CURRENT RESEARCH IN THE PLEISTOCENE

Volume 9

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A Peopling of the Americas Publication

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Editor

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A Peopling of the Americas Publication

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From the Editor

This issue is my last as Editor for *Current Research in the Pleistocene*. I believe that it is time that *CRP* has a new editor, one with a fresh look at the scope and direction of the journal.

In 1983, Rob Bonnichsen (then at the University of Maine) hired me to come to Orono to do a number of projects, one which was to develop a journal-anyway I wanted to. I thought about the various "problems" surrounding the Study of the Pleistocene. I did not want just an archaeological approach. The problem that I saw, and still see, is that many of those who often study Pleistocene peoples do so as if they are in a vacuum. My approach has always been that archaeological remains are no different and no more important than the sediments, snails, bones, arthropods, pollen-and so on. Any aspect of the study of the late Pleistocene should use a multidisciplinary approach. That was the single largest problem with the study of the Pleistocene-the lack of being multidisciplinary in approach. I do not feel that everyone must always be multidisciplinary, but there always seemed to be a void; Dr. X in archaeology did not know that Dr. Y in paleoecology had information that would have been very useful to him. I realized that the largest problem was that for many researchers it took too much time to read all the various journals to keep up-to-date. That was the answer-get people to produce short communications from their various disciplines. With input from Rob Bonnichsen and Marci Sorg, I designed a journal to provide communication-Current Research in the Pleistocene. For nine years, CRP has provided communication in the Quaternary sciences, at least for North America.

Even though *CRP* is produced only once a year, I get swamped *once* a year with some 70 manuscripts. My greatest project, as Editor, has been getting the prospective authors to follow the style of *CRP*. Authors apparently hate to follow a given style. Dave Meltzer, Southern Methodist University, became my Associate Editor a few years back. He helped me immensely—I am losing less hair now, and what little I have left is not all turning gray. I enlisted the reviewing help of various people near to me here at Northern Arizona University (to save time), including: Larry D. Agenbroad, Stan Ahlers (now University of North Dakota), and R. Scott Anderson. I appreciate all their help through the years. The above people helped me get the various manuscripts read, reviewed, and sent out to other professionals, like yourselves, for

peer review. All this takes precious time. I have tried to get *CRP* out in a timely fashion—it has not always worked the way I wanted.

I have enjoyed being Editor of *CRP*. I am proud of it and I appreciate all the authors and readers. **But**, it is time that the journal have a new caretaker—it is good for both me and the journal. *CRP* will keep going—it must because we all need to keep abreast, to communicate.

Thank you. JIM

Archaeology

Paleoindian-Archaic Range Shifts in Eastern Nevada

Charlotte Beck and George T. Jones

In 1990 we reported on our efforts to build an obsidian-hydration chronology of surface assemblages of predominantly late-Pleistocene/early-Holocene age from Butte Valley, White Pine County, Nevada (Jones and Beck 1990a, 1990b). We have expanded these studies to include nearly 700 obsidian artifacts from Butte and neighboring valleys. In conjunction with hydration analyses, we have conducted source studies using XRF, which are the subject of this report.

The archaeological record from Butte Valley (BV) consists predominantly of surface lithic artifact concentrations lying nearly exclusively on pluvial and relic-alluvial landforms (see Beck and Jones 1991); these landforms likely date to the last stilltands of Pluvial Lake Gale, ca. 9500–10,500 yr B.P. Based on similar associations throughout the Great Basin, researchers have generalized this pattern to one focusing on littoral habitats in valley bottoms and have termed it the Western Stemmed Tradition (WST). To expand understandings of these patterns, we have begun examining lithic source utilization in an attempt to obtain information concerning WST land use and mobility. Our recent studies from Butte and surrounding valleys reveal patterns suggestive of a change in land-use patterns from the WST to the Archaic.

In the obsidian sample analyzed, 35 geochemical types have been identified, a remarkable number in view of the paucity of geologic sources within a 100-km radius of the valley. Of this total, 12 have been matched with sources although we may soon be able to match an additional five (Richard Hughes, personal communication). The sources that are best represented (86.4% of the sample analyzed) include Butte Mountain (a local pebble source), Brown's Bench (ca. 250–275 km north of BV), Panaca Summit (ca. 200–225 km south-southeast of BV), several Utah sources (all ca. 180–200 km east and southeast of BV), and a source of unknown location, designated as "B." An examination of projectile points of WST and Archaic affiliation together with their source composition suggests that there is a temporal pattern in source utilization.

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Of the 104 points analyzed, 79 (80.0%) are made from the obsidians mentioned above. With few exceptions, WST types (e.g., Cougar Mt., Parman, Silver Lake, Lake Mohave) are made primarily from Brown's Bench obsidian (n = 23), with three of Panaca, one of "B," and three of Utah obsidians. There are an additional eight points manufactured from Brown's Bench obsidian; although these are untyped, their hydration readings (9.1–15.2 microns) overlap almost completely with those of WST types (9.5-16.1 microns), suggesting similar age. Early-Archaic types (e.g., Pinto) are also manufactured primarily from Brown's Bench (n = 6) and Panaca (n = 5) obsidian, with three made of "B" and three made of Utah obsidian. There are, however, nine untyped points also manufactured from "B" obsidian whose hydration readings (4.5-5.5 microns) overlap with those of both the WST point (5.3 microns) and the three Pinto points (4.6-4.7 microns), again suggesting similar age. In the remaining Archaic types (e.g., Humboldt, Elko, Rosegate, and Desert sidenotched), Utah dominates (n = 9), with only four of "B," two of Panaca, and one of Brown's Bench obsidian.

The overall picture of source use as indicated by the BV projectile points suggests that Brown's Bench, Panaca, and "B" were utilized most heavily during WST and early-Archaic times (ca. 11,500–7,500 yr B.P.) while obsidian use during later Archaic times (after ca. 7,500 yr B.P.) shifted to Utah. Looking outside Butte Valley, we find support for these patterns in that 22 WST points from Spring, Long, Railroad, and Little Smokey valleys (to the east, west, south, and south-southwest of Butte Valley) are made from Brown's Bench and "B" obsidian, while only one is made from Utah obsidian. The three Archaic points examined from these valleys are all made from Utah obsidian.

The locations of the Brown's Bench and Panaca source areas suggest that WST and early-Archaic populations were moving on a roughly north-south trajectory while the pattern appears to shift to a more east-west direction by the mid-Archaic. At the least these patterns suggest a change in source use, but also imply a shift in areal use and possibly distance traveled, over time. These patterns are admittedly general, but our source studies are ongoing, not only in obsidian, but also in basalt and chert, and thus we hope to provide more support for these ideas in the future.

Funding for source and hydration analyses was provided by grants from Hamilton College and the National Science Foundation (BNS-8915392).

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Engraved Cobbles from the Gault Site, Central Texas

Michael B. Collins, Thomas R. Hester, and Pamela J. Headrick

We recently reported cobble-sized pieces of limestone bearing complex engraved designs found by collectors in early contexts at the Gault site (41BL323) in central Texas (Collins et al. 1991). In May and June, 1991, staff of the Texas Archeological Research Laboratory, University of Texas at Austin, students, and volunteers excavated in the area of these previous finds; additional engraved stones and numerous associated artifacts recovered in geologic context indicate that the engraved stones are Paleoindian and possibly very early Archaic in origin.

The investigated part of the site is near the head of a small valley where permanent springs and seeps from karstic Edwards Limestone bedrock give rise to Buttermilk Creek. Early cultural deposits are closely associated with the springs.

From the base upward (Figure 1a) are bedrock and five late-Quaternary units. Zone 1 is silty clay with carbonate granules, culturally sterile. Zone 2 is weathered and has downslope, fluvial (2a) and upslope, colluvial (2b) facies. Zone 2a is silty clay with carbonate granules and limestone clasts; only the



Figure 1. Gault site: a, schematic geologic section; b, Clovis point; c & d, engraved stones; e, blade core.

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upper 10 cm of this zone could be investigated due to ground water; recovered were one complete Clovis point (Figure 1b), a fragmentary Clear Fork tool, three Clovis blade segments, one Plainview-like point fragment, two engraved stones (Figure 1c and 1d), exotic quartz crystal and chalcedony flakes, debitage, and bifacial preforms and fragments. It is from lower in Zone 2a that collectors have reportedly recovered engraved stones and only Clovis diagnostic points at times of lower water table. Zone 2b is a massive clay loam with weathered limestone clasts; it yielded a few flakes. There is some mixing of Zone 2a and overlying Zone 3. The mixed zone 2a-3 yielded a unifacial Clear Fork tool, two earlyStemmed dart points, an Angostura point, a Plainview-like dart point, and debitage. Zone 3 is clay loam with carbonate granules; recovered were 4 engraved stones, a Scottsbluff point base, a San Patrice point, 3 Plainview points, a large blade core (Figure 1e), 3 Clear Fork tools, 3 Dalton adzes, 26 early-Archaic dart points, and debitage. Zone 4, the uppermost, is a dark anthrosolic clay loam with snail shells, burned rock, and debitage with middleand late-Archaic dart points.

These investigations recovered 6 engraved stones from early contexts; an additional 15 are now documented from the site (including 10 previously reported; Collins et al. 1991). These compare favorably to specimens from Folsom contexts at the nearby Wilson-Leonard site (41WM235) and the Clovis site (Hester, Lundelius and Fryxell 1972: Figure 93g).

We want to thank C. Vance Haynes, Jr., Shelton Properties (especially Emment Shelton and Jeffery Douchen), R. C. Harmon, R. J. Mallouf and staff of the Office of The State Archeologist, our student crew and other volunteers for their help.

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Excavations at the Bolton Site: An Early Paleoindian Crowfield Phase Site in Southwestern Ontario

D. Brian Deller and Christopher Ellis

Recognizing biases in previous southern Ontario early-Paleoindian (EPI) research to spatially/artifactually large sites associated with the strandline of

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pro-glacial Lake Algonquin (cf. Jackson and McKillop 1990), the authors directed a project in 1990 to investigate small sites in the "interior" of southwestern Ontario. From a data base of over forty known sites of this nature in southwestern Ontario, several sites were selected for investigation and we were able to carry out relatively extensive excavations at three of these sites.

One site investigated was Bolton (AfHj-89). A major reason this site was chosen for investigation was the recovery through surface collection of fluted bifaces of the distinctive Crowfield form which we have suggested represents the terminal EPI occupation of the area (Deller and Ellis 1984, 1988, 1991; Ellis and Deller 1990). Of the several suggested EPI manifestations in the eastern Great Lakes area, Crowfield is the poorest documented and is well known in Ontario only through excavations at the multi-component early- and late-Paleoindian Zander site (Stewart 1984) and the Crowfield site itself (Deller and Ellis 1984). Moreover, because the Crowfield site assemblage consisted largely of over 200 heat-fractured artifacts from a ritual feature, probably a cache of grave goods associated with a cremation, the possibility can be raised that rather than representing a distinct Great Lakes EPI manifestation, Crowfield points may represent a distinct form of ritual biface produced by groups who otherwise produced utilitarian points of another type. Hence, the investigations would help to evaluate that possibility.

The Bolton site is located some 25 km west of the modern city of London, Ontario, and some 6 km east of the Crowfield site. It is on a sand dune in a plowed field just below the strandline of pro-glacial Lake Whittlesey (ca. 13,000 yr B.P.). Some 184 m² was excavated at Bolton, and this seems to have uncovered most or all of the EPI component which consisted of two artifactually (and presumably functionally) identical but spatially distinct artifact clusters of ca. 50–75 m² each. In addition to EPI materials, evidence of Archaic and Woodland components was noted but detailed spatial analyses combined with a consideration of the raw materials used for tools allowed the separation of components (Ellis and Deller 1991).

The EPI occupation evidence consists solely of lithic tools/preforms and debris, as evidence of features was lacking. The twenty-six tools/preforms are dominated (42.3%) by eleven fluted bifaces or fragments thereof. Two of these bifaces are definite preforms, while five are finished points and the remaining items are of uncertain class. All of these bifaces conform to the Crowfield type, being very thin (<5 mm) and wide (>25 mm) with shallow basal concavities (<5 mm), markedly expanding lateral edges from the base, and the presence of long but often multiple flute scars. One of the preforms has a shoulder on one edge and was definitely intended for the distinctive shouldered Crowfield points reported elsewhere (Deller and Ellis 1984:44-45). The finished points are represented by two snapped bases, a mid-section and two snapped foresections, one of which was clearly tip-resharpened and then used as a projectile component as it has a tip impact fracture produced by such use. The remainder of the tools include a backed biface identical in form to those recovered from other Crowfield components (see Deller and Ellis 1984:46; Ellis and Deller 1988:114-115); a side scraper; four denticulated/retouched flakes; three

micro-piercers or gravers; a single distinctive combination tool incorporating a massive spur, denticulated edge and notches as reported from other sites (e.g., Deller and Ellis 1991); and five uniface fragments.

