insight into the formation of the more typical, large, cone-shaped fossil deposits found at Rancho La Brea (Woodard and Marcus 1973; Shaw and Quinn 1986). To help determine the origin of this unusual deposit, comprehensive stratigraphic, sedimentologic and taphonomic data are being recorded as preparation proceeds.

The location of exposed fossils within the sedimentary matrix is measured and recorded using a system similar to that employed in the current excavation of Pit 91, Rancho La Brea (Miller 1971). Relative to a triaxial coordinate system, three previously defined, anatomically distinct points are measured for each osteological element (Shaw 1982). However, for the first time, a sophisticated three-dimensional (3D) sonic digitizer and personal computer (PC) (Figure 1) are being utilized to measure and record precise osteologic orientation and taphonomic data from within this sedimentary matrix.

In 1984, Morlan et al. proposed the use of such equipment to record locational data of archaeological specimens in field excavations. These authors recognized the value of directly capturing provenience and catalog information as each specimen is recovered. The use of grid squares, hand-held levels and scales or rulers is very timc-intensive, and analysis of the data requires subsequent electronic capture of catalog information. Once fully implemented, the GCPM system will reduce the time spent on measuring, cataloging and data capture by 60%.

The sonic digitizer uses sound signals to measure the distance between a point and an array of microphones. Principal hardware elements include a Science Accessories Corporation (SAC) GP-8-3D Sonic Digitizer and Multiplexer Control

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

Unit, which acts as a smart terminal, connected via an RS-232-C port to a compatible PC. An MS-DOS operating system and an 80287 math coprocessor are required. The GCPM system employs an American Telephone and Telegraph 6300+ PC.

The tip of a hand-held stylus (Figure 1), designed by the PixSys company for use with the SAC GP-8-3D, is placed on the point to be measured by the system. Two sonic emitters on the stylus provide the sound signal. These twin emitters, located in-line with, but 25 and 50 cm from the stylus tip, permit the measurement of points sonically hidden from the microphones (offset digitizing). During operation, the emitters produce a continuous stream of 70 KHz impulses, 80 per second (audible as a series of rapid clicks). The signal is detected by four microphones, and the sound travel time to each microphone is captured at the push of a button located on the stylus grip. Microphones are mounted at the corners of a 2.46 m square, plasticcoated tubular steel frame suspended from the laboratory ceiling about 1.5 m above the working surface (large plaster jacket). Slant range distances (= sound travel times) are automatically converted to cartesian coordinates, and calculated to the nearest 0.01 cm for X, Y and Z axes. The axial origin is user-defined. Presently, accuracy within the 15 m³ of active volume is in the range of ±0.5 to 0.6 mm under normal operating conditions. All standard catalog parameters and locational information for each specimen can be directly recorded and are then available for editing and analysis.

Computer-generated 3D images of osteologic specimens recovered from above and/or penetrating through any working/excavation surface can be constructed from the digitized positional data. These can be used to monitor and direct the progress of preparation and exposure of specimens. These images can also be used to identify potential sample locations (e.g., for preserved stomach and/or gut contents). An understanding of the formation of the deposit and the relationships between individual skeletons will be greatly enhanced through imaging the specimens from any view, free of enclosing matrix.



Figure 1. Schematic drawing of sonic digitizer. "A" illustrates the ceiling mount. "B" is a detail of the stylus.

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Oxygen Isotopes as a Method of Determining the Provenience of Silica-Rich Artifacts

Nelson R. Shaffer and Kenneth B. Tankersley

Stable isotope techniques, as pioneered by Craig and Craig (1972), O'Neil and Hay (1973), and Herz and Wenner (1978, 1981), have proven useful in determining the provenience of Old World artifacts. The strength of these techniques lies in the fact only minute quantities, i.e., milligrams, of scarce archaeological materials are needed. Oxygen isotopes are a potentially powerful method of determining the provenience of quartzite and silica-rich artifacts because more than 50% of crystalline quartz is composed of oxygen. Therefore, this technique is less subject to the type of variance that bedevils trace element content analysis.

Oxygen isotopes for certain quartzite sources in eastern North America vary more than 6 parts per mil. These ratios are reproducible at about ± 0.5 per mil for a single rock unit, and the variability between samples is greater than that produced by experimental error, which is considerably less than ± 0.5 per mil. Quartzite ratios are radically different, up to 20 per mil lighter than sedimentary forms of quartz, such as chert.

In order to determine the variability of ratios from individual quarry sites, we conducted 45 isotopic analyses on raw materials and fluted projectile points. The raw materials sampled included Hixton quartzite (Cambrian) and Baraboo quartzite (Proterozoic) from Wisconsin, Munising quartzite (Proterozoic) from southern Ontario, quartzites from glacial deposits of Indiana, Tuscaloosa

Nelson R. Shaffer, Department of Geology, Indiana University, Bloomington, IN 47405.

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

"quartzite" (Cretaceous), and sedimentary Borden chalcedony (Mississippian) from Kentucky. The latter material is frequently mistaken by archaeologists as quartzite (Webb 1951).

Samples for isotopic analyses were collected from prehistoric procurement areas. These areas display petrographic homogeneity within exposures of several hundred meters. Nine untreated Hixton quartzite samples taken from different parts over 1.5 km of outcrop gave a mean of 14.5 per mil and a standard deviation of ± 0.46 . Fluted projectile points manufactured from this raw material gave values of 14.4, 14.6, and 13.6. Heat-altered samples (n = 4) of Hixton quartzite gave a mean of 13.3 and $\sigma = 0.36$ (Figure 1). These data suggest that one of the fluted points manufactured from Hixton quartzite was heat treated to enhance the stone's knapping properties as suggested by Behm and Faulkner (1974).

Six Baraboo quartzite specimens yielded a mean of 12.1 ($\sigma = \pm 0.54$) and the Munising quartzite averaged 10.9 per mil ($\sigma = \pm 0.46$). The mean value for quartzites from glacial deposits (10.53 °/oo) fell near the mean of Munising quartzite, demonstrating that at least some of the glacial material probably derived from Munising sources, but glacial deposits exhibited a significantly higher standard deviation of 1.1. Glacial data also suggest that oxygen isotopes may prove useful for geological provenience studies.



Figure 1. Isotope values of fluted points are clearly related to petrographically determined source areas. Untreated Hixton quartzite can be distinguished from heat-altered material (a).

Tuscaloosa quartzite was not suitable for oxygen isotope analyses because it is actually a silicified arkose containing an inhomogeneous mixture of clasts of variable origins and showed a wide range of values (25.4 to 28.3 $^{\circ}/_{\circ\circ}$).

Borden chalcedony, even though contaminated by carbonate minerals, gave a distinctive heavier 28.28 per mil) value. The contamination problem in sedimentary rocks is easily resolved by an acid pretreatment, but no treatment was necessary for quartzites. Previous studies by Shaffer et al. (1987) indicated that very subtle distinctions among sedimentary quartz-rich rocks can be used to differentiate possible artifact sources even from geographically and geologically similar rocks.

The low variability in isotope ratios from individual metamorphic bodies would, at first, seem surprising especially given existing metamorphic literature. Several factors, however, could lead to the observed homogeneity. The quartzites, especially the Hixton material, are homogeneous and mostly monomineralic with few non-quartz components. Paleoindians selected for homogeneous materials due to their technical needs (Goodyear 1979) and so would most likely have avoided contact zones and other areas where rapidly changing geologic conditions would have imposed mineral and isotope gradients. They quarried relatively small sites. Even if isotope homogeneity may not have occurred over distances of hundreds of kilometers as suggested by Shieh and Schwarcz (1974) it is likely that such homogeneity is known on scales of hundreds of meters (Wada 1988) certainly suitable for artifact tracing.

Oxygen isotope sourcing appears to be a valuable new tool that can be used to trace quartz-rich artifacts to raw material procurement sites. They show some promise as geologic provenience indicators and deserve wider study.

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Paleoenvironments: Plants

The Mid- and Late-Wisconsin Pollen Stratigraphy of Potato Lake, Coconino County, Arizona

R. Scott Anderson, Susan Smith, David Rothstein, Lyndon Murray, Elizabeth Hadly, Chris Force, and Steven Diveley-White

Continuous pollen records with adequate chronological control, spanning the period from the present back into the mid-Wisconsin interval, are uncommon in the American Southwest (Wright et al. 1973; Fine-Jacobs 1985a; Hevly 1985). This is because lakes are rare and localized in this arid environment, and many lakes apparently dried completely sometime during the Holocene, destroying portions of the record. One lake that contains an excellent record stretching back into the Pleistocene is Potato Lake at 2,222 m elevation on the Mogollon Rim in Coconino County, Arizona (Whiteside 1965a). We recored Potato Lake a) to analyze sediments older than in Whiteside's original study, b) to utilize new techniques for separating pollen of *Pinus* to species or species-groups (Fine-Jacobs 1985b), and c) to see if ponderosa pine (*P. ponderosa*) dominated the forests on the Mogollon Rim during the mid-Wisconsin interstadial warm period, as it does during the present interglacial.

A bottom radiocarbon date for the new 9.5 m core shows that the Potato Lake record extends back to 34,850 ±950 yr B.P. Because of a date reversal (Figure 1), age projections for the early late-Wisconsin interval are considered estimates. A least squares regression was fitted for this portion of the core.

Three pollen zones are recognized. In the mid-Wisconsin Zone I interval (core bottom to 600 cm depth; to ca. 23,500 yr B.P.), dominant pollen types are spruce (*Picea*), fir (*Abies*), large haploxylon pine (not pinyon, *Pinus edulis*-type), juniper (*Juniperus*), oak (*Quercus*), sagebrush (*Artemisia*), other Compositae and grasses (Gramineae) (Figure 1). Diploxylon pine pollen (either ponderosa or lodgepole pine, *Pinus contorta*) is conspicuously absent. This assemblage suggests an open spruce-mixed conifer forest, with an understory of sagebrush, grasses and composites. Pinyon pine, juniper and oak may have expanded at lower elevations

R. Scott Anderson, Susan Smith, David Rothstein, Lyndon Murray, Elizabeth Hadly, Chris Force, and Steven Diveley-White, Quaternary Studies Program, and Bilby Research Center, Box 6013, Northern Arizona University, Flagstaff, AZ 86011.



Figure 1. Summary pollen diagram from Potato Lake, Coconino County, Arizona. All pollen types are in the pollen sum. The upper ¹⁴C date (14,400 ±300 yr B.P.) is from Whiteside (1965a).

over that occupied today. *Pediastrum coenobia* (algae) are rare, but *Botryococcus* (algae) colonies are abundant (not shown). Utilizing the interpretation of Whiteside (1965b), lake levels higher than today but lower than the late-Wisconsin are indicated.

Zone II (600–100 cm) includes the late-Wisconsin, dated to begin here by ca. 23,500 yr B.P. Dominant pollen types are spruce, fir, large haploxylon pine, sagebrush, pinyon pine and Chenopodiaceae-Amaranthus. Somewhat lowered percentages of pinyon pine, other haploxylon pine and juniper occur until 470 cm depth (ca. 20,400 yr B.P.), but increase thereafter, suggesting a further expansion of these types. The aquatic record (not shown) indicates that water levels were highest during this period, with highest percentages of *Pediastrum* and lowest of *Botryococcus*, sedges (Cyperaceae) and other marsh and aquatic herbs. By about 14,000 yr B.P., pollen changes suggest a vegetation in major transition to the Holocene.

Zone III begins by ca. 100 cm. During this Holocene interval pollen of boreal conifers (spruce, fir, haploxylon pine), as well as pinyon pine and sagebrush, is very much diminished. Instead, dominant pollen types are diploxylon (probably ponderosa) pine, oak, grasses and other composites. Higher percentages of *Potamogeton* (pondweed), Cyperaceae and other wetland plants (not shown; Whiteside 1965a) indicate much lowered lake levels. Sediment accumulation rates drop considerably; the sampling interval for this section of the core is too coarse to permit subdivision of the zone.

Although complete plant macrofossil assemblages have not been analyzed to date from this core, permitting more specific identification of several important pollen types, we can provide tentative interpretations of vegetation change. Spruce, which occurs today at elevations higher than Potato Lake, appears to have been the dominant tree throughout most of the Wisconsin. The mid-Wisconsin was neither warm enough nor wet enough in the summer to allow the establishment of significant populations of ponderosa pine on or near the Mogollon Rim at this elevation. In the biseasonal precipitation regime of today, ponderosa pine dominates elevations of ca. 2,200 to 2,500 m and above in much of northern Arizona. Its location during the Pleistocene remains a mystery, although it may have grown near Dead Man Lake in northwest New Mexico (Wright et al. 1973).