The flaking debris includes 256 items. Excepting three core reduction flakes, which may be a product of later site occupations, all the debris is dominated by small (<1.5 g each) thinning, finishing and resharpening flakes. Biface-reduction flakes (including thirty-one channel flakes) are most common among those items assignable to biface or uniface reduction (135 of 141 or 95.7%). With the exception of one Fossil Hill (Collingwood) chert waste flake (Storck and von Bitter 1989) and six flakes on a red chert of unknown source, all the debris and tools/preforms are on a high-quality Onondaga chert derived from bedrock outcrops some 130 km southeast of Bolton.

There is no convincing evidence that the Bolton site represents "ritual" activities. Although several of the tools exhibit evidence of heat exposure, this is also the case with much of the simple debris and also, artifacts representative of later site occupations. Therefore, we attribute this heat exposure to postoccupation natural processes such as a brush fire. The nature of the artifact assemblage, including evidence of point rehafting, resharpening and use as projectiles strongly suggests Bolton is simply an occupation site where fluted biface utilitarian-related activities were a major focus. The high percentage of fore-sections lacking bases (2 of 5 points or 40%) might also suggest that butchering and processing activities (done with denticulated flakes and backed bifaces?) were carried out, as fore-sections dominate on known EPI kill sites (e.g. Gramly 1982) and would be expected to be retrieved from carcasses during such activities. The small size of the site and the dominance of the fluted biface class suggest a relatively specialized occupation and that the site is a field (logistic) camp or a "location" of diurnal use in terms of forager settlement types (see Binford 1980; Thomas 1989:86-87). Overall, therefore, the site investigations support arguments made elsewhere (Deller and Ellis 1984:50) that Crowfield points are a utilitarian tool type.

Excavations at the Bolton site were financed by a grant from the Social Sciences and Humanities Research Council of Canada (#410- 90-1642) to the authors and B. Warner. We thank the SSHRC, Lawrence Jackson, Barry Warner, Paul Karrow, David Nobes and collectively, the large field crew for their support, James MacLeod for bringing the site to our attention, and the landowners, Mr. and Mrs. Charles Bolton, for their many courtesies.

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CA-SRI-1: A "Pleistocene" Shell Midden on Santa Rosa Island, California

Jon Erlandson and Don Morris

Santa Rosa Island is one of four northern Channel Islands located off the Santa Barbara coast (Figure 1). During the last glacial, lower sea levels united the islands as a single landmass known as Santarosae (Orr 1968). The islands have been separated from the mainland throughout the Quaternary, however, and contain a depauperate terrestrial fauna. On the northwest coast of Santa Rosa Island, stratified and highly dissected sediments span much of the past 100,000 years (Orr 1967). In a series of controversial Publications, Orr and Berger (e.g., Orr 1956, 1968; Orr and Berger 1966, Berger and Orr 1966; Berger 1982) argued for associations between humans, fire areas, and mammoth bones spanning the last 40,000 or more years. The cultural origin of these localities has been questioned by most scholars (e.g., Moratto 1984; Cushing et al. 1986), however, and accepted by few (e.g., Carter 1980).

Nearly lost in the debate about "mammoths and men" on Santa Rosa Island were "Pleistocene middens" noted by Orr (1968) at Garanon Point (CA-SRI-1),

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Figure 1. CA-SRI-1 and the Santa Barbara Channel region.

Tecolote Point (CA-SRI-3), Survey Point (CA-SRI-5), and Radio Point (CA-SRI-26). According to Orr, charcoal from shell-bearing soils at CA-SRI-3 and CA-SRI-5 produced uncorrected ¹⁴C dates of $11,900 \pm 200$ yr B.P. (UCLA-661) and $12,620 \pm 200$ yr B.P. (UCLA-141), respectively. The contexts and contents of these middens are poorly documented, and it is not clear exactly where the samples came from, partly due to Orr's habit of constructing idealized stratigraphic sequences from widely scattered localities. If verified, however, such 12,000-year-old coastal middens would have obvious implications for a number of issues related to the peopling of the New world.

In 1989 and 1991, we examined Orr's "Pleistocene midden" localities, hoping to clarify questions about their structure, contents, origins, and antiquity. To date, we have found no evidence for Pleistocene shell middens at any of the sites. CA-SRI-3 and CA-SRI-5 are very large and complex, however, and more fieldwork is required before definitive statements can be made.

At the previously undated CA-SRI-1, we appear to have relocated features and strata that Orr cited to support the existence of a possible Pleistocene shell midden. Here, Orr (1968:54, 143) described marine shells and human bones found in sea-cliff exposures up to nine meters below the surface and only six inches above mammoth bones. Our study has identified at least four shellbearing eolian or fluvial strata in the highly dissected sea-cliff exposures at CA-SRI-1. The uppermost is an extensive shell-, bone-, and artifact-bearing midden that has not been dated. About a meter below this upper midden is another relatively large midden that extends for about 80 m along the sea cliff and canyon wall. Artifacts are rare in this midden, although a flake and two crudely flaked cobble tools were found within it. A red abalone (*Haliotis rufescens*) shell fragment from this midden produced an uncorrected ¹⁴C date of $6,420 \pm 95$ yr B.P. (Beta-34923), equal to about 7,150 \pm 100 calendar years B.P. (Stuiver et al. 1986).

Less than a meter below this midden is a thin lens of marine shell fragments extending for no more than about 15 m along the sea cliff. The shells are mostly from large California mussels (Mytilus californianus), but black abalone (Haliotis cracherodii) and barnacle (Balanus sp.) shells also were noted. The shells are scattered through the upper 10 cm of a well-developed paleosol which rests upon a heavily calichified eolianite. This lower paleosol contains mammoth bones, including a cluster of bone fragments found just 10 cm (six inches) below the shell lens. This stratum appears to correspond to Orr's locality where midden and human bones reportedly were found six inches above mammoth bones. Mussel shell fragments from this shell lens produced an uncorrected ¹⁴C date of 8,320 ± 105 yr B.P. (Beta-34922) equal to about 9,050 ± 110 calendar yr B.P. No artifacts or human bones were noted in the shell lens, but its concentrated nature suggests that it is of cultural origin. Despite their spatial proximity, we found no evidence for a temporal association between the mammoth bones and the marine shells. Below the eolianite exposed in the sea cliff is a layer of yellowish alluvium that is several meters thick. In a vertical exposure of this alluvium, we found a single unmineralized black abalone shell in situ, along with a few fossilized oyster shells. The abalone shell eroded into the sea before it could be collected, but its stratigraphic position leaves no doubt about its Pleistocene age. Although Orr (1968:54-5) thought such isolated abalone shells had to be cultural in origin, we found no evidence that these shells were deposited by humans. They seem more likely to have been redeposited from shell-bearing beach deposits that Orr (1968:22) himself recorded on marine terraces at about 8, 23, and 75 m above sea level. The lowest of these beach deposits is exposed in the canyon walls upstream from CA-SRI-1, and contains well-preserved and unlithified shells-including abalone and other taxa common in Holocene middens of the area.

At present, the earliest relatively well-documented evidence for humans on Santa Rosa Island is the Arlington Man skeleton, for which charcoal and human bone samples have been ¹⁴C dated to about 10,000 yr B.P. (Orr 1962; 1968:87-92; Berger and Protsch 1989:59). Shell middens of roughly equal antiquity have been found on nearby San Miguel Island (Erlandson 1991) and on San Clemente Island (Salls 1991) off the San Diego coast. We have yet to find evidence supporting Orr's claims that even earlier shell middens exist on Santa Rosa Island. At CA-SRI-1, any "association" of 9,000-year-old marine shells (and possibly human bone) with mammoth bones appears to be coincidental—there presently is no evidence for a temporal or functional relationship between the two. It is conceivable that Orr's early middens at Survey Point, Tecolote Point, and Radio Point have been destroyed by sea-cliff retreat and other erosion in the nearly 30 years that have elapsed since Orr's fieldwork. If so, similar sites should eventually be found in the excellent sedimentary record on the island's northwest coast. To be fair to Orr, we have barely begun to tap the potential of the late-Pleistocene sediments of Santa Rosa Island, which he studied for over 20 years. Until more convincing evidence is found, however, Orr's claim for the existence of 12,000-year-old "shell middens" on the island remains unsubstantiated.

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New Evidence for Paleoindians on the Continental Shelf of Northwestern Florida

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Diagnostic Paleoindian artifacts were found on the continental shelf of Northwestern Florida 3.5 miles (6.5 km) out to sea in 15 feet (4.6 m) of water during June of 1991. The items were found along the margins of the relict Aucilla River, but their stratigraphic context is in reworked marine sediments.

The local area onshore is known for high frequency middle- and late-Paleoindian artifacts and probable associations with Pleistocene fauna (Anderson 1990; Dunbar 1991; Webb et al. 1984). The geologic regime is karstic, and archaeological remains are frequent in sinkholes which make up the river course. At the end of the Pleistocene, with much lower sea levels, these sinkholes were canyon-like features with pools of water. Now-extinct fauna found access to this water source, and Paleoindian hunters dispatched them there (Neill 1964).

Research into the potential of finding evidence for human occupation in stratigraphic context out on the continental shelf began in 1986. The initial research focus was on chert outcrops and discoveries of segments of visible relict river channels. Field sessions in 1986, 1988, and 1989 built an inventory of offshore archaeological sites including several lithic quarry locations (e.g., 8 Je 739, the Fitch site), a middle-Archaic shell midden and quarry (8 Ta 139, the Econfina Channel site), and a possible early-Archaic habitation site (8 Je 740). These discoveries range in distance from 3 to 6 miles offshore in 5 to 20 feet of water, and in time from 5,000 yr B.P. to possibly as early as 8,000 or 9,000 years old. A single radiocarbon date has been run on wood samples located at the Econfina Channel site (8 Ta 139; 5,140 \pm 100 (A-4696)), confirming an interpretation based on diagnostic artifacts discovered there.

Research specifically designed to find Paleoindian materials in stratigraphic context began in the summer of 1991. The objective was to seek a replicate of the Page/Ladson site inland (8 Je 591), whose setting is in a sinkhole of the modern Aucilla River (Dunbar et al. 1989, 1990). The technique was (1) to trace the subbottom course of the relict channel with remote sensing and to inventory sinkholes therein; (2) to core in potential sinkholes looking for deep sediments and possible "bone beds"; and finally (3) to excavate in the most promising of these sinkholes seeking in situ cultural items. The first two of these activities were successfully completed last summer (1991).

The diagnostic items were discovered by SCUBA-diver survey and systematic collections radiating from the margins of the newly identified course of the relict Aucilla offshore. They include a "Suwannee preform," diagnostic of mid-

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or possibly late-Paleoindian manifestations in Florida (Daniel et al. 1986), and the base of a fluted point or biface. These items were found along with other lithic debris in sandy shelly marine deposits directly overlying limestone bedrock.

The stratigraphic context observed at all offshore archaeological sites encountered to date in this drowned karst region is replacement of terrestrial sediments with marine deposits but with moderate disturbance of artifact clusters. Artifacts are not sorted to size and have no apparent wear by rolling or tumbling. However, there is some degradation by corrosion. Coring undertaken in relict river channel revealed a stratigraphic sequence of freshto-brackish-to-saltwater sediments within various sinkholes. A zone of dolomite cobbles and boulders impedes the coring of sediments below which are known by means of subbottom profiling and other stratigraphic exposures. We believe that in situ materials will be discovered below this dolomitic unit.

The potential of other discoveries along, and in this relict river in contexts that have not been disturbed by people since at least 5,000 years ago is great, and the excavation phase will begin this summer (1992).