During the pleniglacial, pinyon-juniper woodlands expanded at lower elevations, while sagebrush was found in forest openings, probably at a variety of elevations. The timing of pinyon pine expansion is different at Potato Lake than at Hay Lake (Fine-Jacobs 1985a) farther to the east and ca. 600 m higher in elevation. Maximum pinyon percentages occur during the mid-Wisconsin interval at Hay Lake and during the late-Wisconsin at Potato Lake. This may be a function of more open forest conditions at Hay Lake than Potato Lake during the mid-Wisconsin, and consequent greater deposition of pollen transported from lower elevations. Warming conditions began to prevail beginning ca. 14,000 to 15,000 yr B.P. with the decline of all boreal elements and the establishment of plants typical of the modern ponderosa pine forest.

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Fungi as Indicators of Past Environments

Jane M. Beiswenger and Martha Christensen

Fungal ecologists have shown that the A horizons of soils harbor assemblages of microfungi that are specific to the surface vegetation (Christensen 1981). Our data suggest that, in addition, some species of fungi are able to persist within a soil long after the environmental conditions have changed.

We compared the species composition and cold adaptation of microfungi from soils of the Laramie Basin in southeastern Wyoming and soils of the Pawnee Grassland in northeastern Colorado. The present-day vegetation at both sites is an arid, shortgrass community dominated by *Bouteloua gracilis* (blue gramma grass), and the physical and chemical characteristics of the soils are similar. The Laramie Basin, however, is within a periglacial zone that Mears (1981) has documented for Pleistocene time. We hypothesized that some of the fungi in the Laramie Basin soils would be interpretable as relics from this former, periglacial environment.

Figure 1, an ordination based on coefficients of similarity for the 30 most prevalent microfungal species (Christensen 1981), shows the relationship of these two sites to well-defined tundra and desert sites. The Laramie Basin soils contain fungi that are present in the tundra communities. In contrast, the Pawnee Grassland mycoflora is compositionally intermediate, with a desert component not seen in the Laramie Basin mycoflora. *Chrysosporium pannorum* and *Cylindrocarpon destructans*, common in contemporary alpine and polar tundras, accounted for 48% of all isolates in the Laramie Basin, but were not present in our samples from the Pawnee Grassland. Other fungi common to alpine tundra and Laramie Basin soils include: *Aphanocladium alpinum, Mortierella alpina, Trichoderma* sp., and *Trichocladium* sp. Results from this comparison suggest that *Chrysosporium, Cylindrocarpon*, and certain species of *Mortierella, Fusarium*, and *Embellisia* are indicators of periglacial conditions.

Isolates of *Gliomastix murorum* and *Mortierella alpina* from the Laramie Basin subsurface (1 m deep) show adaptations to lower temperatures than do subsurface

Jane M. Beiswenger and Martha Christensen, Department of Botany, University of Wyoming, Laramie, WY 82071-3165.



Figure 1. First, second, and third axes of an ordination constructed using percent similarities among different fungal communities (based on Mosca 1960; Ranzoni 1968; Scarborough 1970; Bissett and Parkinson 1979; Christensen 1981). AT = Alpine Tundra.

isolates from the Pawnee Grassland, indicating ecotypic differentiation. Additional growth rate studies demonstrated that 40% of the Pawnee isolates, but none of the Laramie forms, grew at 37° C. At 15° C the average diameter of the Laramie isolates was 68% of that at 25° C, while the average diameter of the Pawnee fungi at 15° C was only 31% of that at 25° C. Nine of the Laramie Basin isolates grew at 10° C and 3 showed optimum growth below 25° C. In contrast, only 2 of the Pawnee isolates grew appreciably at 10° C and none showed optimum growth under 25° C.

In conclusion, fungi appear to be useful indicators of past environments. Species composition and cold adaptation in the present-day soil microfungi indicate that a tundra community occupied the Laramie Basin during the Pleistocene glaciation.

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A Preliminary Investigation of Green Algae in Reservoir Lakes Bog 2 Core, Northeastern Minnesota

James K. Huber

Preliminary investigations of green algae from a bog core in the Cloquet River watershed of northeastern Minnesota have been undertaken as part of a multidisciplinary research effort aimed at understanding the late Pleistocene and early Holocene paleoenvironments of the region. Previous palynological investigations of the Reservoir Lakes Bog 2 core indicate vegetational changes beginning with a shrub tundra to a mixed conifer-hardwood forest (Huber and Hill 1987).

The 5-meter core was extracted from Bog 2 south of Island Lake (a large reservoir that inundated the locality). Two radiocarbon dates of $9,270 \pm 190$ yr B.P. (UCR-1825) and $9,420 \pm 180$ yr B.P. (UCR-1826) were obtained for the 350 to 355 and 350 to 364 cm intervals, respectively. These dates suggest that the basal sediments are probably related to outwash from the Automba glaciation of northeastern Minnesota, which ended before 13,500 yr B.P. (Matsch and Schneider 1986).

In the early stages of lake development, dominant green algae are *Botryococcus*, *Pediastrum boryanum*, and *P. simplex* (Zone 1, Figure 1). Zone 2 is characterized by the appearance of additional taxa and a major increase in the abundance of *Scenedesmus*, an indicator of high nutrient concentration (Cronberg 1982). *Scenedesmus* then decreases at the beginning of Zone 3. An increase and subsequent decrease in *Scenedesmus* in the early stages of lake development have been documented for Big Rice Lake (Huber 1988) and August Lake (Liukkonen and Huber 1988), both in Minnesota. The increase and subsequent decrease of *Scenedesmus* may indicate that some lakes in Minnesota underwent a more eutrophic stage early in their development but became more oligotrophic with time. Fredskild

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

(1973) found a similar sequence of development in several lakes and bogs in Greenland, based on the distribution of *Pediastrum*.

Continuing efforts to understand the algae assemblages associated with pollen records should provide another useful tool for interpreting past lacustrine conditions.





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A Holocene Pollen and Plant Macrofossil Record From the Upper Mississippi Valley

Brenda K. Nations, Richard G. Baker, and E. Arthur Bettis III

A core from Klum Lake, an abandoned Mississippi River channel in southeastern Iowa, contains a pollen and plant macrofossil record that spans the last 10,300 years. The pollen sequence is similar to that of other sites in the Midwest, suggesting that regional vegetational changes are recorded at this site. Plant macrofossils provide a record of local vegetation and permit assessment of local pollen production.

The pollen diagram from the site is divided into three zones (Figure 1). Zone 1 dates from 10,300 to 7,290 yr B.P. and corresponds to the early Holocene oak-elm zone documented throughout the upper Midwest (Van Zant 1979; Webb et al. 1983). Oak (*Quercus*) and elm (*Ulmus*) pollen percentages are dominant, and hickory (*Carya*) is also common. Elm declines dramatically at the top of this zone and disappears in Zone 2. Grass (Gramineae) and chenopod (Chenopodiineae) percentages rise concurrently with the elm decrease. Macrofossils from this zone are dominantly aquatic and semi-aquatic taxa that, along with ostracods, fish scales, and molluscs, indicate the presence of a permanent lake.

In Zone 2, dated between 7,290 and 2,560 yr B.P., arboreal pollen percentages decline to less than 10% with an accompanying rise in pollen of grass, chenopod, and composites (Figure 1). This zone reflects the spread of prairie into eastern Iowa during the Hypsithermal.



Figure 1. Pollen percentage diagram of Klum Lake, Iowa.

Brenda K. Nations and E. Arthur Bettis III, Iowa Department of Natural Resources-Geological Survey Bureau, 123 N. Capitol St., Iowa City, IA 52242.

Richard G. Baker, Geology and Botany Departments, University of Iowa, Iowa City, IA 52242.

A dramatic increase in ragweed (*Ambrosia*) and a decrease of grass and chenopod pollen occurs in Zone 3. Arboreal pollen percentages increase, with oak and willow (*Salix*) being the most abundant tree taxa. Zone 3 represents the well-documented late Holocene increase in oak forest in the upper Midwest. The ragweed peak at the top of this zone marks Euroamerican settlement, in this area about 1840 A.D. (Baker et al. 1987). Macrofossils of aquatic and semi-aquatic plants decrease in zones 2 and 3; other aquatic indicators such as fish scales, molluscs, and ostracods are absent, and disturbed ground taxa become dominant. These changes indicate shallowing of the wetland and a decrease in open water.

Detailed pollen and plant macrofossil assemblages are also available from other wetlands in the Mississippi Valley (King and Allen 1977; Guccione et al. 1988; Royall et al. 1988). These records, and others from sites not yet investigated, should prove to be very useful for understanding relationships between environmental and cultural change, as well as providing information pertaining to prehistoric plant resources available in the riverine environment.

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Paleoenvironments: Invertebrates

An Oyster-Bearing Locality from the Wicomico Terrace in South Carolina

David R. Lawrence

In southeastern United States, Quaternary studies have led to the recognition of various Lower Coastal Plain surfaces or terraces reflecting past stands of the sea (Cooke 1936). To these features Colquhoun (1981) applied the notions of Stephenson (1928) that Coastal Plain units may be cyclic in nature and that terraces may reflect both marine and continental sequences developed during submergence and emergence. Using this viewpoint, Colquhoun (1981) recognized four Lower Coastal Plain "morphostratigraphic" units as Terrace-Formations in South Carolina (from youngest to oldest, with typical landward edge elevations): the Silver Bluff (3 m), Princess Anne (5 m), Talbot (12 m), and Wicomico (33 m). In each, marine/ estuarine parts of the sequence typically include back barrier and salt marsh sediments which are primarily clays, silts, and clayey sands, are commonly cut by channels, and may contain shells of the American oyster *Crassostrea virginica* (Gmelin) (Hoyt 1972; Colquhoun 1981).

The uppermost and oldest Wicomico is considered to be Yarmouthian or Aftonian in age (Colquhoun et al. 1968). Outcrop studies and extensive auger drilling have shown that macroinvertebrate fossils are rarely preserved and observed in this unit (D.J. Colquhoun, pers. comm. 1988). Here I record a new (and the only presently accessible) oyster-yielding surface exposure of the Wicomico from this region.

The locality, first discovered in 1985, is 1.2 km N25E of Kennedy Crossroads, Florence County, South Carolina (NW quarter of SE quarter, U.S. Geological Survey Florence East 1:62,500 Quadrangle, 1940; U.T.M. Easting 677,750, Northing 3,772,900). It originally occurred in wooded terrain along a small tributary to Jeffries Creek where erosion, overhung gully edges, and slumping led to discontinuous exposures of in situ strata, extending over 15 m along drainage. Repeated altimeter readings established an elevation of 25 m (within 1 m) for the top of the oyster bed described below. During the late winter of 1986 the area was cut clear for its hardwood trees, with extensive alteration of topography. By late 1988 tributary drainage had been re-established, and gullying was proceeding. The original locality is 16 m N40E of a large (American beech) tree (rectangular tag 2 m

David R. Lawrence, Department of Geological Sciences, University of South Carolina, Columbia, SC 29208.

above ground on N side) left standing during timbering. The in situ strata can be exposed with a shovel.

Here largely grayed oyster remains form a nearly intact framework in the basal 6 cm of a blocky claystone (52 cm of bed observed). Disarticulate and entire valves of *C. virginica* (large for the species; up to 14.8 cm in height) do occur but fragmented valves and broken lamellae are most numerous. Oyster planes of commissure are mainly horizontal, and upward and downward convex valves occur in subequal numbers. The main of the valves display the relative massiveness, ovate outlines, small attachment areas on left valves, and cupping which characterize living subtidal oysters in the southeastern United States today (Lawrence 1988). Traces of boring clionid sponges (trace fossil genus *Entobia*) are present on nearly all larger valves and fragments, and they commonly penetrate the internal valve surface, where juvenile oyster left valves are also preserved.

Following Lawrence (1975) the oyster concentration indicates that original life sites were very close to the exposure. Epibionts (e.g., *Entobia*) indicate that the valves were exposed at the surface, after the oysters' death, for some significant period of time. The preserved bed is here interpreted as part of an original and migrating back-barrier channel complex, but lying outside the region of most confined channel water flow. In that setting, the oyster debris was concentrated as lag deposits during storms, with the enclosing sediment matrix ultimately derived from channel margin environments and accumulating between the times of storms. In the original exposures, the oyster-bearing claystone was bounded laterally and upward by silty sands with a scoured base, indicating nearby channeling. The size and massiveness of these Wicomico oysters (and ongoing archaeological studies) add support to the proposal (Sohl and Kauffman 1964) that the living species *C. virginica* is a member of a lineage characterized by the loss of shell massiveness, and decreases in size, over the past 20 to 40 million years.