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Early Occupations at Agua de la Cueva— Sector Sur, Province of Mendoza, Argentina

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Recent research in Agua de la Cueva—Sector Sur, a site located in the middle west region of Argentina, revealed the presence of final Pleistocene hunter occupations. Agua de la Cueva is a rockshelter situated in the northern mountain zone of the province of Mendoza, at 2,900 m above sea level.

Some remains belonging to early hunters had already been found in this region. In some cases, findings could not be dated accurately (Lagiglia 1979; Schobinger 1971); in others (Gambier 1974), radiocarbon dates were between 8,500 and 8,200 yr B.P. First occupations in Agua de la Cueva are about 2,000 years earlier.

Until now, 10 m² has been excavated. Lower strata, between 2.0 and 2.5 m in depth, yielded abundant lithic and osseous material, corresponding to hunter groups that are thought to have seasonally occupied this mountain region. Stratigraphic profiles show ten principal strata; early-occupation remains were recovered from the two lowest ones, composed by eolic deposits of light brown-yellow fine-grain sediment. These strata offered several hearths with a great deal of bones and lithic artifacts into and around each of them (more than two hundred instruments have been recovered from these early levels). Mixing of remains from different assemblages has not been observed in these lower layers. Evidence for rodent activity was found in some caves, but rodent alteration activity was restricted. So the association between bone (predominantly of guanaco) and lithic remains is very clear and undoubted.

The site location is strategic, for it is in the middle of a path which has been utilized during the last centuries, and surely also in prehistoric times. Likewise, there are some high plains ("pampas altas") nearby, extensive grasslands that provide a secure food resource to guanacos (Lama guanicoe), a wild camelid species. Paleoclimatic studies from northern Mendoza (Markgraf 1983) suggest that no drastic vegetational changes occurred during the last 11,000 years in the region; hence, hunting of guanaco was probably the main reason for the presence of man in that place from late Pleistocene until Spanish-Indian contact. In support of this, analysis of bone remains from the oldest levels (15% of which are burnt) points out that almost 90% are guanaco bones. Unfortunately, only a few mandibles were recovered, so we cannot confirm the seasonality through bone analysis. Instead, very significant is the complete absence of pits or marks of some kind of artificial shelter or dwelling, or a special place to deposit garbage. Moreover, Spanish chronicles relating to this area do not refer to the presence of permanent occupation sites in mountain zones, and no habitation sites or constructions from any prehispanic period have ever been

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found there. Also, hearth width indicates that the respective occupations were brief (hearths do not seem to have been "cleaned" or disturbed).

Commonly, winter temperature is very low, so these groups must have occupied the site solely during the summer period. It is quite possible that they lived in the "longitudinal valleys" west of the Precordillera (Uspallata or Calingasta Valleys) or in the eastern plain during cold seasons, and that they moved to high mountain zones by beginning of spring, following the movements of guanacos.

Up to the present, only a small part of lithic material from these early occupationshasbeen analyzed; therefore, technologic characteristics of debitage and morphologic features of instruments have not been well defined yet. However, according to a preliminary observation of the collection, some aspects can be pointed out: (1) Nearly all of the raw materials used in instruments making are local. These are mainly rhyolite, quartz and certain kinds of flint, all of which can be found in the surrounding area. Other rocks present, like obsidian, opal, basalt and quartzite, are not available in this area. (2) In general, instruments are big or medium-sized. (3) The morphological variability of the instruments is very evident. Most of them are scrapers and "knives," but there are no standardized types, and a great part of the instruments that do not fit typical descriptions are simply classified morphologically as convex, rectangular or concave, long or short, sharp, with half-abrupt or abrupt edges, with unifacial or bifacial retouch or natural edges showing "complementary traces." (4) Almost the entire collection of instruments presents unifacial retouch, even when some well-made bifacially retouched ones also appear. (5) There are relatively many multiple or double instruments, presenting several sharp and abrupt edges, most of them with unifacial retouch. (6) Only one fragment of projectile point was uncovered, and its shape, presumably lanceolate, could not be precisely inferred; it is 48 mm in length, thin, and its edges are convex, but the proximal part is absent.

There are two radiocarbon dates for these occupations. A charcoal sample from level 46 yielded a date of $10,350 \pm 229$ yr B.P. (Beta-26250). Another charcoal sample from level 45 yielded an age $9,840 \pm 90$ yr B.P. (Beta-26781). These dates have already been reported (García and Sacchero 1989). Analysis of the lithic collection from Agua de la Cueva will continue during 1992.

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The Denali Complex at Panguingue Creek, Central Alaska

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The central Alaskan Panguingue (pronounced *pan-ghin-ee*) Creek site (HEA-137) is located along the Nenana River, 4.5 km northwest of Healy, Alaska. The site was discovered in 1976 by T. Smith during a Nenana Valley archaeological reconnaissance survey. Test excavations in 1977 and 1985 revealed three separate cultural components ranging in age from 10,000 to 4,000 yr B.P. (Powers and Maxwell 1986; Powers et al. 1983). Full-scale investigations began in 1991; an area of 100 m² has been excavated.

The Panguingue Creek site is situated on a narrow, south-facing promontory of the Healy (early Pleniglacial) terrace, 200 m above the modern river floodplain. Here the Healy outwash is mantled by 1.8–2.0 m of sand and loess, late Pleniglacial to Holocene in age (Figure 1).

At the base of the sand/loess mantle is a 10-cm-thick silt loam lying uncomformably on the outwash surface. This unit is gleyed with minor oxidation mottles, some of which contain preserved rootlets. Capping this basal silt is a 1-m-thick unit of medium sand intercalated with 2-cm-thick bands of coarse sand, pebbles and granules. These bands are horizontally continuous, although difficult to see when the sediments are dry. Vertical cracks, occurring about 10 m apart, run from the top of the sand unit to the top of the underlying silt. These cracks are nearly 1 cm wide and filled with well-sorted, medium sand distinct from the surrounding matrix. Overlying the bedded sand is approximately 10 cm of unweathered silt loam. This is in turn capped by 30 cm of loam with intermittent lenses of granules and small pebbles. The top of the profile is characterized by a homogeneous silt loam 30 cm thick.

Four separate paleosols have been identified within the upper half of the section (Figure 1). The first of these, Paleosol 1, consists of 1 and sometimes 2 levels of discontinuous, nearly horizontal organic stringers. Each stringer is about 0.5 cm thick and at most 25 cm long. Paleosol 2, the dominant weathering horizon of this packet of sediments, is characterized as a nearly continuous, although contorted, 1- to 10-cm-thick Ob horizon, often with an associated Bwb horizon. Paleosols 3 and 4 are discontinuous organic-rich lenses lying just below, and sometimes within, the modern soil. The modern soil itself contains distinct Bw and gleyed BC horizons, with little evidence of organometallic leaching.

The Panguingue Creek sediments and their paleosols reflect changing depositional environments. The basal silt loam capping the outwash gravel appears eolian in origin, while the 1-m-thick bedded sand is probably a lowenergy colluvial deposit. The absence of pebbles and granules in the overlying silt loam suggests a brief interval of renewed eolian activity, in turn

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followed by the formation of a loam deposit perhaps through low-energy sheetwash colluviation. The discontinuous stringers of Paleosol 1 within this loam may in fact be nothing more than detrital organics. The silt loam capping the stratigraphic section is eolian in origin, and the three paleosols within this unit likely formed during brief hiatuses in wind-related sediment deposition.

Three separate cultural components have been found at Panguingue Creek, each occurring in direct association with the three upper paleosols. Component I is stratigraphically associated with Paleosol 2. Although three ¹⁴C dates have been obtained from this level, one (AA-1687) (on carbonized sediments) is noticeably discordant and has been discounted. The remaining two dates (both on natural charcoal) average $9,951 \pm 56$ yr B.P. The Component I lithic assemblage includes 1 subprismatic blade/flake core, 6 tools, and 60 flakes and debitage pieces. Tools include 2 transverse scrapers on short, wide flakes, 1 *chi-tho*, and 2 lanceolate projectile points. No features or faunal remains were recovered.

Component II, stratigraphically correlated to Paleosol 3, represents the major occupation of the site. Associated with this component are five ¹⁴C dates on cultural charcoal averaging $7,711 \pm 97$ yr B.P. Two separate activity areas 8 to 10 m in diameter have been identified, one of which contained a hearth feature characterized by a dense concentration of charcoal and calcined/ burned bone (Powers and Maxwell 1986). Poor organic preservation has



Figure 1. Representative stratigraphic profile from the Panguingue Creek site, showing associated paleosols, ¹⁴C dates, and lithic artifacts.

precluded faunal identifications. The lithic assemblage includes 9 cores, 60 tools, over 150 microblades, and over 5,000 flakes. Microblade cores (7 in number) are wedge-shaped and sub-conical. Tools include 5 lanceolate and 2 ovate bifacial knives, 7 side scrapers, 5 end scrapers, 5 burins (transverse, angle, and dihedral types), 10 burin spalls, 16 retouched flakes, 2 chopping tools, 2 *chi-thos*, 2 hammerstones, and 2 anvil stones.

ComponentIII, the uppermost component, occurs in stratigraphic association with Paleosol 4. Two dates (on natural charcoal) average $5,250 \pm 54$ yr B.P. Included in this component are over 20 lithic waste flakes, 2 end scrapers and 1 side scraper. Neither faunal remains nor features have been recovered.

Components I and II have been assigned to the Denali complex—both are early Holocene in age and contain artifacts characteristic of this central Alaskan lithic industry, as defined by Powers and Hoffecker (1989) and West (1981). Although lacking wedge-shaped cores and microblades, the Component I assemblage does contain transverse scrapers, *chi-thos*, and lanceolate bifacial points, which are commonly found among other Denali complex industries dating to about 10,000 yr B.P. (e.g., Dry Creek Component II [Powers and Hamilton1978], Mt.Hayes111 [West1981]). Such toolstyles donot appear in the more ancient Nenana complex industries pre-dating 11,000 yr B.P. (e.g., Walker Road, Dry Creek Component I [Goebel et al. 1991; Powers et al. 1990]).

Panguingue Creek Component II, with wedge-shaped cores, microblades, burins, and lanceolate bifaces, is likewise Denali complex in character; however, a number of technological and stylistic differences have been noted between this and other earlier microblade industries in central Alaska (Powers and Maxwell 1986). Artifact styles present in the Component II assemblage that are rare or absent at Dry Creek Component II and Mt. Hayes 111 (Goebel et al. 1991; West 1981) include sub-conical microblade cores, parallel-flaked bifaces, and end scrapers.

Component III, finally, lacks diagnostic cultural remains, making assignment to any specific cultural complex tenuous.

The finds at Panguingue Creek represent the first occurrence of successive, well-dated and well-stratified Denali-complex occupations at a single locality. More detailed analyses of these stone tool industries and their sedimentary contexts will ultimately lead to a greater understanding of the effects of climate change on human settlement in central Alaska across the Pleistocene-Holocene boundary.

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Archaeological and Pedological Investigations at Smiths Lake Creek (38AL135), Allendale County, South Carolina

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In 1985, a preliminary report was issued concerning chert quarries in Allendale County, South Carolina, which contained Paleoindian components in alluvially stratified deposits on the Savannah River floodplain (Goodyear et al. 1985). One of these sites, 38AL135, was particularly significant in that it possessed a stratigraphically discrete, alluvially buried lithic horizon 10 cm thick and 110–120 cm below surface. The chert artifacts from this layer are highly weathered, a condition typical of early-Holocene chert artifacts of the Southeastern U.S. Coastal Plain. The base of a partially fluted lanceolate preform of weathered chert, which matched the weathered chert from the buried layer, was found on the beach in front of this profile (Goodyear et al. 1985:Figure 1A). The site has received additional fieldwork, which allows geoarchaeological clarification of its context.

At the time of the initial report (Goodyear et al. 1985), fieldwork at 38AL135 was limited to surface collections in front of an eroding cutbank profile of Smiths Lake Creek which exhibited the stratigraphically discrete, cultural layer of chert debitage and tools; three 2-m² test excavations and 8-inch bucket-auger tests in the terrace behind the exposed artifact layer; and a two-day underwater archaeological reconnaissance to evaluate the presence of archaeological remains in Smiths Lake Creek, which yielded six lanceolate preforms. Since that time, three phases of fieldwork have been conducted

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which enhance considerably the chronological and geoarchaeological picture for the site.