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Paleoenvironments: Vertebrates

An Initial Reappraisal of San Josecito Cave and Its Late Pleistocene Fauna

Joaquín Arroyo-Cabrales, Eileen Johnson, and Ronald W. Ralph

San Josecito Cave (Stock 1943; Kurtén and Anderson 1980) is a paleontological locality that has demonstrated a great potential for a detailed late Pleistocene record. The cave is located on the eastern flank of the Sierra Madre Oriental (elevation ca. 2,350 m) in southern Nuevo León, México, at the eastern edge of the Mexican Plateau. The cave is a multidrop fissure that occurs in folded late Jurassic limestone. Between 1936 and 1941, personnel of the California Institute of Technology, directed by Dr. Chester Stock, quarried the uppermost chamber and recovered a rich vertebrate fossil fauna (Stock 1943).

The San Josecito Cave fossil fauna includes 1 species of amphibian, 2 species of iguanid lizards, 2 species of snakes, more than 43 species of birds, and more than 45 species of mammals, as well as some mollusc shells (Jakway 1958; Kurtén and Anderson 1980; personal observations). Among the vertebrate taxa are at least 23 extinct species, 12 of which are described based on fossil specimens from this cave. Although the fauna may be from different points in time throughout the late Pleistocene (Kurtén and Anderson 1980), it has been viewed as a single temporal entity. Prior analyses have not been done stratigraphically and radiocarbon dates are not available. Taxonomic studies of particular taxa form the primary research base with the assemblage.

During our August 1988 reconnoiter of the cave, a sketch map was made that shows an upper room (ca. 25 by 11 m) lit by three skylights, two of them 30 m above the floor, and another large upper opening (southeast of the room) that probably served as a trap for the fauna. An access tunnel descends 41° from the east to a 7 m drop or very steep climb down to the floor of the main room. Backdirt from the earlier paleontological excavation is stacked or piled behind dry-laid rock walls on most of the main room floor with some spilling south into a non-climbable pit that leads down to an unexplored passage. From Stock's correspondence, that passage

Joaquín Arroyo-Cabrales, Museum of Texas Tech University, Lubbock, TX 79409 and Departamento de Prehistoria, Instituto Nacional de Antropología e Historia, Moneda 16, Col. Centro, 06060 México, D.F. México.

Eileen Johnson, Museum of Texas Tech University, Lubbock, Texas 79409.

Ronald W. Ralph, Texas Parks and Wildife Department, Austin, TX 78744.

was said to be excavated by the local people looking for a "treasure" prior to the paleontological excavations. Additional entrances may connect with this lower room and other bone deposits.

From a review of the available documentation referring to Stock's excavations, it appears that the cave was divided in five north-to-south blocks. In each block, workers shovel-excavated in "5 ft" levels, removing all the sediments from the upper levels. At the "65 ft-level," a test pit was excavated in the southern portion of the chamber where Stock's crew had encountered the heaviest bone deposit. The crew excavated a 2 by 2 m unit, 4.5 m deep, and a smaller 1.75 by 1.35 by 1.7 m deep unit adjacent (east) and contiguous to the large unit. Our sidewall cleaning of the deep pit during the reconnoiter indicates well-stratified deposits with large quantities of small bones throughout the 4.5 m exposure.

An initial study of the fossil remains at the Natural History Museum of Los Angeles County has yielded the first clues to the kinds of excavation data that are associated with the bones. Bones were boxed up in the cave, for shipment to California, by excavation block number and depth and the provenience data indicated by a slip of paper in the box. Today, only a small percentage of the bones have provenience data and those are recorded directly on them. Extensive field photodocuments indicate rigging and scaffolding techniques, excavation technique, preservation problems, the disarticulated and jumbled nature of the bones, the relationship of the excavation blocks to the main entrance being used by Stock's crew, and the relationship of different excavation floors to the original cave floor. Some taphonomic data such as rodent and carnivore gnawing, manganese staining, and strong weathering also were recorded during the first examination of the bones.

Stock's excavation and the collection data reanalysis constitute the foundation of the next step of our study, that is, the renewed, stratigraphically controlled excavations of San Josecito Cave. The objective of the new excavations is to recover high-resolution data, both stratigraphically and taphonomically, that will contribute to the paleoenvironmental reconstruction of the ecosystem(s) preserved in San Josecito Cave.

The San Josecito Cave fauna is a building block towards a regional understanding of late Pleistocene paleoenvironments, climate, and faunal communities on the Mexican Plateau and the Southern Plains. Once San Josecito Cave is better understood, it can be compared with other approximately contemporaneous sites on the Mexican Plateau (e.g., El Cedral, San Luis Potosí; Lorenzo 1986) and in the southernmost part of the Southern Plains to form a more detailed paleoecologic framework for that part of the region. The research project is a joint venture between U.S. and Mexican researchers.

Support for this project has been provided by the following institutions: American Museum of Natural History (Theodore Roosevelt Memorial Fund); Natural History Museum of Los Angeles County; Departamento de Prehistoria, Instituto Nacional de Antropología e Historia, México; and the Graduate School and the Museum of Texas Tech University. The senior author also greatly appreciates the continuous support of CONACYT (49479). This project is part of the ongoing Lubbock Lake investigations into Quaternary cultural and ecological changes on the Southern Plains.

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Late Pleistocene Small Cricetids in the Central Mojave Desert, California

H. Thomas Goodwin

Thousands of microvertebrate specimens were recovered from the Solid Waste site (San Bernardino County Museum Locality No. 1.76.33; Reynolds and Reynolds 1985), located in the Mojave Desert near Daggett, San Bernardino County, California. Most specimens were associated with a charcoal date of $12,210 \pm 430$ yr B.P. (GK-10420). The low elevation of the site (593 m) is significant; there are few late Pleistocene microvertebrate localities in the desert Southwest below 750 m in elevation.

I examined lower jaws (n = 18) of small cricetid rodents (Cricetidae) from Solid Waste. Measurement comparisons were made with eight extant species (Figure 1), five of which now occur at low elevations in the Mojave Desert—*Reithrodontomys megalotis* (western harvest mouse), *Peromyscus crinitus* (canyon mouse), *Peromyscus eremicus* (cactus mouse), *Peromyscus maniculatus* (deer mouse), and *Onychomys torridus* (southern grasshopper mouse). Three additional species—*Peromyscus californicus* (California mouse), *Peromyscus boylii* (brush mouse), and *Peromyscus truei* (pinyon mouse)—occur in adjacent highlands and might have colonized lower elevations in the late Pleistocene.

Measurement data reveal two size classes of fossil specimens, as shown in Figure 1. Small specimens (n = 9) probably represent *R. megalotis*, a widespread species which occurs today in the Mojave Desert but which typically inhabits more mesic habitats (Webster and Jones 1982). Sedimentological evidence from Solid Waste indicates marshy habitat (Reynolds and Reynolds 1985) probably suitable for *R. megalotis*. Larger specimens (n = 9) cluster around *P. eremicus*, but *P. maniculatus* cannot be excluded with available evidence. Accessory cuspules between major cusps of M1 generally distinguish *P. maniculatus* from *P. eremicus* (Ingles 1965), but fossil M1s available to me are too worn or damaged to preserve this character. All fossil specimens are too small to represent any of the three extralimitals considered here.

The cricetid record from Solid Waste suggests that species now extant in the central Mojave Desert occurred in the region during the late Pleistocene; extralimitals from adjacent highlands evidently did not invade these low-elevation habitats. This contrasts with the record of sciurid rodents from Solid Waste (Goodwin and Reynolds 1989) which documents the absence of the desert-adapted

H. Thomas Goodwin, Museum of Natural History, University of Kansas, Lawrence, KS 66045.

ground squirrel subgenus *Spermophilus* (*Xerospermophilus*) and the dominance of the extralimital *Spermophilus townsendii* (Townsend's ground squirrel), now found in the Great Basin. These differing responses may reflect differences in vagility or adaptability between these two groups; faunal response to late Pleistocene climatic conditions in the central Mojave Desert was evidently complex.

R.E. Reynolds made this material available for study. L.D. Martin and J.A. McCallister reviewed the manuscript.

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Figure 1. Bivariate plot of alveolar length versus length of m3 for fossil specimens (darkened boxes; 8 of 18 fossil specimens preserve both measurements) and sample means of eight extant species (open boxes; n is given for each species). Bars represent 95% confidence intervals for sample means.

Mammoth and Mastodon Socioecology

Gary Haynes

The frequent grouping of mammoths (*Mammuthus*) and the solitary nature of many mastodons (*Mammut*) in death assemblages possibly reflect social behavior when the animals were alive. The age and sex ratios of mammoth death samples often resemble the expectable inferred ratios of live populations, determined by modeling *Mammuthus* social behavior along the lines of the social behavior of living elephant (*Loxodonta* and *Elephas*) populations. Mastodons probably formed few lasting associations with each other, but may have had nonexclusive home ranges.

Sexual dimorphism in modern elephants is dramatic, with adult males weighing nearly twice as much as same-age females and standing up to 40% taller (or more). Femora and humeri in males may measure 17-25% longer in males than in sameage females. Femora and humeri of north Asian woolly mammoth (Mammuthus primigenius) show length differences of 14 to 20%, presumably reflecting sexual dimorphism on the same order as in Loxodonta. Measurable samples of American Mammuthus and Mammut limb bones exhibit similar degrees of differences, reflecting the evolutionary result of intense sexual selection for larger male size and armament. Males would have had greater mortality than females, and died younger as a result of confrontational disputes or physiological stresses resulting from elevated adrenal or gonadal functions during breeding episodes. Mammoths and mastodons would have been "polygynous" breeders, but males did not keep harems or defend females as property. Males would have lived apart from mixed herds and the majority of other males. Males continued body growth longer than females (clearly seen where male and female schedules of skeletal maturation are calibrated against tooth progression and wear). If these predictions hold true, then few massbone assemblages of Mammuthus or Mammut will contain similar proportions of males and females, unless the animals were under 12 to 15 years of age (the average age of sexual maturity), since the sexes were segregated in life and only occasionally shared feeding ranges.

Comparative measurements of *Loxodonta* and *Mammuthus* skeletons indicate that fully grown wild African elephants (male and female) are often taller at the shoulder than fully grown mammoths (either columbian or woolly); even very large mammoths such as those found at the Hot Springs site in South Dakota were not taller than the largest *Loxodonta* individuals on record. If we refer to the theory of allometric scaling (in which body size is scaled against life-history parameters), and compare data from animals of the same sex and age, we find that mammoths, mastodons, and modern elephants are predicted to have had similar biological characteristics, including length of gestation period, age at first reproduction, birth rate, and life span.

However, the extinct taxa had much more massive bone elements in their skeletons than do modern elephants, so their body weights might have exceeded weights of modern elephants having similar or even much greater body stature. This factor complicates the use of the theoretical tool allometric scaling to "predict" lifehistory parameters for extinct mammoths and mastodons. A valid scaling exercise

Gary Haynes, Department of Anthropology, University of Nevada-Reno, Reno, NV 89557.

requires comparison of data from large samples of *Loxodonta, Mammut*, and *Mammuthus*, using animals of the same sex and growth stage. A proper study would factor out size differences resulting from sexual dimorphism, Bergman's Response, and growth rates during different life intervals.

It has recently been suggested that because bones of mammoths and mastodons were much more massive than those of modern elephants, reproductive rates of the extinct taxa must have been much lower and excessively long, resulting in relatively more vulnerability to pressures such as human hunting or environmental change. Lower reproductive rates might therefore account for extinction of mammoths and mastodons. This suggestion possibly results from biased sampling of modern elephant and mammoth bones. If only the largest mammoths (such as found at Hot Springs, South Dakota) are measured and then compared to the relatively small and young *Loxodonta* shot in east African culls, then of course life-history parameters will be predicted to differ greatly for the two taxa. To be valid, data from the large mammoths of Hot Springs must be compared with data from large *Loxodonta*. My own comparative studies indicate that mammoth reproductive rates might have been 1 to 3% lower (per year) than *Loxodonta* rates, and that gestation periods were not excessively longer in mammoths.

Fossil mammoth and mastodon assemblages that contain bones of several individuals and that represent restricted time intervals (that is, that are not extensively time-averaged), exhibit four different types of age profiles, similar to the age profiles seen in bone assemblages of recent *Loxodonta*. In type A, subadults predominate but all age classes are represented by progressively decreasing proportions. This profile is created by either time-averaged or abrupt but nonselective death events. In Type B, subadults also predominate, but mature animals are conspicuously missing. This profile is created by short-term and selective death processes such as starvation or drought. In type C, subadults are rare, and prime-age adults predominate. This profile results from time-averaged selective mortality, especially human hunting for ivory but not meat. In type D, either the sample size is too small to produce clear patterning in age-class representation, or the shape of the graph is not similar to the other three types.

In North America, large mass assemblages of mammoths are usually type B when chipped stone artifacts are present, or type C when clearly recognizable stone artifacts are not present. In Eurasia, mass mammoth sites are usually type A or B, although so little is known about the age profiles of large assemblages that type C sites might also exist. No mass-mastodon sites seem to be type A or B; all of the few known mass occurrences are type C.

It appears that type C assemblages are often male-dominated, while type A or B are female- and young-dominated. Just prior to the time interval when extinction occurred, many mass assemblages were dominated by subadults (type B).

Mousterian Bison Hunters of the Northern Caucasus: Analysis of Faunal Remains from Il'Skaya I

John F. Hoffecker, G.F. Baryshnikov, and O.R. Potapova

A fresh examination of vertebrate faunal remains recovered from II'skaya I has produced a wealth of new data on this Mousterian open-air site, located in the foothills of the Caucasus on the southern margin of the Russian Plain. Steppe bison (*Bison priscus*) predominates heavily among the mammalian remains, although a variety of other vertebrates are present, including several previously unreported taxa. Some preliminary results of our study are reported below.

Il'skaya I is located at the northern edge of the Caucasus foothills, on the left bank of the Il'River (a left-bank tributary of the Kuban'), approximately 30 km southwest of Krasnodar. It was originally discovered in 1898 by the French archaeologist J. de Baye, and excavated in 1926 and 1928 (ca. 250 m²) by S.N. Zamyatnin (1929, 1934), in 1936–1937 (ca. 370 m²) by V.A. Gorodtsov (1940, 1941), and in 1963 and 1967–1969 (ca. 100 m²) by N.D. Praslov (Praslov 1964; Praslov and Muratov 1970). In 1979, another site (Il'skaya II) was discovered 150 m east of Il'skaya I (Shchelinskij 1985).

The archaeological remains at Il'skaya I are contained in colluvial loam overlying alluvium of the third (?) terrace. The main occupation level occurs at a depth of 5 m in a thick buried soil. Praslov (Praslov and Muratov 1970) has identified 11 upper occupation horizons in the overlying loam; the uppermost horizon is associated with a second palaeosol at a depth of 1.7 m. Above this lies a younger palaeosol and a well-developed modern soil layer. Portions of the sediment containing the artifacts and faunal debris have been saturated with oil from natural seeps, sometimes preserving plant and insect remains (Vereshchagin 1959).

The age of the site is problematic. Both the alluvium of the third terrace and the lower buried soil are thought to date to the last interglacial (Praslov and Muratov 1970; Praslov, pers. comm.). However, the main occupation horizon may post-date the formation of this soil; in any case, the upper occupation levels appear to be of early glacial age (oxygen-isotope stages 5a–5d and possibly 4?). Ongoing research at II'skaya II will probably shed additional light on stratigraphy and chronology; we plan to retrieve samples for TL dating during 1989.

Several thousand artifacts have been recovered from II'skaya I, but missing and unpublished data make it difficult to provide a precise estimate. Dolomite, chert, and quartzite predominate among raw materials. Although a systematic and comprehensive description of the assemblages is not available, our examination of Zamyatnin's 1928 collection (2,541 artifacts) indicates that the cores are typically discoid (radial or sub-radial) or polyfaceted (multi-directional), and Levallois technology rare. Small and medium chert pebbles were often used for cores and

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

G.F. Baryshnikov and O.R. Potapova, Zoological Institute, USSR Academy of Sciences, 199034 Leningrad, USSR.

tool blanks. Among retouched items (ca. 500), side-scrapers (simple straight, simple convex, double straight, canted, and others) predominate heavily; points and bifaces are rare. The 1928 collection appears to be derived mostly, if not wholly, from the main (i.e., lowermost) occupation level; some technological and typological differences have been noted between the latter and the younger artifacts (Anisyutkin 1968; Dmitrieva 1986).

Our analysis of faunal remains from the site was confined to the collections from 1926–1928 and 1936–1937 (stored at the Zoological Institute, USSR Academy of Sciences). Although these samples are not subdivided by occupation level, they are mostly derived from the main occupation horizon; faunal remains from the upper levels are reportedly rare (Gorodtsov 1941; Praslov and Muratov 1970). The samples have undoubtedly been biased against smaller bones and fragments by the lack of sediment-sieving during excavation. Loss of material has also occurred during storage, especially for certain taxa (e.g., mammoth).

The following mammalian species were identified (number of bones and teeth/ minimum number of individuals): Lepus europaeus (brown hare) (4/1), Canis lupus (wolf) (15/3), Cuon alpinus caucasicus (Caucasian dhole) (1/1), Spelearctos spelaeus (cave bear) (3/1), Crocuta spelaea (cave hyaena) (12/3), Mammuthus cf. chosaricus (mammoth) (7/2), Equus (Hydruntinus) hydruntinus (wild ass) (6/2), Equus (Equus) cf. mosbachensis (horse) (21/2), Megaloceros giganteus (giant deer) (25/3), Cervus elaphus (red deer) (16/2), Bison priscus (1,334/58), and Saiga tatarica (saiga) (2/1). It should be noted that this list differs in many respects from those previously published for II'skaya I (e.g., Gromova 1937; Vereshchagin 1959). Furthermore, the following remains of birds (previously unreported) were identified: Anas platyrhynchos (mallard, (1/1), Aegypius monachus (black vulture) (2/1), Pica pica (magpie) (2/1), and Aves indet. (12/?).

Although most bones exhibit some surficial cracking and exfoliation, those exposed to oil seepage are often less weathered. With respect to breakage patterns, most bones exhibit sawtooth, spiral, or V-shaped fractures, and thus appear to have been broken when fresh. There is little evidence of gnaw-marks or stone tool cutmarks, although this may be at least partly a function of weathering. The size and breakage characteristics of many of the bird bones do not suggest consumption by carnivores or other birds.

Steppe bison, which accounts for 92% of the identified mammalian remains in our sample, was the prime focus of the study. Although lack of cranial remains precluded subspecific classification, comparative measurements of the astragalus indicate that the II'skaya bison were smaller than *Bison priscus* from the central Russian Plain and Siberia. Virtually all skeletal parts are represented, but isolated teeth are especially abundant (approximately 40% of the total). Mandible fragments (81), distal tibiae (54), and distal scapulae (29) are also relatively common. Poorly represented skeletal parts include rib fragments (3), proximal humera (1), and proximal scapulae (1).

An age profile for bison was obtained from crown height measurements on isolated molars (no complete mandibles were preserved intact). Measurements were taken from all six molars; M1s and M2s were distinguished by size and shape. The crown height profiles indicate that adults predominate among age groups; juveniles, subadults, and old individuals are significantly less common. However, it should be kept in mind that the low proportion of young individuals may be partly a function of differential preservation and collector bias (i.e., lack of

sediment-sieving). Sex ratio was estimated from measurements on distal tibiae and distal metapodials, which indicate that (at least for these skeletal parts) males comprise over half the adult sample.

Season of death for bison was determined by measurement of wear on deciduous teeth (n = 29); these data may be used to infer kills in the summer-fall and winter (at least for very young individuals). Additional seasonality information was obtained from a single giant deer cranium; in this case, naturally shed antlers suggest that death occurred during the winter.

The overall composition of the fauna reflects a mixture of steppe and woodland species, with a primary emphasis on the former. Plant macro-fossils recovered from oil-saturated bone fragments are confined to nonarboreal taxa (Vereshchagin 1959), but wood charcoal was apparently encountered in former hearths (Gorodtsov 1941). Cold-tolerant fauna (e.g., *Rangifer tarandus* (reindeer), *Alopex lagopus* (arctic fox)) are completely absent.

The diversity of represented artifact types and vertebrate taxa indicates that II'skaya I (main occupation level) was probably a multiple-activity, long-term habitation site. Skeletal element frequencies for bison may reflect selective retrieval of body parts from kill sites located elsewhere. The age structure indicates that the Mousterian occupants of II'skaya I were not practicing a strategy of attritional predation on bison; prime-age adults were being harvested, possibly in groups. Adult males were taken in large numbers, but females and young were also hunted. Kills appear to have occurred in the summer-fall-winter. Other prey species included several large mammals (mammoth, giant deer, horse, etc.) and possibly some small game (hare, mallard). The remains of several large and medium carnivores are present, but their relationship to the inhabitants of the site is not clear.

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Late Pleistocene Caribou from Northern Ontario

Lawrence J. Jackson

In February of 1988, I examined a large shed caribou (*Rangifer*) antler curated in a small museum in northwestern Ontario and obtained permission to detach one of the antler tines for AMS dating. The specimen was recovered in 1956 during dredging operations to reach iron ore deposits at the bottom of Steep Rock Lake near Atikokan. Sluicing revealed it embedded in about 20 m of silt and clay of possible late Pleistocene age.

The East Arm of Steep Rock Lake is a huge crater gouged out of bedrock about 2,000 m in diameter and 246 m at its greatest depth. Caland Ore Company, a division of Inland Steel, leased the east arm "C" ore-body from Steep Rock



Figure 1. Sample measurements on the Steep Rock Lake *Rangifer* antler. Mediolateral diameter of base at burr = 65.4 mm; main beam thickness ranging from 40 to 60 mm.

Lawrence J. Jacks on, Department of Anthropology, Southern Methodist University, Dallas, TX 75275, and, Northeastern Archaeological Associates, P.O. Box 493, Port Hope, Ontario, L1A 3Z4.

Resources in 1953. This followed Steep Rock's own massive water-diversion projects: rerouting the Seine River, damming lakes, and drilling tunnels to alter water-flow and allow mining of the lake bottom.

The antler site was in a shoreline indentation below the former Seine River Falls about 185 m west of the old river channel and 30 m below lake level. The silt and clay was capped by a thick lens of coarse gravel. The two surveying engineers who made the discovery reported it to the mine manager, and the antler was sent to the Royal Ontario Museum in Toronto for conservation. It was returned to Atikokan and displayed for many years, but the site itself was never examined.

Many geologists were called in to examine the Steep Rock Resources mine before Caland began its operations. Among these was Ernst Antevs who noted that the thickness of the sediments, consisting of "lacial silts and clays, was due in large part to repetition by sliding. Complex glaciofluvial processes precluded precise interpretation of the deposits. The unstable silt and clay around the edges of the lake became increasingly treacherous as it drained and claimed at least one life in an enormous slide.

Surface penetration by preservative indicated that removing a tine of the antler for coring had the best chance of producing a reliable ¹⁴C date. Dr. Alex Wilson, at the University of Arizona Laboratory of Isotope Geochemistry, supervised the coring procedure and reported no difficulties with the analysis. An AMS age of 9,940 \pm 12⁽¹⁾ yr B.P. (AA-3285) represents the first dating of late Pleistocene caribou in Ontario (Figure 1). Within a single standard deviation, the date brackets the Pleistocene transition of 10,000 yr B.P.

Julig (1985; Julig et al. 1987) has noted a geochronological age of about 10,100 yr B.P. for deeply buried water-worn artifacts at the Cummins site near Thunder Bay. An AMS date of about 8,500 yr B.P. on fragments of a cremation burial from the site, and caribou-like bone fragments excavated in a separate context, suggest early Holocene caribou use by late Paleoindian groups. Fox (1975, 1977) assigns many such strand-based sites north of Superior to the distinctive Lakehead Complex.

The presence of barren-ground caribou (*Rangifer tarandus*) near the edge of retreating ice sheets is strongly suggested by the Steep Rock antler. The Cummins site remains also date just before the Cochrane readvance of about 8,100 yr B.P. that reached towards the northeast shore of Lake Superior.

Shed antler is an excellent indicator of ranging behaviour since caribou shed at particular times of year—male and female six months out of phase. Adult males typically shed in rutting season between October and December. The Steep Rock antler, probably barren ground caribou judging from its cross-section, may represent a bull male returning from summer range north of Atikokan to winter range several hundred km to the south (Banfield 1974). Although fluvial transport is certainly indicated, the antler is unlikely to have originated farther north than the retreating Laurentide ice sheet. It may well represent a local event with transport over the Seine River Falls the likely depositional agent.

The presence of caribou calving grounds within 200–300 km of Atikokan is a reasonable speculation. Suitable interception points along migration routes offer a viable explanation for the distribution of many late Paleoindian sites north of Lake Superior. Twenty years ago, the Holcombe beach site (Cleland 1965) emphasized that caribou were used by late Paleoindians in the Great Lakes area. Additional records of Pleistocene and early Holocene fauna may well provide a new focus for Paleoindian settlement studies in northern Ontario (Jackson 1988).