A two-week underwater project was conducted in 1985 that was designed to recover samples of lithic technology associated with the inundated chert quarry known to exist in the channel of Smiths Lake Creek, and to recover artifacts which had collapsed into the creek from outbank erosion. Twenty-one different loci were dredged over a 120-m stretch of the creek. This resulted in the recovery of 12 Paleoindian lanceolate point preforms and two "fluted" blanks created by end thinning (cf. Callahan 1979). A Simpson point and a Dalton point were also found on the beach some 50 m downstream from the area of buried layer. Five early-Archaic notched points were also found underwater as well as a few hundred thermally altered bifaces probably related to a late middle-Archaic occupation of the creek.

In 1988, an intensive collection was made of all artifacts and flakes larger than 2 cm which had accumulated on the bank from the collapsing of the terrace in front of the buried layer. Prior to this, there was still some question about the assemblage purity of the Paleoindian layer. To wit, surface collections from the beach in front of the buried layer and resting on the terrace behind it at the same depth had indicated only a Paleoindian occupation. No early-Archaic notched points or any middle-Archaic points older than ca. 5,500 yr B.P. had been found. However, the underwater work also produced a few early-Archaic points indicating that, at least in the quarry area, the site was not absent in early-Archaic occupation. This is a critical consideration in the Southeast, as Paleoindian sites were often reoccupied by early-Archaic groups and, due to minimal sedimentation during this period, stratigraphic separation is slight or absent (Goodyear 1991). To further complicate the archaeology, except for the points, the lithic assemblages from both are greatly similar. Thus, to quickly and inexpensively increase the sample of diagnostic lithic material known to have come from the buried layer, artifacts were collected thoroughly from the beach in front of it.

This collection produced five more of the lanceolate preforms, which were similar in technology to those reported in 1985 from underwater (Goodyear et al. 1985:Figure 1). No early-Archaic diagnostic bifaceswerefound, strengthening the case for a pure Paleoindian lanceolate cultural identity for the buried lithic layer. A total of six preforms including the partially fluted base found earlier (Goodyear 1985:Figure 1A) can be confidently attributed to the buried layer. These preforms, plus at least 18 more that have come from the inundated quarry in the creek, indicate a non-Clovis, probably pre-Dalton type of Paleoindian lanceolate technology. The preforms are largely in the percussion stage of shaping, precluding a definitive diagnosis. However, the final state implied by the preforms would appear to be something like a Suwannee point.

Finally, in 1986, a pedological study of the terrace at 38AL135 was done by John E. Foss. Soil samples were taken and descriptions made of the cutbank bank profile plus two backhoe trenches excavated to a depth of 1.8 m (Foss 1986). The Paleoindian layer is associated with a fluvial sand with coarse or medium texture, which was classified as a C horizon (unmodified alluvium) or BC horizon, when a sandy loam. The sands are overlying two B horizon paleosols, which fits a geoarchaeological pattern seen elsewhere in the Piedmont portion of the Savannah River as well as the floodplains of the Southern Appalachians (Goodyear 1991). The pattern is that of initial Holocene fluvial sands overlying terraces marked by probable Pleistocene B horizon paleosols.

In sum, 38AL135 appears to be a single-component, middle-Paleoindian (10,900–10,500 yr B.P.) quarry and quarry-related site, essentially sealed under 1.0 m of alluvium. In the area of the buried lithic layer, there is no evidence for an early-Archaic occupation thereby providing unusual stratigraphic purity for a southeastern U.S. Paleoindian site. Plans are being made for extensive excavations and more detailed geoarchaeological studies.

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Paleoindian Archaeology at McFaddin Beach, Texas

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On November 15 and 16, 1991, a conference was held in Port Arthur, Texas, to examine and evaluate archaeological remains from McFaddin Beach (4IJF50), a locality on the upper Texas coast. The site was originally published by Long

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(1977) and is best known for the large number of Paleoindian projectile points found there over the years. These include more than 65 Clovis points. Earlier study and photography of some of the McFaddin Beach materials had been done by Story and Lawrence Aten in 1987 (on file, Texas Archaeological Research Laboratory, The University of Texas at Austin).

The 1991 conference was organized by Story, Turner and Tanner, and was designed to bring together professional archaeologists and geologists with avocational archaeologists and collectors who had frequented the beach, some since the 1960s. In addition to the authors, other researchers at the conference included Sherwood Gagliano, Paul Goldberg, Richard Weinstein and Don Wyckoff. Local participants were contacted by Tanner and Long, and 27 collections were assembled for review, photography, and preliminary documentation.

McFaddin Beach is a locality about 24 km in length, stretching from High Island on the west to Sea Rim State Park on the east. Lithic artifacts, sometimes beachrolled but sometimes little altered, occasionally wash ashore, along with Pleistocene faunal remains. Examination of several kilometers of beach at the time of this conference revealed little more than a flake and some weathered faunal remains. In essence, discovery of artifacts and fauna is the result either of serendipity (some collectors have worked the beach for a year or less) or dogged persistence, year after year.

Geological studies by Pearson (1977) have provided a fairly detailed picture of geomorphological change and sea-level rise at McFaddin Beach. Briefly put, the coastline at the time of Clovis was about 80 km to the south and 120–140 m below present sea level. The continental shelf was cut by a deeply entrenched Sabine River, flowing at that time through earlier deltaic deposits formed by the Trinity River, which had abandoned the area around 20,000–25,000 yr B.P. The McFaddin Beach archaeological and paleontological remains are presently eroding from submerged relict deltaic landforms—an upland area not fully inundated by rise in sea level until 2800 yr B.P. Wave action, particularly at times of elevated wave energy, transports the dislodged materials and deposits them on the present-day beach. The older artifacts tend to be pristine whereas the younger types are heavily rolled. This is interpreted as evidence that erosion has relatively recently cut into older deposits. The geologic scenario fits well with the archaeological remains, which are truncated in late-Archaic times.

Space permits only a few summary observations on the McFaddin assemblage. Pearson (1983:1) has listed the Pleistocene fauna as "mammoth, mastodon, peccary, deer, horse, bison, sloths, giant armadillo, sabre-toothed cat . . . small mammals, fish, and turtles." He notes a radiocarbon assay (laboratory not given) on mammoth tusk of 11,100 \pm 750 yr B.P.

Paleoindian artifacts include numerous Clovis points, some of great length and others much reworked, a Clovis preform, Clovis blades, a single Folsom point (of Keokuk variety, Boone Chert, Oklahoma), San Patrice, Scottsbluff, Pelican, Golondrina, Dalton, Midland (?), Plainview, and Angostura. Three of the large Clovis points (120+mm in length) are highly similar in workmanship and raw material. These were found in close proximity along the beach, and two were found within days of each other. These circumstances raise the possibility that a cache was disrupted and at least some of its contents washed onto the beach. Early-Archaic diagnostics include Big Sandy and Bell; the middle to late Archaic includes the Gary, Evans and Pedernales types, and Poverty Point-related forms, such as Pontchartrain, Epps, and Delhi. Banks observed that 90–95% of the raw materials are central- and east-Texas cherts. One Archaic-style contracting stem biface of obsidian has been sourced by Precise X-Ray Fluoresence technique at the Lawrence Berkeley Laboratory (F. Stross, F. Asaro and R. Giauque, pers. comm.) to the source at Zacualtipan, Hidalgo, Mexico, more than 1000 km to the south.

The McFaddin Beach data offer a tremendous resource for the study of typology and technology of Paleoindian and later assemblages on the upper Texas coast. Eventually, investigation of offshore deposits may be warranted.

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Folsom Occupation at the Waugh Site in Northwestern Oklahoma

Jack L. Hofman, Brian J. Carter and Matthew Hill

The Waugh site (34HP42) was discovered in January 1991 by Leland Waugh when he found a Folsom point in association with bones of *B. bison antiquus* eroding from a dry stream bank in southwestern Harper County, Oklahoma. The site is located on a tributary of Buffalo Creek, which drains into the Cimarron River, and is close to the narrow divide separating the Cimarron and North Canadian rivers. The Waugh site is about 85 km northeast of the Folsomage Lipscomb site (Hofman et al. 1991; Todd et al. 1992). Limited field investigations were made in February and May 1991, primarily to map the finds, recover exposed bone, establish datum points, and provide initial profile descriptions (Hofman and Carter 1991). Four localities have now been defined at the site; three are upstream from the original Folsom bonebed discovery, which is designated Locality 1.

Locality 2 is some 200 m south of Locality 1, on the west stream bank, and

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consists of mammoth bone elements in colluvial material on a high terrace deposit. The terrace fill below the mammoth includes gray ponded deposit of late-Pleistocene age, which contains an abundant snail fauna and limited vertebrate material. Limited excavation to recover a partially exposed mammoth (*Mammuthus*) ilium produced no artifacts. Locality 3 is about 90 m south of the original find and consists of bison (*Bison bison antiquus*) bones including articulated thoracic vertebrae and ribs eroding from the east bank at approximately the same level as the original find. A flake of Edwards chert was found near these bones, but no excavation has been conducted. Locality 4 is some 40 m south of Locality 3 and was the find spot of a mammoth tooth and unifacial tool of Alibates flint. Further evaluation of these localities is planned for 1992, but the primary concern of this note is with the original discovery area at Locality 1.

The deposit in Locality 1 is valley fill composed of alluvium and colluvium inset against Permian sandstone and shale of the Rush Springs formation. The bonebed occurs in sandy alluvium about 1.5 m above Permian bedrock. There is no evidence of a stable surface, lithiological discontinuity, or soil at the level of the bonebed which was covered soon after the carcasses were deposited. Rapid burial is also indicated by several articulated units, limited surface-bone weathering, and the lack of evidence for carnivore gnawing. There was apparently a period of rapid filling in the stream valley which resulted in burial of the bonebed by more than 3 m of sands and gravels during the early Holocene, before later erosional events recut the channel re-exposing bonebed level.

A thin (ca. 5 cm) gleyed horizon is associated with and limited to the lower periphery of the bones. This gray sediment apparently resulted from reduction of iron-containing compounds originally in the parent soil material and still obvious throughout the surrounding reddish soil matrix. Decomposition of organic matter (carcass remnants) by facultative aerobic and anaerobic microorganisms produced the gray reduced soil from the red-oxidized matrix.

The bison bones which originally drew attention to the site were on the margins and floor of a short deep gully cut into the east bank of the stream. This small gully has provided a partial stratigraphic profile of the valley fill in the immediate bonebed area (Hofman and Carter 1991). The full extent of the bonebed remains unknown, but in situ elements have been documented across an 8-by-10-m area. A number of the larger bison bones were removed or dislodged prior to our investigation, and the remaining material was mapped in place (ca. 100 pieces) or recovered from fine screening about 20 1-by-1-m units. The surface and fine-screened bone material (ca. 6,800 bone fragments with an average weight of 1.2 gm) reflects a high frequency of rectilinear drybone breakage, which is also evident on much of the in situ mapped material (Hill 1991). No definite green-bone breaks have been observed, and the only possible cut marks occur on the proximal shaft of a metatarsal.

An MNI of five is indicated to date. Although there are some articulated elements, each skeleton is represented by only a fraction of its original bones. A high degree of disarticulation is indicated, but whether this is primarily due to modern erosion and disturbance, past taphonomic factors, or cultural action remains to be evaluated. The most complete articulation includes a skull-through-thoracic unit, with associated ribs and scapula, of a large adult male. Two additional large (mature male) atlas vertebrae are represented, as are some large forelimb elements and phalanges. A smaller (female) adult bison is represented by a distal humerus and proximal radius. The fifth animal is immature and evidenced by small unfused elements including a radius, metacarpals, and femurs.

Size of the measurable humerus and radius pieces indicates that the Waugh male bison were very large and comparable to the largest males from the Lipscomb Folsom site (Todd et al. 1992). The smaller mature elements are similar to the mean size of the females from Lipscomb. Mandibles and teeth are fragmentary, with the only lower molars being in full wear and from an old adult, so no seasonal estimate for the time of death has been made.

No radiocarbon dates are available for the site. No charcoal has been encountered during the limited testing, and chemistry of one bone sample indicates that it would not produce a reliable radiocarbon date. Therefore, chronometric dating of the site must await further investigation.

Artifacts recovered are limited to two projectile points, two scrapers and a few flakes. A nearly complete Folsom point manufactured from Edwards chert and exhibiting an impact-damaged tip wasdiscovered among the bison bones when the site wasfirst visited. A second Folsom point, represented by an impact-damaged tip is manufactured from Alibates flint and was found during fine screening of the sediments from around the in situ bones. Three small flakes representing Edwards chert and unidentified material were also recovered during screening of the bonebed matrix. Two scrapers have been found on the terrace immediately east of and above the bonebed. This terrace was probably the closest level area near the bonebed where camp and processing activities could take place. One spurred endscraper of Niobarara jasper and a sidescraper/wedge tool made of Alibates flint were found in this area about 20 m east of the bonebed.

The lithics include materials with sources from about 250 km north (Niobarara), 200 km southwest (Alibates), and 440 km south (Edwards chert) of the site. Although these distances are not unusual for Folsom sites, this is the first Folsom site where these three lithic types are thought to occur within the same assemblage.

The position of the Waugh site, in the upper reaches of a stream that heads at a very narrow bottleneck area on the Cimarron and North Canadian River divide, is similar to the situation recognized for other Paleoindian and later bonebeds in the region. This suggests the possibility that an intercept hunting strategy was used during periods of east or west bison movement along the major river divides on the Southern Plains.

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Re-investigations of Sheguiandah Site Geochronology and Geoarchaeology

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The Sheguiandah site on Manitoulin Island in northern Ontario was discovered and excavated by Thomas Lee in the early 1950s. The site was interpreted to contain artifacts in glacial deposits (till) below an Eastern Plano stratum, and thus was argued to document greater antiquity for human occupation in the New World than was generally accepted at the time (Lee 1954, 1955, 1956, 1957; Sanford 1957). The lack of a final excavation report on the site and the continued controversy over the antiquity of human occupation in the New World have caused the reports from Sheguiandah to remain both interesting and ambiguous (e.g., Lorenzo 1978; R. Lee 1986).

In 1989 the senior author initiated a re-analysis of existing samples of archaeological and geological materials. The controversial "till-like" sediments containing artifacts are diamictons (mixed). However, the quartz sand-grain surface morphologies are not characteristic of continental glacial deposits (Julig et al. 1991). Also, some of the artifacts appear to have been "water worn," and conjoinable pieces indicate considerable post-depositional mixing of site sediments in the habitation area.

This paper reports on renewed efforts in 1990 and 1991 to resolve the outstanding questions on the age, environmental context, and cultural affiliation of the people who deposited the artifacts in the so-called "till" deposits and were interpreted by Lee (1957) to represent pre-Paleoindians dating to 30,000

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yr B.P. or greater. These investigations were conducted mostly within the context of a CRM Archaeological Master Plan study commissioned by the local municipality of Howland Township and the Native Reserves of Sucker Creek and Sheguiandah, and carried out by Archaeological Services Inc. under the overall direction of Dr. Ron Williamson.

Five cores were taken from swamp 3 in November 1990, with the assistance of Dr. Thane Anderson of the Geological Survey of Canada. Lee (1957) determined through excavations that the depths of sediments in swamp 3 were about 2.7 m, with the base of the peat at approximately 1.7 m. Lee had reported quartzite artifacts at the interface of the basal organics and underlying mineral sediments, with the date of the peat dated $9,160 \pm 250$ yr B.P. (W-345). We obtained five TMAS radiocarbon dates from our cores. Three of these dates, from the interface of the basal peat and underlying mineral sediments (160 cm. $9,230 \pm 80$ yr B.P. [TO-2345 wood], 170 cm. $9,440 \pm 80$ yr B.P. [TO 2346 peat], 190 cm. $9,170 \pm 80$ yr B.P. [TO-2347 wood]), are comparable to the date previously reported by Lee (1957).

Excavations in the so-called habitation area were to examine the cultural and natural stratigraphy reported by Lee (1957) and Sanford (1957), particularly the controversial mixed deposits with artifacts, stratigraphic levels III and IV. These strata occur within the upper 50 to 75 cm of the sedimentary sequence, within the B soil horizons, and are considerably altered by pedogenic processes. These sediments are diamictons (mixed), but do not have the characteristics of primary glacial deposits, as claimed by previous investigators. First, these deposits contain no evidence of till fabric, and oblong pebbles and artifacts in the matrix are randomly oriented. Secondly, these diamictons overlie a boulder pavement at the 0.6 m level in the habitation area, but the boulders lack consistent glacial striations on their upper surfaces, which would be expected if the overlying mixed deposits were till. Also, as mentioned above, the evidence from conjoinable artifacts indicates considerable post-depositional mixing of local sediments, with some refitted biface fragments crossing four of Lee's (1957) stratigraphic levels. Finally, SEM studies of surface textures on fine and very fine quartz sand grains from these diamictons indicate no fresh glacial crushing, abrasion, or other surface textures characteristic of transport by glacial ice (Krinsley and Doornkamp 1973; Mahaney et al. 1988).

It appears that the controversial mixed deposits are not till but rather colluvium and/or nearshore beach sediments, considerably altered by pedogenic processes, and mechanical mixing (such as tree falls). Research is continuing on the cultural and geological history of the site, and to determine whether it may have been flooded by the proposed early Mattawa flood event from Lake Agassiz at ca. 9,600 yr B.P. (Lewis and Anderson 1989). To this point, the evidence indicates that Sheguiandah was probably inhabited first by Eastern Plano people, probably about 9,500 years ago.

Analysis of collections and sediments obtained by Thomas Lee nearly 40 years ago was supported by research grants to P. Julig from the Social Sciences and Humanities Research Council of Canada and the Ontario Heritage Foundation. Robert Lee provided valuable information on the work of his father, Thomas Lee. Geological consultants included Thane Anderson, Peter Barnett, Paul Karrow, and Peter von Bitter, and their help is gratefully acknowledged. The Royal Ontario Museum provided travel support to visiting consultants.

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Japan's "Early Paleolithic": A Changing Controversy Charles T. Keally

The controversy over the Japanese "early Paleolithic"—defined as everything older than 30,000–35,000 years—began seriously in the 1960s with Serizawa's excavation at the Sozudai site and his hypothesis of a "Chert Culture" based on his excavations of the Hoshino and Iwajuku Location D sites. Serizawa's hypothesis was never widely accepted in Japan. The first major turn in the controversy came with the excavation of a number of sites in Miyagi Prefecture beginning in the late 1970s. These sites were more widely accepted. The controversy now seems set to take another major turn, with several new publications by the Miyagi archaeologists and with the recent excavation of the Ohira site in Fukushima Prefecture. One of the publications by a Miyagi archaeologist presents a detailed argument against Serizawa's "Chert Culture,"

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the first published criticism of Serizawa's hypothesis by one of his own colleagues (Okamura 1990). This publication finally puts all major participants in the "early Paleolithic" controversy on record as opposed to the "Chert Culture," with the exception of Serizawa himself.

Initially the support for the Miyagi hypothesis was based mainly on materials excavated from the Zazaragi, Nakamine C, Shibiki and Babadan A sites (Keally 1987). This scheme also included Serizawa's Sozudai materials. But many archaeologists and geologists expressed doubts about these materials (Oda and Keally 1986; Keally 1987). Recently the arguments in favor of the Miyagi "early Paleolithic" have been strengthened by the publication of three volumes of research on the Babadan A site (Tohoku Rekishi Shiryokan and Sekki Bunka Danwakai 1986, 1988, 1989), and by detailed reports published on the Aobayama B (Sudo et al. 1987) and Takamori sites (Sekki Bunka Danwakai 1991). These reports add many more reasonably consistent radiocarbon, fission-track, and thermoluminescence dates, as well as some equally consistent dates based on amino acid racemization, electron spin resonance and depositional remnant geomagnetism. Several well-dated widespread tephras have been clarified in the geological sequence, adding further support to the early dating given to these sites. Additional support for the human origin of the lithics comes from analysis of natural remnant magnetism that has found spots thought to be burnt earth ("hearths"), analysis of lipids on some of the lithics that has tentatively identified as Nauman's elephant (Paleoloxodon naumanni) and Yabe's elk (Sinomegaceros yabei) (Nakano 1988), use-wear analysis that has determined human functions for some of the "tools," and intra-site distribution analysis that has shown patterns suggesting human activities.

Still, those archaeologists who have opposed the Miyagi hypothesis continue to point to the many problems in the dates, the lack or near lack of refittable pieces (evidence of tool manufacturing), the lack of non-local stone, and the lack of vertical displacement of the lithics. Refittable pieces, non-local stone and vertical displacement of 15-50 cm are universal characteristics of late-Paleolithic sites in Japan, and it seems odd that this is not the case with the "early Paleolithic" sites. These archaeologists have also raised serious questions about the validity of the remnant-magnetism studies finding "hearths," the lipid studies so conveniently finding the generally imagined main prey of the Paleolithichunters, the use-wear studies finding indications of human functions rather than natural scratches, and the distribution studies demonstrating human activities rather than random scatterings or natural clusterings. Despite the volume of new support, the controversy over the Miyagi materials seems to be stalemated. The Ohira site (and a handful of related sites) is the most recent candidate for "early Paleolithic" status. But unlike the other sites proposed as "early Paleolithic," there is absolutely no question about the human workmanship of the Ohira artifacts, and the context and dating both seem relatively secure. The loam deposits in which the artifacts were found are quite similar to those in South Kanto late-Paleolithic sites, which everyone agrees are primary tephras. The key layers at Ohira are distinctive and should be easy to identify accurately on the site (microscopic analysis is in progress to confirm this identification). There are many consistent dates for these key layers, all

from other locations and all determined by geologists prior to the Ohira excavation. And at least some of the lithic materials are not local. Moreover, typologically and temporally the Ohira artifacts could be predecessors of the oldest late-Paleolithic artifacts in eastern Japan. The only possible problem I see at the moment is the small chance that the key layers at Ohira have been misidentified. Given the information that is already available, however, I think this is very unlikely. What is more likely is that Ohira will soon become the first fully accepted Japanese site dating earlier than 35,000 years ago. Although this will only push the age of the first fully accepted human settlement in Japan back by 10,000–15,000 years, it should at least move the controversy off of dead center.

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Paleoindian Occupation at Piedra Museo Locality, Santa Cruz Province, Argentina

Laura Miotti

During the last two decades, archaeological research in the Patagonian region has renewed the interest in Paleoindian occupations. These investigations bring outreliable information about Pleistocene peopling and the relationships between the first Americans and the massive Pleistocene extinctions. In this context Fishtail projectile points (FPP) are considered to be diagnostic indicators of South American Paleoindians.

The pioneer excavations in southern Chile (Bird 1938) suggested the presence of new archaeological contexts of early hunter-gatherers. In these levels the major technological feature was the FPP. These lithic artifacts were associated with extinct megamammals and hearths (Bird 1938), and dated between 11,000 and 10,000 yr B.P. (Bird 1969). However, for many years since Bird's findings in Fell and Palli Aike sites, archaeologists only recorded these points surficially. Recently, several FPP were found in central Chile and Argentina with accurate stratigraphic provenance and associated cultural and faunal materials. These findings are accomplished in the Cueva del Medio site (Nami 1987), Tagua-Tagua site (Nuñez Atencio, pers. comm.), both in Chile; and Cerro La China and Cerro El Sombrero sites in Pampa Region (Flegenheimer 1980, 1987) and AEP-1 site at Piedra Museo locality in the Patagonian region, Argentina. The last site mentioned is the first in the south cone of Argentina with FPP in stratigraphic context.

The aim of this paper is to present the first archaeological results of our fieldworks at Piedra Museo locality (Santa Cruz province). In the AEP-1 site one archaeological component with this type of projectile point was discovered in stratigraphic sequence (Miotti 1990). This finding shapes the first reliable FPP of Patagonia, Argentina.

Our present research in Central Plateau of Santa Cruz province is especially focused on Piedra Museo and nearby localities, between 30 and 100 km east of Los Toldos; likewise with Paleoindian contexts (Cardich et al. 1973). In Piedra Museo, Paleoindian lithic artifacts, located surficially, workshops and quarries have been found. The fieldwork showed a cultural sequence with abundant archaeological and faunal records. The archaeological levels seem to be a reliable means for understanding the early peopling of southern Patagonia; radiocarbon datings are still being processed.

Piedra Museo is an endorreic basin, surrounded by a bed bench of conglomeratic "tobas" corresponding at La Matilde Member of Bahía Laura Group, Cambrian Formation. The main caves and rockshelters display several prehistoric art aggregates of paintings and grooves.