I would like to thank the Atikokan Centennial Museum staff for their support, as well as the French Lake employees of the Ministry of Natural Resources at Quetico Park. Charlie Brooks and Horace Stromberg gave generously of their time. My thanks go to Lorraine, Shirley, Andrea, Lisa, Michelle, and Dawn for their hospitality and to Jon for his encouragement.

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Bison exiquus in Northeast China

Peng Jiang

Abundant *Bison exiquus* (bison) fossils have been found in northeast China. At the very beginning *Bison exiquus* was identified as *Bison priesus*. In 1947 the Americans Skinner and Kaisen revised the former *Bison priesus* as *Bison exiquus*. From then on, all the bison in northeast China have been considered as *Bison exiquus*, and *Bison exiquus* has been subdivided into three subspecies. This paper deals with the *Bison exiquus* found from the upper Pleistocene in northeast China. I believe this will help to understand *Bison exiquus*, the relationship among its subspecies and its natural environment.

Bison exiquus occurs in Guxiantun and Qunli formations in the upper Pleistocene. Guxiantun Formation: This occurs on the bottom of the second terrace of Songhuazian River and Dong-lianhe River. It is composed of yellowish sands, gravels and sandy silt, or greyish green, dark clays. Its thickness may reach 10 to 15 m. Mammuthus-Coelodonta Fauna are mainly uncovered from this formation.

Qunli Formation: Loess or loess-like silty clay. It lies in the Songhuazian River and Harbin area and is very well developed in the plain around Fuyu; with Songliao to the west and Tongliao to the north.

Bison exiquus exiquus Skinner and Kaisen, 1947.

The core of horn is relatively coarse and short, directing backward and spiraling distinctively upward. The tip of the horn is higher than the frontal bone, constitutes

Jiang Peng, Jilin Institute of Archaeology, 3 Guangfu Bei Road, Changchun City, Jilin Province, Peoples Republic of China.

a very small angle with the frontal bone and spires slightly outward. Distinctive ridges and grooves occur at the base of the core. The frontal bone is broad and flat. *Bison exiquus curriornis* Skinner and Kaisen, 1947.

The core of the horn is small and short, extending downward at the one-third part of the core. The tip of the core is directed upward and higher than the frontal bone. It is semi-circular in section. The tip of the core does not spire outward. The longitudinal grooves are distinctive. Frontal bone is flat, and the occipital sagitals approach backward and downward.

Bison exiquus harbinensis Skinner and Kaisen, 1947.

The core of the horn is coarse and short. At the part of the one-third of the corelength, the core extends downward and is lower than the frontal bone. It extends gradually upward and finally at the same level of the frontal bone. The core is circular in section. A distinctive bulge occurs between the parietal bone and the posterior edge of the frontal bone.

Though the fossils of *Bison exiquus* have also been found in Henan, Shanxi, and Sichuan provinces and Inner Mongolia Autonomous Region in upper Pleistocene, most of the fossils occur in northeast China. According to statistical data, *Bison exiquus* was found at 35 palaeontological sites in northeast China. They represent three subspecies dated around 20,000 yr B.P.

The fossils of *Bison exiquus* were found in the first and second terraces of the rivers and lakes in Songliao plain and in some pocket-like cave deposits. They are especially rich at the sites like Zhouziayoufan (Yushu), Antu (Yienbien), Guxiantun (Harbin) and Yianjiagan (Harbin). The frequency of occurrence increases northward and westward in northeast China, which may be correspondent with the geographic environment and climate in the region in late Pleistocene.

After palynologically analyzing deposits containing *Bison exiquus*, we found *Abies* (fir), *Picea* (spruce), *Pinus* (pine) and *Corylus* (hazelnut), which indicate periglacial environment. *Selaginella* and *Lycopodium* spores were found. Furthermore, wet environmental elements such as *Betula* (birch), *Ulmus* (elm), *Artemisia* (sagebrush), and Fabacea were present, representing a continental climate. The pollen diagram shows the climatic alternation of wet-cold and dry-cold in late Pleistocene. Thus, *Bison exiquus* probably lived in the old periglacial tundra or grassland environment.

The Burial of a Bison's Body on the Bank of the Indigirka River, North Yakutia, USSR

P.A. Lazarev

The remains of a bison (*Bison*) were found by hunter H.M. Struchkov on the right bank of the Indigirka River at the locality Mylakhchyn on September 1971. The excavations were carried out the same year by a group of specialists under the leadership of the author from the 24th of September to the 6th of October.

P.A. Lazarev, Institute of Geology, Yakutian Branch, Siberian Department, USSR Academy of Sciences, Lenin Avenue, 39, Yakutsk, 677891, U.S.S.R.

The river at this place intensively washes away a riverside outcrop 30 to 35 m high and about 1 km length. The outcrop is built by thick wedges of vein ice, up to 10 to 15 m wide; between them there are earthen columns 7 to 4 m wide. At upper part of the outcrop ices occupy 80 to 85% of visible area and at lower part they break down into narrow wedges, which reach the water-level. Ice is grey, soiled, with vertical stripe and small bubbles. As a result of intensive thaw at the base there form mud streams, which together with above crumbled trunks and other vegetable rubbish slip down to the river. Here and there as fat as ices thaw, cone-shaped earthen juts ("baidgerahs") are formed.

The lower part of one of these juts, where a bison's body was buried, is made up of grey loess-shaped loams with streaks of yellow small-grained sands and peat. Higher on the section there occurred brown loess-shaped loams with thread-like rootlets of the grasses. At the talus and floodland, numerous bone remains of woolly mammoth (*Mammuthus primigenius*), woolly rhinoceros (*Coelodonta antiquitatis*), bison, reindeer (*Rangifer tarandus*), and horse (*Equus*) were gathered.

According to the facts of palynological analysis, spores (up to 88%) predominate over pollen of grassy plants (up to 34%) in the samples of loams from the place of the bison's burial. It indicates a relatively cold climatic conditions of that time. Among spores, hepaticae, Bryales, Sphagnales, Polypodiaceae, horsetail (*Equisetum* sp.) prevail, while among grasses—Gramineae, Cyperaceae, and Caryophyllaceae, and sagebrush (*Artemisia* sp.). A quantity of grass plants and spores was found to be nearly equal in the contents of a bison's large intestine (Ukraintseva et al. 1978).

The body's remains were buried at a height of 1.5 to 3.4 m from the river waterlevel. The body was at a tumbled-down state, but anatomical succession remained. Small displacement of some parts of the body down slope occurred owing to slipping of superficial beds of the enclosing sounds. The main part of the body lay at a height of 2.6 to 3 or 4 m on the right side with its head in the direction of the river current. The bison's body at the last pectoral vertebrae was cut into two parts by a wedge of ice. To one side of the icy wedge was the debris of a broken skull, shoulder blade, shoulder, fore legs with skin and hair, vertebrae, ribs preserved, and to the other side-vertebrae, tail, bones of hind legs and parts of an alimentary canal. A lot of hair was gathered around the body. According to the preserved ovary and some other features it had been ascertained that the bison's body belonged to young female bison at the age of about two years. An outward appearance of the bison, reestablished by Flerov (1977) by preserved without coloration changes hair, was found to be identical with recent forest bison of Canada (Bison priscus athabascae Roads). This is not astonishing, because the described bodies from Indigirka and Alaska belong to late Pleistocene bison (Bison priscus occidentalis Lucas), which is direct ancestor of recent Canadian bison. Muscles and other soft tissues became greatly mummified and were much more diminished in size under the influence of the enclosing frozen sounds. Judging by the taphonomical peculiarities and cryptogamic-pollen analysis data, the bison had died at the beginning of summer, stuck in the offshore mud streams. An absolute age of the body, determined by soft tissue remains and hair at Institute of Geology and Geophysics of SO AN SSSR, was found to be 29,500 ±100 yr B.P. (SO AN-1007). Therefore, in accordance with stratigraphic scheme of Siberian, the bison had died at the end of Kargian interglacial epoch. It was considered that bison at the north-east Asia died out together with mammoths, woolly rhinoceroses at the beginning of the Holocene climatic optimum about 10,000 years ago. Flerov (1977), guided by the materials of

latest finds, supposed that Siberian bison had died out only about 2,000 years ago. The reason of its mass dying out, as the majority of investigators consider, was sharp change of natural conditions in connection with the Holocene rise in temperature. In North America, owing to emollient influence of oceanic basins, ecological adaptation of bisons was not disturbed and they well preserved up to our days.

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New Paleontological Investigations at Blonquist Rockshelter, Summit County, Utah

Michael E. Nelson, Douglas D. Dreiling, and Richard S. Vandenberg

The Blonquist Rockshelter is located in Summit County, Utah, on the northern flank of the Uinta Mountains. A preliminary report was published in 1988 (Nelson 1988); this paper will present results obtained during the 1988 field season.

The rockshelter functioned as a sediment trap during the late Pleistocene and Holocene and attracted both exogenous and endogenous sediments. The original Pleistocene development, and subsequent backwall collapse, was initiated by groundwater solution and freeze/thaw mechanisms in an Eocene conglomerate. The sediment package in the rockshelter consists of an undulatory, conglomeritic floor covered by a 15 cm thick organic-rich, fossiliferous layer, overlain by a fossiliferous eboulis. Deposition of the sediment package is the result of cave collapse, flowing water, wind action, frost action and animals (*Neotoma* sp.). Holocene modification of original stratification by human activity can also be observed.

Contained within the eboulis are several charcoal or burn layers. The organic-rich layer that overlies the conglomeritic floor has not been radiometrically dated. However, the lower burn layer, located approximately 1 m above the floor, has produced a radiocarbon date of 9,665 \pm 550 yr B.P. (GX-14139). An intermediate burn layer dates at 7,985 \pm 480 yr B.P. (GX-14138) and contains obsidian chips that indicate human activities (Madsen 1988, pers. comm.). Approximately 1 m of sediment overlies an upper burn layer (date of 5,640 \pm 260 yr B.P. (B-19612); Madsen 1988, pers. comm.).

All parts of the sediment package, including the burn layers, are extremely fossiliferous. Although a few invertebrates (gastropods) have been located, most fossils are small mammals. There are a few isolated bones of a deer-size animal and

Michael E. Nelson, Douglas D. Dreiling, and Richard S. Vandenberg, Department of Earth Sciences, Fort Hays State University, Hays, KS 67601-4099.

a medium-size carnivore (coyote?); however, most bones are from animals the size of a marmot or smaller. A preliminary analysis indicates that bones and teeth of the packrat (*Neotoma* sp.) and marmots (*Marmota* sp.) are the most common mammals.

Additional bird bones also were collected from most layers during 1988. At the present we know of sage grouse, hawks, an owl and several passerines. Reptiles are represented by a rattlesnake (*Crotalus* sp.) and perhaps other snakes and/or lizards. A few unidentified amphibians and fish vertebrae have also been noted.

The fauna is under study at Fort Hays State University while personnel from the U.S. Geological Survey are examining the burn layers for pollen and/or larger plant fossils. We are also attempting to analyze the sedimentological and geomorphological history of the adjacent stream valley.

The Blonquist Rockshelter shows promise of producing fossils from sediments that: 1) span the Pleistocene/Holocene boundary; and 2) encompass most, if not all, of the Holocene. In addition, human activity at the 7,985 yr B.P. level may be one of the older records in the western part of the Central Rocky Mountains. Additional field work is planned for the summer of 1989.

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Skeletal Remains of *Equus* from the Page Museum Salvage, Rancho La Brea: a Preliminary Report *Eric Scott*

Since 1985, work in the Paleontology Laboratory of the George C. Page Museum in Los Angeles, California, has concentrated on preparation of material from the Page Museum Salvage deposit. This 10 by 3 m, 0.4 m thick tabular deposit, containing a terrestrial late Pleistocene fauna, was recovered in 1975 during excavation for the foundation of the Page Museum (Duque and Barnes 1975; Jefferson and Cox 1986). Of 20 plaster jackets salvaged, 8 contiguous blocks from the eastern part of the deposit have been prepared. Eighty-six fossil specimens attributed to *Equus* cf. *E. occidentalis* (extinct western horse) have been recovered, and five individuals have been identified. Most of this material occurs as isolated skeletal elements.