The AEP-1 site was excavated during 1990, and at a depth of 120 m a

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Figure 1. Profile walls NW and SW, Rockshelter AEP-1, Piedra Museo locality.

fragmented FPP was recorded (Figure 1). The raw material is a red ftanita with high content of ferrum oxide. A few artifacts and bone remains were associated. However, the faunal assemblage is very significant because bones of one species of a small extinct camelid [*Lama (Vicugna) gracilis*] were identified. This component could be related to the early peopling of the Patagonian Region, which at present occurs in a few localities with this particular projectile points: Fell 1 and Cueva del Medio lower component. Besides, it could be related with Nivel II and initial Toldense components of Los Toldos locality, although these did not get FPP, but it seems to have similar lithic technology in the other artifacts. Likewise, extinct species of megamammals were associated in the contexts.

At 0.70 m above the oldest archaeological component of AEP-1 was registered other context, with hearths, remains of living autochthonous fauna and lithic artifacts similar to those of Fell III, late-Toldense Industry, and Regional level Rio Pinturas I; all of them assigned at early Holocene (Miotti 1989). It is expected that new excavations at Piedra Museo Locality will throw light on the Paleoindian occupation in the south cone of South America.

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Additional Blades from Blackwater Draw Locality No. 1, Portales, New Mexico

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Five more blades have been discovered at the Blackwater Draw Locality No. 1. The blades are assigned to the Llano complex based on inferential evidence. While monitoring erosion along the west bank south of the Mitchell Locality (Boldurian 1990) for erosion, two blades were discovered in sediment from a collapsed portion of the west bank wall. The largest blade had its tip missing. Two months later, three blades were found in the same area, although further downslope. A month after this, the tip of the first blade was discovered partially exposed downslope.

All five blades were created by the indirect-percussion or a punched-blade technique. The small oval striking platforms on all the blades are well prepared and range from 50 to 60 degrees on the "vertical removal angle" (Tunnell 1978).

The blades are a very fine cryptocrystalline chert. Three of the blades vary in shades from light to dark brownish gray with some mottling and inclusions of brown specks. Two blades have the graytones, and the cortex is thinner and not as weathered. Two other blades have 2 mm thick cortex on a portion of the dorsal side.

Artifact 1. The size is $15 \times 5.6 \text{ cm}$ and 1.5 to 1 cm. The flat bulb of force has two round eraillures. The multifaceted platform has a prominent lip and measures $4 \times 17 \text{ mm}$. The blade has two previous blade removal scars on the dorsal side. The tip is missing. It has one dorsal arris. Retouch (edge damage) appears on both lateral edges.

Artifact 2 (tip of artifact 1). The tip measures $7 \times 5.3 \times 1.2$ cm thick at the snap. Only the 2-cm-wide triangular-shaped tip has been bifacially retouched.

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The lateral edges are unifacially retouched. When fitted with Artifact 1, the entire blade measures 21.5 cm long.

Artifact 3. This blade measures $12 \times 3 \times 0.6$ cm. There are three previous blade scars on the dorsal face. One major dorsal arris with two other blade scars is located near one lateral edge. The prepared platform measures 2×4 mm. The bulb of force is very flat.

Artifact 4. This blade measures $13.5 \times 4.4 \times 1.4$ cm. A central arris runs the length of the blade with two previous blade scars on one side and four blade scars perpendicular to the central arris on the other. The blade has a well-prepared flat striking platform that measures 3×5 mm and a flat bulb of force. A thin lip is on the ventral side.

Artifact 5. This blade measures $13 \times 4 \times 1.5$ cm. The arris travels down the center of the blade. The striking platform has been damaged. The flat bulb of force has been removed with an eraillure flake.

Artifact 6. This blade measures $13.7 \times 3.4 \times 1.2$ cm. Two blade scars are visible on the dorsal side. One arris travels almost down the center. The other arris is on a lateral edge. The small oval platform is damaged. A small flake removed from the dorsal side also removed part of the striking platform. There is a lip on the ventral side and a small, flat bulb of force.

Several blade tools associated with the remains of four mammoths (*Mammuthus*) were excavated in 1962 and 1963 by the El Llano Archaeological Society (Hester 1972). These mammoth were located 72 m east of the new blades. F. E. Green discovered a cache of 17 punched blades 260 m south of this area in 1962 (Green 1963). These five blades are very similar in technology, material, and size to the cache of 17 blades. Finding these five blades reinforces the fact that Llano complex lithic manufacture employed a characteristic blade technology.

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The Puckett Site (40SW228) A Paleoindian/Early Archaic Occupation on the Cumberland River, Stewart County, Tennessee.

Mark R. Norton and John B. Broster

The Puckett site (40SW228) is located on the banks of Lake Barkley, within the Cross Creeks National Wildlife Refuge, in Stewart County, Tennessee. This location is within the floodplain of the Cumberland River near the confluence of an unnamed tributary. This portion of the Cumberland River is within the Western Highland Rim physiographic region. An Archaeological Resource Protection Act permit (ARPA No. 02-TN-1-91) was issued to the Tennessee Division of Archaeology by the U.S. Department of the Interior, Fish and Wildlife Service, to perform limited test excavations at 40SW228.

Two Dalton projectile points (Figure 1) were recovered from an intact cultural midden deposit (2.55 m below surface), varying from 8–16 cm thick within test unit 1. Wood-charcoal flecks recovered from this deposit were radiocarbon dated 9,790 \pm 160 yr B.P. (Beta-48045, uncorrected). Modern botanical and synthetic remains were recovered from the upper levels of test unit 1, confirming the reported looting activities within this area.

A second 1-by-1-m test unit was excavated to ascertain the complete cultural occupation of this site. The undisturbed midden deposit was encountered at 1.67 m below surface, which varied from 69–74 cm thick. Four Kirk Cornernotched projectile points were recovered from this deposit, which was



Figure 1. Dalton projectile points recovered from the Puckett site.

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radiocarbon dated at8,490 ± 180 yr B.P. (TX-7413, uncorrected) and 8,820 ± 180 yr B.P. (TX-7412, uncorrected).

Of the total 4,777 lithic artifacts recovered from these excavations, tertiary (n = 2323) and angular debris (n = 2380) compose the majority of this assemblage. The small number of primary (n = 11) and secondary (n = 17) decortication flakes suggests that prepared blanks were transported to this locale for biface/projectile point manufacture. The two Daltons and the four Kirk points recovered were considered expended projectiles, which along with the decortication data suggest use of this site as a rearmament locality.

The radiocarbon date for Dalton at the Puckett site represents the first radiometric determination for Dalton in Tennessee. This date falls within Goodyear's (1982) speculative range for Dalton in the southeast.

The radiocarbon date for Kirk Corner-notched at the Puckett site represents the first radiometric determination for Kirk in middle Tennessee. This date is comparable to the radiocarbon dates obtained from the Little Tennessee valley in east Tennessee (Chapman 1976).

The Puckett site represents one of the most extensive and important Paleoindian/early-Archaic sites in middle Tennessee. Additional research is needed to determine (1) the exact size and extent of the intact midden, (2) whether or not the site is single or multifunctional, and (3) the complete occupation sequence for the site area.

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Butler 1991: Excavations at a Fluted Point Site in the Central Great Lakes (20 GS 104)

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Excavations at the Gainey site (Simons et al. 1984) were interrupted in 1991 to work at the Butler Site (20GS104) in Genesee County, Michigan. Butler will be developed as part of a 344 ha housing complex commencing in 1992. Developer Brian Mansour was very supportive of our excavations for an archaeological

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salvage. Volunteers excavated 1,166 m² and recovered a major inventory of Paleoindian cultural materials.

Butler, 1.6 km east of Gainey, is located on a prominent sandy hill with an elevation of 283.4 m above sea level. To the west and south a mix of marsh and low-relief fields are drained by sluggish streams.

Butler was discovered when a distal biface fragment, exhibiting part of a fluting flake scar on one face, was recovered in 1988. The biface is similar to more complete fluted bifaces from Gainey and from the Leavitt site (M. J. Shott in press).

To test Butler, the fallow field was moldboard-plowed and worked with a spring-tooth drag. Grid points were installed, and all cultural products were plotted. The productive areas were selected and gridded for excavation. The adjacent areas were tilled and collected throughout the season. This procedure was extremely effective in locating tool clusters for excavation and in recovering material from low-density loci.

Over 95% of the formal tools are manufactured on nodular Bayport chert which outcrops north of Saginaw Bay. Other cherts are Upper Mercer from east-central Ohio and Stoney Creek from southeast Michigan. A partial inventory includes 26 whole and fragmentary bifaces intermediate between Gainey and Parkhill samples (Figure 1a-c), 5 fragmentary bifaces without fluting, 5 fluting flake fragments, 22 single- and multispurred gravers (Figure 1f and g), 63 complete and 45 fragmentary endscrapers including unusual notched examples (Figure 1d and e), 44 complete sidescraper/knives and over 200 miscellaneous fragments of large flakes, most of which exhibit some degree of unifacial retouch. Uncommon forms include an alternately beveled biface, two narrow endscrapers (Figure 1h), one bladelet with fine bilateral retouch and several bipolar-derived flake and core tools made on quartzite. Many of the end- and sidescrapers are made on secondary decortication flakes. Bifaces rarely exhibit cortical remnants. Most bifaces and large sidescraper/knives exhibit evidence of heat alteration. The ratio of waste flakes to tools is very low at Butler. The major category of debitage consists of scraper retouch flakes with a lower incidence of bifacial retouch flakes. Our excavations defined four major and two minor discrete cultural clusters of artifacts. The major clusters each had fluted bifaces and the tool types mentioned above. Both minor clusters consisted almost exclusively of endscrapers.

The authors wish to thank the many participants who volunteered to share the effort of this project. We are especially grateful for the contributions of Scott Beld, Tom Lavey, Micke Mauer, and Pat Sarver.

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Figure 1. Butler Site artifacts: bifaces a-c; unifaces d-h; Chert types: Bayport a-f and Upper Mercer g and h.

Recent Investigations at the Thomson Site Complex, Ontario, Canada

Peter L. Storck

An early-Paleoindian workshop was discovered in the fall of 1991 on the Thomson Site complex in the Blue Mountain highlands of southern Ontario. This discovery was the result of a long-term geological and archaeological survey project conducted by the Royal Ontario Museum (ROM). The survey project was initiated in 1978 by Storck and Dr. Peter von Bitter (Department of Invertebrate Paleontology, ROM) to determine the geologic source of a chert type which was widely used for toolmaking by early-Paleoindian peoples in southern Ontario (Storck and von Bitter 1981). The project was developed in anticipation that a knowledge of the geologic source of the chert would indicate the direction and distance of band movements in the province and, secondly, provide an alternative geographic focus for systematic survey work for Paleoindian sites. Up to 1978, most surveys for Paleoindian sites in southern Ontario had focused on the strandlines of glacial lakes and the Champlain Sea (see, for example, Deller 1976, Storck 1982). While the strandline surveys were very productive, they provided information on a limited aspect of the settlement pattern; survey work oriented in other ways was needed to provide more balanced information on early-Paleoindian land-use.

In the spring of 1980, von Bitter identified the chert type mentioned above as coming from the Fossil Hill Formation in the southern Georgian Bay region (Storck and von Bitter 1981, 1989; Eley and von Bitter 1989). The chert is referred to as the "Collingwood type" to distinguish it from a somewhat different chert ("Manitoulin type") of the same bedrock formation on the Bruce Peninsula and Manitoulin Island (von Bitter and Eley n.d.). In the spring of 1982, two years after discovering the geologic source of the chert, site survey work along exposures of the Fossil Hill Formation in the Blue Mountain uplands led to the discovery of the Thomson Site complex. The site complex is situated on a relatively flat field above a southwest-northeast-trending Fossil Hill escarpment which contains four chert beds, the largest ca. 20 cm thick. The field above the escarpment is densely covered with angular blocks of chert and debitage. At the present time, there is no evidence indicating whether the chert was actually quarried from the exposure in the escarpment or obtained by using naturally available blocks of chert which had been plucked from the exposure by glacial action and dropped on the field above when the ice overrode the escarpment.

Until recently, the site complex was known to consist of seven partially overlapping concentrations of chert blocks, debitage, and fragments of bifacially worked preforms in various stages of reduction. A year after the site was discovered, a single culturally diagnostic artifact was recovered in surface

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collections—a highly reworked fluted point (possibly of the Gainey type)—indicating that early-Paleoindian peoples visited the site (Storck 1984). Although it is likely they also made tools at this location, evidence for that activity—such as points broken during the fluting process or other diagnostic artifacts broken during manufacture—was not discovered. Unfortunately, the field in which the fluted point, other artifacts and debitage were found was under cultivation, and, since itseemed unlikely that a discrete early-Paleoindian workshop could be identified in the nearly continuous mass of disturbed workshop material (possiblyresulting from multiple occupations by Paleoindian and later peoples), no follow-up excavation was conducted.

In the fall of 1991, we conducted renewed survey work at the site complex and discovered a surface scatter of debitage in a field at the base of the Fossil Hill escarpment a considerable distance northwest of the workshop material described above. Among the several artifacts we obtained from the ca. 10-mdiameter scatter are fragments of several bifacially worked preforms, one lamellar flake, and the tip fragment of a projectile point that broke during a fluting attempt. Because the surface scatter is widely separated from other workshop debris it may represent a single occupational event, the point fragment suggesting an early-Paleoindian workshop. The surface scatter is approximately 40 m west of the Fossil Hill escarpment, which in this portion of the site complex is buried under colluvium. The proximity of the Fossil Hill escarpment to the workshop suggests the knappers may have obtained their chert directly by quarrying, rather than by surface-collecting naturally available blocks of material. Excavation of the scatter and sections of the escarpment face may provide information about Paleoindian approaches to chert extraction/ selection, techniques used to prepare the material for knapping/reduction, and possibly quarry-related occupational/subsistence activities. Preliminary excavations are planned for the spring of 1992.

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Upland Stratigraphy and Paleoindian Contexts at the Bostrom Site, St. Clair County, Illinois

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Topographically, the Bostrom site is situated on a relatively narrow upland spur that is bordered by wooded low-order side valleys. Along its longitudinal axis, the spur is stepped similar to stepped upland landscapes that reflect multiple Pleistocene upland erosional surfaces buried by Wisconsinan loess (Ruhe 1965). From the principal upland divide towards the creek, progressively lower, very shallowly sloping "steps" are set apart by more steeply, yet still subtle, sloping "risers."

The nose of the spur overlooks the confluence of Ogles and Silver Creeks, the latter being tributary to the Kaskaskia River. This confluence area occurs immediately south of a significant constriction in the valley of Silver Creek. The constriction is formed by the downcutting of Silver Creek through resistant layers of Peoria Loess and glacial till. Above the constriction the valley is about 2.0 km wide and tapers rapidly at the constriction to about 0.2 km.

During the summer of 1991, our efforts focused on a small 400-m² area in the extreme southeastern corner of the site. According to the landowner, this portion of the site had never been cultivated, although youthful timber suggests that the area had been logged; it was protected by a fence and woodland vegetation. This area is on the lowest step and consists of a local narrow summit above Silver Creek formed by two opposing shoulder slopes.

A 400-m² grid, aligned with the cardinal points, was staked off into 100 excavation units in the wooded area. Each unit consisted of four 1-meter squares, 30 of which were hand-excavated in 2-cm levels to depths ranging from 10 to 50 cm. The deeper units were excavated in areas displaying complete soil profiles generally along the longitudinal axis of the local spur. Sediment was screened through 0.6-cm hardware cloth.

While this portion of the site had never been cultivated, there were several sources of subsurface disturbance including bioturbation, post-Paleoindian habitations, and a historic farm road. A Paleoindian horizon was identified in Unit 94 on the summit of the spur. The horizon was defined by the presence of a spurred end scraper displaying the pressure-flake removal of the bulb of percussion from the ventral side (Figure 1). These traits appear distinctive of Old World late Paleolithic (Haynes 1982:389) and New World Paleoindian assemblages (Rogers 1986) and suggest that a Paleoindian horizon is present between Peoria Loess and Holocene sediments.

The end scraper was found at the interface of the E and Btl soil horizons and below cultural debris from younger cultural periods. This situation suggests that a slight degree of soil upbuilding occurred as a thin increment of Holocene or terminal Pleistocene material was incorporated within the upper

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soil solum. It also suggests that the Paleoindian material is at or near the surface of the late Wisconsinan Peoria Loess. The local age for the top of the Peoria Loess has not been determined, but the genetic relationship between the Mississippi River glaciofluvial system and Peoria Loess sedimentation allows a general estimate. Major Peoria Loess sedimentation ends with the end of major glaciofluvial aggradation in the Mississippi Valley between 13,300 and 12,200 yr B.P. (Hajic 1990). Only minor increments of silt would have been deposited across uplands between 12,200 and 9,800 yr B.P. as the Mississippi River incised and multiple magnitude deglacial floods passed through the valley (Hajic 1990). The Paleoindian material could have been buried in part by these very youngest increments of Peoria Loess. Further burial occurred during the Holocene by local sheetflood sedimentation, microcolluviation, and possible additions of eolian dust.

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The Richard Beene Site: A Deeply Stratified Paleoindian to Late Prehistoric Occupation in South-Central Texas

Alston V. Thoms and Rolfe D. Mandel

Excavation of a 15-m-deep trench through the Applewhite Terrace of the Medina River exposed deeply stratified cultural remains. This locality, known as the Richard Beene site (41BX831), is 25 km south of San Antonio, Texas. Five distinct cultural horizons were investigated, and 50 radiocarbon ages, ranging from ca. 3,100 to 32,000 yr B.P., were determined on charcoal (cultural and non-cultural) or bulk organic carbon from paleosols and alluvium.

A complex stratigraphy of soils and fine-grained alluvium was exposed at the site. All cultural materials are in the upper 10 m of the Applewhite Terrace fill (Figure 1). Late-Prehistoric artifacts are contained in silty and fine-sandy levee deposits within the upper 40 cm. However, no features were recorded in the 25 m² excavated in this component, and it yielded a comparatively low density of tools and only a few bone fragments.

Approximately 100 m² were excavated in a stratified late-Archaic component in the Leon Creek Paleosol about 1.0-1.75 m below the terrace surface. This paleosol has a moderately thick AK-BK profile developed in levee deposits. Late-Archaic cultural materials, including bifaces, edge-modified flakes, and large, barbed projectile points, were recovered from the Ak and Bk horizons. Faunal remains, including deer, rabbit, turtle, and other small animals, were few and poorly preserved. Charcoal from a feature at the top of the Ak horizon yielded a radiocarbon age of $3,090 \pm 70$ yr B.P. (Beta-36702).

One of two middle-Archaic components was excavated in unweathered alluvium just below the Bk horizon of the Leon Creek Paleosol. Artifact density and diversity were low in the 30-m² excavation area, suggesting that the

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Figure 1. Generalized profile of the west wall, Richard Beene Site (41BX831), Bexar County, Texas.

occupation was of short duration and limited activity. Charcoal from this component yielded a radiocarbon age of $4,135 \pm 70$ yr B.P. (Beta-43330).

The second middle-Archaic component is in the upper portion of the Medina Paleosol about 2.5 m below the terrace surface. The Medina Paleosol has a thick Btk-Bk profile developed in fine-grained overbank deposits; most or all of the A horizon was stripped off by erosion. The artifact assemblage from the top of the Btk horizon is dominated by chipped-stone debitage. No formal tools were recovered, and there were a few mussel shells, deer-size bones, and remains of rabbit, turtle, and other small animals. Charcoal from this cultural zone yielded a radiocarbon age of 4,570 \pm 70 yr B.P. (Beta-38700).

Much of the excavation focused on the extensive and well-preserved early-Archaic component at the bottom of the Medina Paleosol. Approximately 180 m^2 was excavated in this cultural horizon at about 6.5 m below the terrace surface. The assemblage of temporally diagnostic projectiles is dominated by stemmed, indented-base types. Edge-modified flakes were fairly common, but camp-maintenance tools were virtually absent. Faunal remains were relatively well preserved, and there were many scatters of mussel shells. In addition to deer, turtle, and rabbit, antelope and porcupine were represented in the faunal assemblage. More than a dozen small, basin-shaped features, including some with fire-cracked rocks, were excavated. Charcoal was present in the features and elsewhere, but always in low quantities and poorly preserved. A small charcoal sample from a hearth-like feature yielded a radiocarbon age (AMS) of 6,930 \pm 65 yr B. P. (Beta-47525). A radiocarbon age of 8,780 \pm 210 yr B.P. (Beta-44544) was determined on bulk carbon from organic-rich sediment 75 cm below the early-Archaic component.

The Elm Creek Paleosol is the next lowest buried soil in the site's profile. It has a thin, weakly expressed Bk-C profile developed in fine silty alluvium. Bulk carbon from the upper 20 cm of the truncated Bk horizon yielded a radiocarbon age of 9,200 \pm 130 yr B.P. (Beta-44545). Few cultural materials and no features were observed in this paleosol.

A late-Paleoindian component is encased in laminated, fine-grained alluvium beneath the Elm Creek Paleosol, as well as in the truncated Bk horizon of the underlying Perez Paleosol. Bulk organic carbon from the artifact-bearing stratum yielded a radiocarbon age of $9,780 \pm 120$ yr B.P. (Beta-43877). A similar age ($9,800 \pm 140$ yr B.P., Beta-44546) was determined on bulk organic carbon from the upper 20 cm of the truncated Perez Paleosol. Many of the artifacts were found on the eroded Perez about 9 m below the terrace surface. However, a lens offire-cracked rock and chipped stone was documented about 1.25 m below the top of the Perez Paleosol. Bulk organic carbon from soil within this lowest late-Paleoindian component yielded a radiocarbon age of $9,870 \pm 120$ yr B.P. (Beta-47565).

Excavation of about 150 m² in the late-Paleoindian components yielded 11 Angostura projectile points. Clear Fork gouges were also characteristic of the component, and there were many scrapers, gravers, drills, and edge-modified flakes. Mussel shells and fire-cracked rocks were common, but only one intact cultural feature was recorded, and charcoal was virtually absent. Burned and unburned faunal remains consisting mostly of deer and small animals were present, but they were smaller in size and occurred in lower densities compared with the other components. Overall, the assemblage of artifacts from the late-Paleoindian components represents a comparatively high-density/high-diversity assemblage, suggesting more camp-maintenance activities than was characteristic of any other excavated cultural deposits at the site. Although there is evidence that the uppermost component has been reworked by fluvial processes, this part of the site represents extensive late-Pleistocene/early-Holocene occupations in the floodplain setting, and excavations yielded a large assemblage of cultural materials from a time period that is otherwise poorly represented in the regional archaeological record.

Three weakly developed paleosols (Soils 6, 7, and 8) and a partially eroded petrocalcic horizon (Somerset Paleosol) were identified below the Perez Paleosol (Figure 1). Soils 6, 7, and 8 are products of separate, short episodes of floodplain stability between ca. 12,000 and 15,000 yr. B.P. Development of the Somerset Paleosol is bracketed between $15,270 \pm 170$ yr B.P. (bulk carbon, Beta-47561) and $20,080 \pm 560$ yr B.P. (bulk carbon, Beta-47563). Although soils 6 and 7 contain a few burned and many unburned bones from a wide variety of as yet unidentified mammals and reptiles, no definite cultural materials were documented in any of the late-Wisconsinan paleosols.

Research at the Richard Beene site was funded by the San Antonio Water Board. Investigations were carried out by the Texas A&M Archeological Research Laboratory under contract to Freese & Nichols, Inc. The U.S. Army Corps of Engineers, Fort Worth District, oversaw the project. We are grateful to Michael Waters for comments on an earlier version of the manuscript.

Big Lake: A Playa Bison Kill Site in West Texas Solveig A. Turpin, Leland C. Bement, and Herbert H. Eling, Jr.

Big Lake is the largest playa on the western Edwards Plateau of Texas (Pool 1977) in a geographical region Ferguson (1986) called the Eldorado Divide. From this arid tableland, tributaries flow south and west to the Pecos River, south to the headwaters of the Devils River, and north and east to the Concho River system. One salient characteristic of Big Lake is a truncated dune or ridge that arcs across its northern edge, presenting at its highest point a 5-meter eroded face. A surficial scatter of bison-tooth fragments and lithic debris near the base of the dune was recorded as 41RG13 and attributed to redeposition of subsurface material by trenching for an earlier pipeline.