Juvenile premaxillae, maxillae, and dentaries representing at least two individuals have erupted upper and lower deciduous premolars that are unworn. Upper and lower deciduous second and third incisors are unerupted. Based on comparisons with tooth eruption sequences in modern equids (Simpson 1951; Getty 1975), these two individuals were less than four weeks old at death. Specimens representing at least two additional juvenile individuals have erupted upper and lower deciduous second incisors and slight wear on the occlusal surfaces of the upper and lower deciduous premolars. A right dentary also has an unerupted, largely unformed, first

Eric Scott, George C. Page Museum of La Brea Discoveries, 5801 Wilshire Blvd., Los Angeles, CA 90036.

molar. These latter two individuals were slightly older at death (one to three months).

Postcranial elements (with one exception) represent juvenile individuals, and consist of 10 isolated vertebrae, 1 rib, 3 radii, 2 ulnae, 4 unfused pelvic elements, 2 distal femora, 1 tibia, and 1 semi-articulated right hind limb (mostly complete from tibia to terminal phalanx, but lacking the cuboid, second metatarsal and one proximal sesamoid). An adult proximal rib represents the fifth individual animal from the deposit.

Age representation of these remains is anomalous when compared to other Rancho La Brea deposits, where individuals of *Equus* younger than six months are estimated to comprise only 10 to 15% of the represented population. Early to mid-spring accumulation of the horse material is indicated, based on comparison with seasonal foaling and maturation periods in modern wild *Equus* (Walker 1975; Moss 1982).

Preservation of these fossils is poor. Disarticulation and scattering of the equid skeletal elements suggest exposure of these remains before burial (Toots 1965; Hill 1979). Surficial cracking and flaking due to climatic weathering is apparent on some elements, indicating that pre-depositional exposure was of short duration (Behrensmeyer 1978; Hill 1980). Carnivore modifications, including tooth marks, furrowing, punctures, shattered long bone diaphyses (indicating marrow-processing activity), and evidence of gnawing (Binford 1981) are not evident on any of these specimens. Element representation does not resemble carnivore-modified assemblages, which are characterized by high frequencies of vertebrae and ribs (Behrensmeyer and Dechant-Boaz 1980; D'Andrea and Gotthardt 1984) or typical Rancho La Brea deposits, in which foot and limb elements are often heavily represented for all taxa (Marcus 1960).

In most cases, equid bones were recovered below semi-articulated skeletons of *Canis dirus* (dire wolf), *Felis atrox* (American lion), and *Smilodon californicus* (sabertoothed cat) (Jefferson and Cox 1986). Scattered elements representing three adult and one juvenile *Canis latrans* (coyote) and one juvenile *Bison* sp. (extinct bison) were recovered along with the horse material in the lower portion of the deposit. The taxa are roughly stratified with some vertical overlap (Jefferson and Cox 1986).

To the south of the deposit, near the source vent of the asphalt, horse bones occur in asphaltic sediments; towards the north, they occur in brown sandy silt or brown clay below a layer of fossil-bearing asphaltic sand (Cox 1985). Some specimens of *Equus* from the non-asphaltic sediments exhibit poor asphalt impregnation. Most of the large carnivore material was recovered from the asphaltic sand overlying the equid bones (Cox 1985; Jefferson and Cox 1986) and is better preserved than the horse remains. The transition between the asphaltic and non-asphaltic sediments is not clearly defined. Molluscan material recovered from throughout the deposit indicates a possible shift from ephmeral pond to sluggish stream conditions, as well as an increase in the rate of deposition, upwards through the deposit (Lamb and Jefferson 1988).

Asphaltic impregnation of horse remains appears to be secondary to deposition. Asphalt viscosity at Rancho La Brea is usually high in the cool months of winter and early spring, during which time asphaltic entrapment of large animals is unlikely (Shaw and Quinn 1986). Low asphalt viscosity during the warmer months of late spring, summer, and early autumn makes entrapment of large animals in asphalt more probable during these months (Shaw and Quinn 1986). Evidence suggests that at least two distinct, apparently unrelated episodes of deposition occurred during the formation of the Page Museum Salvage deposit. The first was the springtime accumulation, disarticulation, and deposition of juvenile *Equus, Bison*, and adult and juvenile *Canis latrans* material in sediments within or near a pond or an ephemeral stream (Lamb and Jefferson 1988). Entrapment in asphalt, proposed as the predominant agent of bone accumulation for other Rancho La Brea deposits (Stock 1949), is not indicated in this instance. The second episode of deposition occurred shortly thereafter, probably during early summer, and involved the accumulation of semi-articulated remains of *Canis dirus, Felis atrox*, and *Smilodon californicus* in asphaltic sediments directly above the equid material.

The carnivore assemblage may represent a single, relatively short-lived asphaltic entrapment event (Jefferson and Cox 1986). The presence of at least one adult, semi-articulated individual of *Bison* elsewhere in the deposit (Duque and Barnes 1975) is sufficient to account for the preponderance of carnivores in the asphaltic upper portion of the deposit. Reasons for the accumulation of juvenile individuals of *Equus* in a non-asphaltic context remain undetermined. Continued preparation and taphonomic investigation are essential to the understanding of the nature of this unique late Pleistocene deposit.

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Paleoenvironments: Geosciences

Late Pleistocene and Holocene Transition on Cedar Mesa, and the Re-evaluation of Kane Springs, Southeastern Utah

Larry D. Agenbroad and Jim I. Mead

The Pleistocene to Holocene transition on the central Colorado Plateau has received little attention as compared with other regions like the Grand Canyon (Spaulding et al. 1983; Van Devender et al. 1987). Cedar Mesa is an approximately 1,300 km² plateau in San Juan County, southeastern Utah. Kane Springs (2,005 m elev.) in Kane Gulch is one southern drainage of the Elk Ridge area ($\pm 2,400$ m elev.) north of the mesa. Preliminary evaluation of the spring deposits included analysis of the pollen (West 1978) and mollusks (Salkin 1975). A 5.4 m column (Agenbroad 1975) was sampled which contained 22 species of mollusks, ostracods, pollen, and an erosional hiatus. We have re-evaluated the locality and produced additional radiocarbon dates (stratigraphically from lowest unit: 9,350 ±130, 8,100 ±345, 7,385 ±80, and from the erosional unconformity denoting the upper unit 6,620 ±85 yr B.P.) (Salkin 1975). Salkin (1975) states that the locality contains a thanatcoenose (transported death) assemblage. In contrast, we believe the site to be a biocoenose (life in situ) assemblage.

Wisconsin full and late glacial fossils in the Cedar Mesa region can be found in Bare Ladder Shelter (1,820 m elev., Mead et al. 1987), White Canyon. Major plant species recovered indicate that *Picea engelmannii* (Engelmann spruce), *Pinus flexilis* (limber pine), *Pseudotsuga menziesii* (Douglas fir) grew in White Canyon and probably along all drainages on Cedar Mesa. Late glacial and early Holocene plant remains can be found in nearby Allen Canyon, Fishmouth Cave, and Bare Ladder Shelter *Neotoma* (packrat) middens (Betancourt 1984; Mead et al. 1987). The macrobotanical remains indicate a community change from late glacial to early Holocene vegetation between 11,300 and 10,700 yr B.P. (Van Devender et al. 1987). Although Fishmouth Cave seems to indicate an additional vegetational shift between 10,400 and 9,700 yr B.P. (Betancourt 1984), the pollen from Kane Springs (West 1978) dating approximately 9,500 yr B.P. implies that *Abies* (fir) and *Picea* were rare, if not absent, on the mesa at this time.

Larry D. Agenbroad and Jim I. Mead, Quaternary Studies Program and Department of Geology, Northern Arizona University, Flagstaff, AZ 86011.

It is not known if Kane Springs was in existence during much of the late glacial, although it surely was present by at least 9,500 yr B.P. Upper Kane Gulch contained flowing and even ponding water at approximately 9,500 yr B.P. as reconstructed from the terrestrial and aquatic gastropods and ostracods. A *Juniperus* (juniper) woodland probably dominated the Cedar Mesa region below 2,000 m elev. by about 9,500 yr B.P. (Betancourt 1984; West 1978). Early through middle Holocene vegetation records are not well documented in the Cedar Mesa region. The Kane Springs profile is complete from 9,500 to 6,600 yr B.P. Although the pollen sequence for these units implies that a fairly complacent juniper woodland occurred in the region, the gastropods and ostracods indicate that an extreme wet phase (flowing, ponding, and probably open water) occurred in the upper gulch between 7,300 and 6,600 yr B.P.

At 6,600 yr B.P. radiocarbon date records a sedimentary erosional hiatus-a downcutting event in the gulch. Below the hiatus, the fine sand, silt, and clay sediments contain on an average 61.1 shells per liter sediment, essentially all the ostracods, a gastropod NISP of 5,014 and 11 gastropod species unique to below the hiatus. Above the hiatus and in the sand and gravels, there are on an average of 4.3 shells per liter sediment, one ostracod (? contaminant), a gastropod NISP of 280, and only 2 gastropod species unique to above the hiatus. Two different hypotheses could account for the observed change. 1) Kane Springs kept a more-or-less consistent discharge during the Holocene, but a climatically controlled downcutting event(s) removed much of the fine clasts and replaced them with coarser sediments, thereby changing the porosity of the channel and not permitting the water to pond and thus not permitting the numerous mollusk microhabitats to occur. 2) Alternatively, Kane Springs could have had a consistant discharge from 9,500 to 6,600 yr B.P., at which time a climatic factor decreased discharge and a concomitant downcutting phase began. The resulting fill sequence represented a drier period of time with much fewer molluscan microhabitats. Pollen remains above the hiatus record a juniper woodland with abundant remains of cheno-Am and Artemisia (sagebrush)-different than prior to the hiatus. The meager packrat midden record implies a fairly homogenous middle and late Holocene vegetation community regime except for the arrival of Pinus ponderosa (ponderosa pine; due to arrival of summer precipitation patterns?) in Allen Canyon by 7,200 yr B.P. (Betancourt 1984). This may correspond to the "wet phase" (7,300 and 6,600 yr B.P.) observed at Kane Springs prior to the erosional hiatus, and may add credence to the climatic-enduced change of hypothesis #2. Additional packrat midden, pollen, and molluscan studies are needed from the Colorado Plateau.

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Geologic Context of Paleoindian and Archaic Occupations in a Portion of the Mississippi Valley, Iowa and Illinois

E. Arthur Bettis III, and David W. Benn

Detailed geologic and archaeological investigations funded by the U.S. Army Corps of Engineers, Rock Island District in Pools 17 and 18 of the Upper Mississippi River Valley, have resulted in the discovery of several Paleoindian and early Archaic sites, and the development of a landscape evolution model that addresses the geologic potential for occurrence of buried sites of this age in the valley (Benn et al. 1988). This information is employed to address two important questions: 1) what percentage of the Paleoindian and early Archaic landscapes, and the occupation areas they may have contained, have been destroyed by subsequent river activity, and 2) in what geologic context(s) are the Paleoindian and early Archaic landscapes buried and not detectable using traditional techniques such as pedestrian survey or shallow test pits. Addressing these questions sheds light on the relationship between the known record of occupation, the potential extant record (known plus buried and undiscovered), and the potential settlement pattern that existed before geologic processes altered it.

This part of the Mississippi Valley was formed when the river was blocked by outwash and diverted through the paleo-Iowa Cedar Valley about 21,000 yr B.P. (Anderson 1968; Bettis 1987). The diversion linked the Upper Mississippi Valley with the Iowa-Cedar system and resulted in the modern valley configuration between Rock Island, Illinois, and St. Louis, Missouri. Between the time of the diversion and 12,000 yr B.P. the valley was occupied by a braided Mississippi River carrying outwash from the southern margin of the Laurentide ice sheet. During this time the valley aggraded with gravelly and sandy alluvium that served as the source of Peoria Loess. Around 12,000 yr B.P. the river incised and isolated the former floodplain, forming a high sandy terrace complex. From 12,000 to 10,500 yr B.P. sandy alluvium accumulated on the floodplain of the braided Mississippi River.

E. Arthur Bettis III, Iowa Department of Natural Resources-Geological Survey Bureau, 123 N. Capitol St., Iowa City, IA 52242.

David W. Benn, Center for Archaeologica! Research, Southwest Missouri State University, Springfield, MO 65894.

Renewed incision at 10,500 yr B.P. left the late glacial floodplain as a low terrace, and the river began a metamorphosis to the modern island-braided channel pattern. During the early Holocene, the Mississippi occupied several paleochannels that were abandoned rapidly by a series of avulsions. The last glacier-related floods to affect this part of the valley were produced by catastrophic drainage of glacial lakes in the northern part of the basin between 9,600 and 9,200 yr B.P. During these floods lithologically distinctive reddish-brown silty clays were deposited in backwater and abandoned channel areas. Alluvial fans and colluvial slopes along the valley margin began to prograde onto high and low Wisconsin-age terraces as well as the early Holocene floodplain around 10,000 yr B.P., and continued to aggrade until the late Holocene.

A series of maps (scale 1:24,000) depicting the evolution of landform-sediment assemblages comprising the modern valley landscape in the area were constructed using color-infrared photographs, published soil maps, USGS topographic maps, outcrops, and an extensive subsurface coring program bolstered with 31 radiocarbon dates. These maps permit calculation of the area occupied by the various landform-sediment assemblages through time, and indicate that approximately 62% of the pre-10,500 yr B.P., and at least 12% of the 10,500 to 7,000 yr B.P. valley landscape has been destroyed by subsequent river activity. Alluvial fans and colluvial deposits bury 14% of the remaining pre-7,000 yr B.P. valley landscape. Younger overbank deposits bury most of the intact early Holocene floodplain in paleochannel areas in proximity to the present meander belt.

Paleoindian sites (4) were found only on remnants of the lowest, late Wisconsin terrace, but as pointed out earlier, much of the Paleoindian landscape has been destroyed or is buried. Seven Dalton and early Archaic sites were located on remnants of the late Wisconsin terrace, and two were found at the distal margin of alluvial fans that have prograded the terrace. These too, may only reflect remnants of a once more extensive settlement pattern that has been severely impacted by subsequent geologic processes. Large portions of the Dalton and early Archaic record may be preserved in buried contexts within alluvial fans and colluvial deposits along the valley margins as well as within overbank deposits in paleochannel areas. With this information in hand it is obvious that statements about Paleoindian and early Archaic settlement patterns based on the record of known sites in this area are quite problematic.

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Late Illinoian(?) Fluvial Sediments in the Upper Minnesota River Valley: Preliminary Pollen Analysis

Jay P. Gilbertson and James K. Huber

Recent investigations into the Pleistocene stratigraphy of northeastern South Dakota have led to the identification at several localities of a suite of glaciofluvial sediments, referred to herein as the Gastropod Silts. The unit occurs between the Hawk Creek and Whetstone tills (Gilbertson and Jensema 1987). The thickness of the unit is variable, as a result of the irregular nature of the lower contact, but averages about 4 m. It is found in several cutbanks along the lower reaches of tributaries of the Minnesota River, the Whetstone River in northeastern South Dakota, and the Yellow Bank and Chippewa rivers in western Minnesota.

The unit is composed of two distinct lithologies; a massive gray (10YR 6/1) sandy silt and a bedded, medium- to coarse-grained, light-brown (7.5YR 6/4) sand. Gastropod shells are scattered throughout the sandy silts, along with a variety of other plant and animal fossils. The sands commonly lack organic remains, except as noted below. The top of the unit is marked by a thin (15 cm) organic-rich horizon that may be developed in either sediment type.

Analysis of two pollen samples from the organic horizon at separate localities of the Gastropod Silts yielded 28 pollen types and one species of Chlorophycophyta algae (*Pediastrum boryanum*). The samples are characterized by high values of nonarboreal pollen, averaging 76%. Cyperaceae (sedge) is the dominant herb in both samples (average = 61%), followed by Gramineae (grass) with less than 5%. Arboreal pollen is dominated by *Picea* (spruce), with an average of 20%. *Pinus* (pine) occurs at 1.0% or less. The pollen spectra are similar to the lowermost levels of a late-glacial profile described by Jelgersma (1962) from Madelia, Minnesota, and suggests a park tundra with spruce.

The age of the unit is problematic. Amino acid racemization values determined from several *Pupilla muscorum* (pupillid snail) tests recovered from the unit gave an age estimate of $140,000 \pm 70,000$ yr B.P. (AGL-540), a range from early Wisconsin to late Illinoian. An early Wisconsin age is tentatively rejected based on the absence of any clear evidence for glacial activity in the region during this period (Fullerton and Colton 1986; Lehr and Gilbertson 1988). The pollen evidence would seem to preclude an interglacial (Sangamon) environment, leaving the late Illinoian as the most probable period of deposition.

This interval is of particular interest because it represents one of the few pre-late Wisconsin fossiliferous horizons in the region. More complete analyses of the pollen record and other organic materials (snails, ostracodes, and small mammals) from the Gastropod Silts are planned, as well as additional attempts to better define the temporal position of the unit.

Jay P. Gilbertson, South Dakota Geological Survey, Vermillion, SD 57069.

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

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Landforms and Quaternary Geology on the Shuidonggou Site in Lingwu, Ningxia

Zhang Guodian

Shuidonggou, situated about 46 km north of Lingwu County in Ningxia, is a famous site of ancient cultural remains. In the early 1920s, Priest P. Teilhard, a French archaeologist, excavated and reported the site. Professor Pei Wenzhong and Professor Chia Lanpo re-examined the site in the early 1960s.

Shuidonggou site is more than 1,200 m above sea level. The hills to the south of the site rise 1,200 to 1,400 m high. The desert districts to the north are from 1,200 to 1,300 m high. There are four terraces in this area: the first is about 3 m above the river bed and several meters to tens of meters wide, and extends continuously along the sides of the river; the second is about 8 m above river, more than 100 m wide and 100 to 200 m long, and extends uncontinuously along the sides of the river; the third terrace occurs about 15 m above river and hundreds of meters wide, and extends uncontinuously along the sides of the river; above river and hundreds of meters wide, and extends uncontinuously along the sides of the river above river.

Moreover, there are two terraces in the southwestern part of the site, one being 50 m above river and another being 100 m above river. As the range of their distribution is large, they would not be formed by the stream of Shuidonggou. The raw material that served as stone artifacts in this site are mainly gravels which were taken from the two terraces.

The Quaternary sediments of Shuidonggou region were accumulated in an erosion depression formed during the end of Tertiary. The sediments are gravels, sands and clay-sands of river facies, and clay and peat deposits of small lake basin bog facies.

The strata of the early-middle Pleistocene have not been studied in detail. The late Pleistocene series may be divided into five layers. The sediments of the two lower parts are river facies deposited under a humid climate. Those of the middle part are lake basin bog facies deposited under a warm-wet climate. The upper part of the series is a clay sandysoil exhibiting melt-freeze folds formed under a cold climate. The top part of it is silt layer accumulated under a dry desert climate.

Zhang Guodian, Bureau of Geology, Ningxia, Peoples Republic of China.

During late Pleistocene, there were rhinoceros, hyaena, gazella, g. mongoliensis, Equus, Struthio, etc. living in this area.

The discovery of Neolithic and Palaeolithic artifacts shows that there was the trace of ancient human activities at the site.

From what has been said above, it will be seen that the characteristics of this section are very similar to the upper part of the Shalawusu formation of the late Pleistocene.

The Holocene sediments can be divided into three units. They were accumulated on the first, second and third terraces in this area respectively, and consist of sandbearing clay and silty clay with various artifacts, pieces of pottery, *Equus* teeth, snail, etc.

From late Pleistocene to Holocene, there were two periods of bog developments in lake basin. The lake basin bog of late Pleistocene was much larger than that of early Holocene (the former is about 600 m long and the latter is about 300 m long).

Late Quaternary Soils and Sediments at 5MF2642, Dinosaur National Monument, Moffat County, Colorado

Michael McFaul and James A. Truesdale

The soil-sediment profile at 5MF2642 (Figure 1) in upper Sand Canyon includes at least three Quaternary buried paleosols in a fill terrace of an ephemeral stream. One of the paleosols, developed in a fill uncomformably mantling an older Argid (?), yielded a ¹⁴C age from charcoal of 11,900 ±240 yr B.P. (Beta-27681).

The dated soil has a restricted saucer-like exposure extending horizontally at least 10 m. The exposure is similar to soils developed on prehistoric pit houses (Truesdale et al. 1987) and soils developed in shallow depressions that have subsequently been buried by colluviation. Archaeological excavations are attempting to determine the areal extent of the soil and to assess its possible human affiliation. The 11,900-year age suggests that the soil below the dated horizon is probably late Pleistocene in age. This is supported by the latter's relatively large clay and carbonate percentages together with the presence of clay bridges and the reddish 5YR hue of the Bt horizon.

An 1,829 m elevation alluvial/colluvial terrace at 5MF2642 is the second of three, discontinuous, Quaternary alluvial/colluvial deposits within upper Sand Canyon. The highest terrace at 1,853 m is reworked cobble alluvium of probable Pleistocene age. The lowest terrace at 1,820 m elevation consists of approximately 1 to 2 m of coarse- to fine-grained alluvium bordering the ephemeral channel. Radiocarbon dating of charcoal in a hearth buried within the lowest terrace indicates that its deposition began prior to $3,500 \pm 70$ yr B.P. (Beta-27678). Weak soil development

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

James A. Truesdale, U.S. National Park Service, Rocky Mountain Region, Dinosaur National Monument, P.O. Box 210, Dinosaur, CO 81610.

and geomorphic position suggest that the parent material of the modern soil on the terrace at 5MF2642 may correlate with this latest fill cycle. Other researchers have noted the presence of three Quaternary fills along the Sand Canyon master drainage. These include two alluvial fill terraces of probable Holocene age below a Pleistocene strath terrace on the Yampa River and at the Yampa-Green confluence (Hansen et al. 1983; McFaul 1988).

The 11,900-year age of the paleosol at 5MF2642 indicates, contrary to prevailing archaeological opinion (Breternitz 1970; Burgh and Scoggin 1948), that subsurface early Holocene and probably Pleistocene soils/sediments are present at Dinosaur National Monument. Recognition of these soils/sediments requires reappraisal of the geoarchaeological significance of the terrains within the monument. Recognition and dating of multiple alluvial/colluvial sequences also suggests it may be possible to assess the coincidence of landform development (Karlstrom and Karlstrom 1986) and test whether the Quaternary alluvium in the monument owes its existence to climatic fluctuations or the non-climatic changes proposed by Hansen (1986).

Abbreviated Soil Description: 5MF2642

- A 0–10 cm. Yellowish brown (10YR5/4 dry = d) sandy loam, loose, slightly effervescent.
- Bk 10–84 cm. Very pale brown (10YR7/4d) sandy loam (76% sand, 13% silt, 11% clay), massive, violently effervescent, 4.5% CaCO₃, pH 7.2, fine- and coarsegrained colluvial/alluvial parent materials. Deposition of these sediments is thought to correspnd to the latest fill event (> 3,500 yr B.P.).



Figure 1. Site diagram.

Disconformity

- Akb 84–118 cm. Brown (10YR5/3d) sandy clay loam (67% s, 10% si, 23% c), violently effervescent, 8.0% CaCO₄, pH 7.7, charcoal flecks and worm casts.
- Bkb 118–128 cm. Grayish brown (10YR5/2d) sandy loam (73% s, 13% si, 14% c), violently effervescent with common (8%), fine, rounded, segregated filaments of lime, 2.5% CaCO₃, pH 8.5, fine- and coarse-grained colluvial/alluvial parent materials.
- Akb 128–145 cm. Very dark grayish brown (10YR3/2d) sandy clay loam (55% s, 26% si, 19% c), violently effervescent with many (30%), fine, rounded segregated filaments of lime, 12.5% CaCO₃, pH 8.4. Charcoal from this horizon dates 11,900 \pm 240 yr B.P. (Beta-27681).
- Bkb 145–162 cm. Yellow (10YR7/6d) sandy loam (75% s, 11% si, 14% c), violently effervescent with common (15%), fine, rounded segregated filaments and masses of lime, 1.5% $CaCO_3$, pH 8.7, predominantly fine-grained alluvial/ colluvial parent materials.

Unconformity

- 2Btkb 162–174 cm. Yellowish red (5YR5/6d) sandy clay loam (57% s, 24% si, 19% c) thin, clay bridges, violently effervescent with many (60%), fine, rounded segregated filaments and disseminated lime, 25% CaCO₄, pH 9.0.
- 2Bkb 174–249 cm. White (10YR8/2d) loamy sand (87% s, 5% si, 8% c), violently effervescent with many (40%) medium, irregularly shaped concretions filling root casts, 4.0% CaCO₃, pH 9.1, fine-grained, thinly bedded alluvial parent material.
- 2C 249-296 cm. White (10YR8/2d) sandy loam (78% s, 7% si, 15% c), strongly effervescent, 7.5% CaCO₄, pH 9.2.

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Evidence for Post-glacial Neotectonism in the Erie Basin

D.F. Palmer, B.B. Miller, and R.G. Craig

Stream profiles for tributaries to Lake Erie show that the streams are generally not adjusted to the present level of the lake. Cumulative distance from the mouth and elevation were digitized from lake level to no higher than 330 m using USGS 7.5' topographic maps. Regressions of distance vs. the log of elevation explain 99% of the variance in 10 of the 20 streams and > 95% of the variance in 18 of the 20. For two rivers the r^2 was .90 and .84. It is assumed that the slope of the regression line represents the stream gradient and the intercept represents the base level. The 95% confidence limits for the base levels of each stream are plotted on Figure 1.

Using this method only two streams have profiles which are adjusted to the present lake level (175 m) and four have profiles adjusted to higher elevations (177 to 180 m). The remaining 14 profiles are graded to different elevations below the present lake level (Figure 1). There is no correlation between the projected base



Figure 1. The 95% confidence limits for the base level intercepts of each stream are plotted as solid segments of the rays. Examples of the range of variance in longitudinal stream gradients are illustrated by the profiles of the Maumee and Vermilion rivers, and Big Creek.

D.F. Palmer, B.B. Miller, and R.G. Craig, Department of Geology, Kent State University, Kent, OH 44242.

level and hydrologic character of the streams, including sinuosity, drainage basin area, discharge, or underlying bedrock lithology. Some streams show two distinct gradients which suggest a disruption in the drainage history. In the western part of the Basin, the Raisin River and the Maumee River (Figure 1) show distinct changes in gradient at an elevation of 190 m, with the gradient increasing downstream. The position of this break in slope occurs near the trace of the Bowling Green Fault. Three streams in Ontario (Grand River, Big Creek (Figure 1), and Big Otter Creek) show a distinct change in slope at elevations of 192 to 198 m, with a steeper gradient upstream. These gradients project to base levels below present lake level. The projected base levels and the direction of change in gradient are consistent with differential post-glacial rebound with greater uplift to the north.

Rivers flowing into Lake Erie in Ohio, Pennsylvania, and New York are graded to different apparent base levels, mostly below present lake level. These discordances may be due to several factors: 1) the streams may be of different ages and adjusted to different former lake levels, 2) differential shoreline erosion may have truncated the stream profiles, 3) differential crustal warping may have altered the stream profiles relative to the lake level, and 4) recent faulting may have uplifted or down-dropped sections of the streams. We have not been able to test the first hypothesis, but our analysis suggests that all of the other three factors contribute to the observed discordance.

Late Quaternary Pluvial Episodes of Lake Cochise, Arizona

Michael R. Waters

The Willcox basin is a topographically closed and internally drained basin in the northern portion of the semiarid Sulphur Springs Valley in southeastern Arizona, that was occupied during the late Quaternary by pluvial Lake Cochise (Meinzer and Kelton 1913; Schreiber et al. 1972). A prominent shoreline, representing a high stand of Lake Cochise, occurs at an altitude of 1,274 m. At this elevation, Lake Cochise had a maximum surface area of over 190 km² and a maximum depth of 11 m. No other shorelines have been observed within the basin at higher or lower altitudes.

Long (1966) proposed that Lake Cochise was characterized by two major lacustral intervals from before 30,000 until 13,000 yr B.P. and from 11,500 to 10,500 yr B.P. Haynes et al. (1987) obtained two radiocarbon dates from sediments comprising the western shoreline that provide additional information on the lacustrine history of Lake Cochise. Recent investigation of the stratigraphy (Figure 1) along the western shoreline of Lake Cochise, coupled with 19 radiocarbon dates, and supplementary evidence indicate that Lake Cochise had high stands above the level of the modern

Michael R. Waters, Department of Anthropology and Department of Geography, Texas A & M University, College Station, TX 77843.

playa during both the Pleistocene and Holocene and that the original chronology of Long (1966) should be modified.

Prior to 14,000 yr B.P., at least two lakes existed in the Willcox basin and extended to altitudes above the 1,274 m shoreline of Lake Cochise (unit A). Shorelines associated with these lakes have been destroyed by erosion or buried by alluvium. The prominent 1,274 m shoreline present in the Willcox basin (composed of sand and gravel, unit B) was in large part created sometime between 13,750 and 13,400 yr B.P. (based on six radiocarbon dates), when a large lake filled the basin. A black, organic-rich lacustrine clay (unit C) overlies unit B and documents a significant resurgence of Lake Cochise, to an elevation slightly below the crest of the 1,274 m shoreline during the early Holocene. Four radiocarbon dates on sediment and soluble humates extracted from unit C provide minimum ages that suggest this lacustral interval occurred sometime around or slightly before 8,900 yr B.P. Two overlying marls (units D1 and D2) indicate two additional fillings of Lake Cochise during the middle Holocene to elevations slightly below its former late Pleistocene maximum. Minimum ages for the lacustral events are estimated by dating the organic fraction extracted from the marls. The earlier lacustral event appears to have occurred sometime around or before 5,400 yr B.P., and the later high stand sometime around or before 3,000 to 4,000 yr B.P. Since the middle Holocene only shallow ephemeral playa lakes have occupied the Willcox Playa basin.

The lacustrine sequence of Lake Cochise provides independent confirmation that several pluvial climatic episodes occurred in southern Arizona and the American Southwest during the late Quaternary. Cooler temperatures, reduced evaporation rates, and increased winter precipitation associated with the southward displacement of the Pacific westerlies and associated winter storm tracks (Spaulding et al. 1983; Spaulding and Graumlich 1986) appear to be the climatic conditions responsible for the creation of the high lake stand during the late Pleistocene. Even though temperatures were rising, intensified summer monsoonal precipitation from 12,000 to 9,000 yr B.P. (Kutzbach 1983; Spaulding and Graumlich 1986), appears to have led to the resurgence of Lake Cochise during the early Holocene.



Figure 1. Generalized geologic cross-section through the western shoreline of Lake Cochise showing the major stratigraphic units and some of the associated radiocarbon dates (not to scale).

Altithermal conditions of increasing temperature and aridity (Hall 1985) account for the absence of lake stands until the end of the middle Holocene. Following the Altithermal, more mesic conditions between 5,000 and 4,000 yr B.P. (Mehringer et al. 1967) may account for the resurgence of Lake Cochise and deposition of the marls. Since the middle Holocene, characterized by modern semiarid conditions with evaporation exceeding precipitation, only shallow ephemeral playa lakes have formed within the confines of the basin.

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Deposits of Interglacial Character, Nenana Valley, Alaska

Christopher F. Waythomas, Susan K. Short, and Scott A. Elias

Organic sediments of interglacial character are exposed in the headscarp of a large earthflow in the outer Nenana Valley approximately 2.5 km southwest of Ferry, Alaska, in the foothills of the north central Alaska Range (63° 59' N, 149° 08' W). Slow movement of the earthflow over the last several decades has exposed up to 50 m of Pleistocene age glacigenic, fluvial and aeolian sediment. The exposure, hereafter referred to as Landslide Bluff, contains several fossiliferous organic-rich beds with rooted tree stumps, wood fragments and logs. The exposure lies well

Christopher F. Waythomas, Susan K. Short, and Scott A. Elias, Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO 80309.

beyond the limits of late Pleistocene Healy Glaciation but within the limits of late Tertiary to early Pleistocene Browne Glaciation (Wahrhaftig 1958, 1970).

Exposed in the bluff face is a sequence of glacial, fluvial and aeolian sediments (Figure 1) that record at least one glacial-interglacial cycle in the outer Nenana Valley. The basal 30 m of the exposure consists of massive to weakly stratified, matrix-supported diamict, containing abundant faceted, soled and striated clasts. Near the top of this unit (Dmm, Figure 1) are several lens-shaped bodies of very



Landslide Bluff

Figure 1. Representative stratigraphic section of Landslide Bluff. Lithofacies code at lower right after Eyles et al. (1983).

weakly stratified to massive, clast-supported gravel and sandy gravel. This sequence of lithofacies is interpreted as a lodgement till that grades upward into meltout till. The till sequence is conformably overlain by clast-supported, massive to stratified gravel approximately 10 m thick. This gravel unit is interpreted as outwash that was deposited in association with the underlying till units. The top of the outwash gravel is marked by a well-developed ventifact pavement that is locally cut by ice wedge casts that penetrate the gravel to a depth of about 1 m. A weakly developed soil occurs on the top of the gravel as well. This soil consists of an oxidized zone that extends between 1.0 and 1.5 m below the top of the gravel. Some clast undersides within the upper 50 cm of the gravel exhibit calcium carbonate crusts that cover iron oxide staining. Many of the coarser-grained igneous and metamorphic rocks within the upper portion of the gravel are weathered to grus. The features associated with the top of the gravel suggest an unconformable relationship with the overlying units.

Overlying this unconformity is a sequence of fine-grained, fluvial sediments that contain at least four distinct peaty beds (Figure 1). The two bottom peaty beds contain abundant wood fragments, logs and significant amounts of organic matter. Tree stumps in growth position were noted in peat 2 (Figure 1). Pollen analyses from peat 1 record high percentages of Picea (spruce, 54%), Alnus (alder, 10.4%), Betula (birch, 19.8%) and Sphagnum (moss, 121%, calculated outside of pollen sum) and lesser amounts of Epilobium (2.5%), Ericales (4.5%) and Filicales (3.5%). Charcoal fragments were particularly common as well, suggesting a regional fire episode. Peat 2 also contained high percentages of Picea (55.5%) but reduced amounts of Alnus (2%) and Betula (2%). Also important were Filicales (20%), Equisetum (horsetail, 10%) and Gramineae (3%). Charcoal was absent from this sample. Peats 3 and 4, which occur higher up in the sequence (Figure 1), record little spruce pollen (3.7% and 5.1% respectively). Dominated by Cyperaeae pollen (64.8%), peat 3 contained lesser amounts of Alnus (5.6%), Betula (3.7%), Artemisia (sagebrush, 7.4%), Gramineae (7.4%) and Rosaceae (5.6%). Peat 4 is also dominated by Cyperaceae (43.6%), with Salix (willow, 2.6%), Compositae (2.6%), Gramineae (15.4%), Rosaceae (2.6%), Filicales (7.7%) and Lycopodium annotinum (5.1%). No Alnus or Betula pollen were recovered from peat 4.

These pollen data suggest a spruce forest at the site during the formation of peats 1 and 2, that was later replaced by a sedge-grassland dominated vegetation during development of peats 3 and 4. This may indicate either a cooling or drying climate over the interval of formation of the peaty beds.

The vegetation that characterizes the region today consists of gallery forest and forest-tundra dominated by *Picea* and *Alnus* with *Betula* shrub tundra (Ager 1983). Other interglacial sites in the north Alaska Range foothills region are rare, and have not been studied in detail. Interglacial pollen spectra dominated by *Picea*, *Alnus* and *Betula* have been reported from the Little Delta River valley (63° 57' N, 146° 52' W), and from the outer Teklanika River valley (64° 10' N, 149° 39' W) (Ager 1980). In contrast, interstadial pollen spectra lack spruce pollen and indicate shrub-herb tundra vegetation. Sparse, discontinuous herbaceous tundra—characterized by sedge and grass pollen—dominated the north-central Alaska Range region during the last glacial interval (Ager 1980) as well as the lowlands of the Tanana Valley (Ager 1975).

Fossil insects found within the peaty beds also suggest forested conditions at the site. *Pterostichus nivalis* and *Leptothorax* sp. indicate treeline conditions were

associated with development of peats 1 and 2. Other beetle taxa are suggestive of northern boreal conditions.

Capping the peat-bearing portion of the sequence is a relatively thin (2 m) coarsening-upward fluvial unit (Figure 1). The top of this unit is marked by a ventifact pavement and a relatively poorly developed soil. The soil consists of an oxidized zone that extends to a depth of generally 50 to 80 cm below the top of the gravel. Discontinous carbonate crusts on clast bottoms are present but rare. An unconformity of unknown duration probably occurs at the top of this gravel unit as well. The upper surface of the gravel coincides with the Dry Creek terrace as mapped by Wahrhaftig (1958, 1970). Throughout the lower and middle Nenana Valley as at Landslide Bluff, the terrace is overlain by up to 2 m of Holocene loess and aeolian sand.

The sequence of stratigraphic relations at Landslide Bluff suggests that interglacial conditions prevailed in the outer Nenana Valley sometime after an episode of widespread glaciation. Following this interglacial period, climatic conditions appear to have cooled (dried?) slightly, perhaps associated with a minor glacial episode in the area. The Dry Creek terrace, which overlies organic deposits of interglacial character at Landslide Bluff may be the outwash terrace associated with this glacial episode.

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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 accepted. No more than 2 papers will be accepted from any one senior author. Time being of the essence, the earlier a paper is received, the better its chance of being published. Manuscripts concerned with any of the above categories should include research dating $\geq 10,000$ yr B.P. or have direct implications for research of that time period.

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