Backhoe trenching to gain a profile of the truncated dune identified a bone bed that was shallowly buried in the calcareous sediment that overlies the clay lake bed, between 10 and 50 cm below the surface, some 5 m from the base of the eroding dune, and 10 m from its steepest face. Hand excavation of an additional 24 m² exposed the skeletal remains of at least nine bison (*Bison*). The vertical stance of articulated lower leg bones suggests that the animals were mired and killed. Dental and postcranial characteristics identify a herd composition of five adult females, three newborn calves ranging in age from one to three months, and one yearling, approximately 14 months old. This age/sex distribution places the kill in spring or early summer, immediately after the calving season when the bulls are separated from the herd. Metapodial measurements of the adults are midway between female *Bison antiquus* and *Bison bison* and within the range of female *Bison occidentalis* (McDonald 1981).

Three ¹³C-corrected radiocarbon assays, two of bone apatite (TX-6165:7530 \pm 150 yr B.P.; GX-16474A:8375 \pm 435 yr B.P.) and one of organics extracted from sediments encasing the skeletal material (TX-7117:8130 \pm 120 yr B.P.), date the kill to about 8,000 years ago. Attempts to extract a collagen fraction from the bone were unsuccessful due to poor preservation. Many of the articular surfaces where butchering marks would be most evident were replaced by salt-saturated sand during diagenesis.

Two projectile-point fragments were recovered from the bone bed, but only one of these has chronological value: a straight-sided, heavily ground dartpoint base similar in form to either Scottsbluff or Milnesand types. The absence of processing tools suggests that butchering took place elsewhere, probably on the ancient lake shore which is now buried beneath several meters of calcareous sand redeposited from the lake bed by south-southwesterly winds (Reeves 1965) during a long period of aridity that postdates the kill.

Under the modern climatic regime, in which the lake fills on an average of every 20 years, undercutting and wave action are eroding the sand ridge. Aerial

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photographs, exposure of buried pipe, and local residents agree that the dune face receded 10 meters during the last filling episode in 1970, indicating that the deep sand cover was removed from the bone bed in the 20th century.

The Big Lake bison kill can be reconstructed as follows: 8,000 years ago, a herd of cows and calves was purposefully or fortuitously mired in shallow water and dispatched with a minimum expenditure of weapons. Select portions of the carcasses were removed to another location for processing, leaving less-productive skeletal elements to sink into the muck of the lake bed. During a subsequent period of aridity, the site was buried beneath accreting dunes that are now truncated to form a bluff that is further eroded by every episode of lake filling.

Big Lake is in a poorly studied area of the Southern Plains, midway between the famous bison kill sites of Bonfire Shelter and Lubbock Lake. Temporally, the Big Lake bone bed is younger than Bonfire Bone Bed 2 (Dibble and Lorrain 1968; Bement 1986) and roughly contemporaneous with Lubbock Lake strata 2e (Johnson and Holliday 1986), marking a point during the trend toward smaller, modern bison species. The accretion of the now-eroding sand dune probably coincides with extreme aridity noted at Lubbock Lake in strata 3 and 4, thus expanding the evidence for the Altithermal onto the Eldorado Divide and the western Edwards Plateau.

Initial work at Big Lake was funded by the All American Pipeline Company. Excavations were authorized by Texas Antiquities Permit 945. The assistance of Steve Hartmann, General Manager, University of Texas Systems Lands, and local representatives Sid Sullinger and Ken Moore is gratefully acknowledged. A legion of volunteers from the Concho Valley and Iraan Archeological Societies participated in the field work. Drs. Tom Hester and Mott Davis provided useful comments.

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The Cody Complex in Eastern Oklahoma's Arkansas Basin

Don G. Wyckoff

If late-Pleistocene-early-Holocene hunter-gatherer adaptations in eastern Oklahoma's Arkansas Basin were interpreted solely from excavated findings, our understanding would be sketchy at best. Dalton and Plainview-like points are reported for a few, typically shallow, often mixed sites along the Arkansas River and its immediate tributaries (Baerreis 1951:45-58; Odell and Vereeken-Odell 1989; Ray 1965). So far, Dalton materials from a good stratigraphic context are known only for the now-inundated Packard site (Figure 1). There, they occurred in a 9,600-year-old silty loam horizon buried deep in a first terrace near the Grand River (Wyckoff 1964, 1985, 1989). Surprisingly, this Dalton component was underlain by an earlier occupation, one evidenced by Agate Basin-like points, a side-notched biface, several cutting/scraping implements, scattered flakes, cores, and preforms broken while knapping local cherts (ibid.). These artifacts were clustered around a shallow hearth that was TAMS dated at 9800 years ago (Wyckoff 1989). While recording surface finds of Agate Basin and Dalton points in the region, avocationalists provide evidence of yet another early-Holocene cultural complex. Although superficially similar to the stemmed Hardin points reported (Chapman 1975; Justice 1987:51-53) for Midwestern early-Archaic assemblages, these Oklahoma specimens have the stem and blade attributes of Scottsbluff or Alberta points and Cody knives reported for the High Plains (Frison 1978:181-191; Frison and Todd 1987). Twenty-two artifacts attributable to the Cody complex are recorded for the study region. These come mainly from three localities and one site. This latter is 34MI136, a McIntosh County site exposed along the Lake Eufaula shoreline. The three localities include two 16-km segments of river beds below U.S. Army Corps of Engineers impoundments: the Arkansas River in Tulsa county below Keystone Dam and the Canadian River in Haskell County below Eufaula Dam (Figure 1). The third locality is a 16 ha tract (called site 34HS90) covered with sediments dredged from channel straightening along San Bois Creek in Haskell County. The exact source of these sediments is unknown; the dredging may have destroyed several discrete sites whose habitation debris was spread over the 16 ha tract. Other artifacts found here include Dalton points and adzes, Agate Basin points, and a wide variety of early-Archaic to early-Caddoan implements (Galm and Hofman 1984). Two of the eight specimens found along the Arkansas River are of exotic raw material: a complete spearpoint of central Texas Edwards chert and a complete Cody knife of Alibates agatized dolomite. A complete and a broken spearpoint are of patinated cherts, possibly from the Ouachita Mountains some 135 km to the southeast. A complete Cody knife is of Ozarks flint, and a broken spearpoint

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is of Flint Rills material. A broken spearpoint and one broken Cody knife are of locally obtainable Wreford chert. The other 14 Cody complex artifacts come from the Canadian River watershed some 110 km south-southeast of the Tulsa County finds. Not surprisingly, given their intermediate find spots (Figure 1), these artifacts are usually of Ozarks or Ouachita Mountains raw materials. From site 34MI136 come one broken and two complete spearpoints of Ozarks cherts and a complete Cody knife of Ouachita Mountains chert. Just 20 km northeast of site 34MI136, a complete Cody knife of Ozarks flint was found. Some 20 km down the Canadian watershed from site 34MI136, five Cody artifacts come from the Canadian River's bed: two complete spearpoints and a complete Cody knife of Ozarks cherts, a preform of Ouachita Mountains quartzite, and a complete spearpoint of unknown translucent yellow chert. Meanwhile, two complete and two broken spearpoints from location 34HS90 are all of Ozarks chert. The artifacts recorded thus far are only a hint of a material culture. Its full composition, its age, and the origins and practices of its users remain to be determined. The Oklahoma finds are intriguing because their makers were

Figure 1. Northeastern Oklahoma sites (stars) and localities (crosshatched boxes) where Cody complex artifacts occur. Specimens a and b are from Arkansas River in Tulsa County; specimens c an d are from site 34Mil36; and specimen e is from the Canadian River in Haskell County.







b



clearly familiar with diverse sources for the best knappable stone in the region. It may be noteworthy that these finds cluster around the Cherokee Prairie (Figure I), a southern wedge of the tall grass prairie that historically stretched from eastern Kansas into Illinois and Indiana (Blair and Hubbell 1938:431.433; Shelford 1963:328-355). Perhaps future findings will demonstrate this grassland association of the Cody complex is more than coincidental.

The information compiled herein would not be available were it not for the interest, cooperation, and support of avocationalists Jack and Ann Bullard, John Coffman, Vera McKellips, and Bill Ross. Discussions with Jack Hofman and LeRoy Johnson have stimulated continued research on eastern Oklahoma's earliest inhabitants.

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The Ohira Site: A Probably "Early Palaeolithic" Site in Fukushima Prefecture, Eastern Japan

Toshio Yanagida

The Ohira site is located in the village of Nishigo, just south of the city of Shirakawa, in Fukushima Prefecture, in eastern Japan. This is the southern edge of the intermontane Koriyama Basin, and just across a low watershed north of the Kanto Plain. The elevation of the site is 426 m, about 5 m higher than the nearby lowlands. The site was discovered during survey work in the area in October 1989 (Fujiwara and Fujimura 1990). At that time six lithic artifacts were found in a cutting from strata tentatively identified as dating about 45,000 years. Excavation work for two weeks in 1990 unearthed 78 m² of these old strata and recovered 19 more lithic artifacts in primary context (Yanagida 1990). A second two-week excavation in 1991 unearthed an additional 124 m² and recovered 30 more artifacts, including some technologically very sophisticated bifaces resembling either spear points or axes or adzes (Yanagida 1991).

The site was excavated to a depth of about 4.5 m from the present surface. All of the strata are volcanic tephras called loam. Several key geological layers were recognized: Stratum 2, the Nasu Scoria/Pumice (NSP); Stratum 6, the Namekawa Pumice (Nm-2); and Stratum 8, the Kaisan Kurayoshi Pumice (DKP). The artifacts were clearly below Stratum 6 (Nm-2) and above Stratum 8 (DKP), thus placing the cultural layer within Stratum 7.

Stratigraphic correlations of key pumice and scoria layers in the vicinity of Ohira show the stratigraphic order from youngest to oldest to be Aira-Tanzawa Ash (AT), Akagi-Kanuma Pumice (Ag-KP), Haruna-Hassaki Pumice (Hr-HP), Akagi-YunokuchiPumice (Ak-UP), Nm-1, Nm-2, DKP, Akagi-Mizunuma Pumices (MzP-1 to MzP-5), Aso 4 Ash (Aso-4) and Ontake l Pumice (On-Pm-1) (Suzuki 1990). Several of these key layers are dated by radiocarbon, uranium series, fission-track and stratigraphic methods (Machida 1991: Machida et al. 1984; Machida and Suzuki 1971; Suzuki 1990): AT (21,500–22,000 yr B.P.), Ak-KP (31,000–32,000 yr B.P.), Hr-HP (40,500–44,000 yr B.P.), Ak-UP (Ca. 45,000 yr B.P.), DKP (45,000–46,000 yr B.P.), MzP-1 (56,000–59,000 yr B.P.), Aso-4 (70,000 or 80,000–84,000 yr B.P.), and On-Pm-1 (73,000–82,000 or –95,000 yr B.P.). These dates are internally consistent and suggest an age of 45,000 years for the Ohira site.

The most-outstanding lithic artifacts are the bifaces found during the 1991 excavation (Figure 1). These tools are worked fully on both faces with fine flaking and retouch. They range in size from about 7 cm to about 10 cm. Some are pointed on one end and round on the other end, and clearly convex on one face but tending toward flattish on the reverse. There is, however, considerable variation in the shapes of these tools. Most other artifacts are simple tools on

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flakes and blade-flakes, some with marginal retouch and some with little or no retouch. Of these the most common are unmodified flakes and various types of scrapers. The raw materials include hard shale, black shale, clay slate, agate, ferruginous quartz, jasper, chalcedony, rhyolite and chert. The sources of these lithic materials are not known, but none are in the immediate vicinity of the site. The quality of the stone is very good.

None of the pieces can be refitted, although a few possibly come from the same original nodule of stone. There is no evidence at the site of stone



Figure 1. Artifacts from the Ohira site, Fukushima Prefecture, Japan.

tool production, resharpening or other working of the stone materials. There are no cores either. But the artifacts do form a spatially defined cluster with only a few of the pieces at all widely scattered from the main group on the excavation surface. The vertical displacement of the lithics is about 10–15 cm, which is normal for Paleolithic artifacts of this size in primary loam deposits in Japan.

Similar components have been identified nearby at the Kaminodejima site (Fujiwara and Fujimura 1990) and at the Nanamagari site just across the watershed in Tochigi Prefecture (Toda 1990). Both are stratigraphically a bit younger than Ohira. Further to the south in Tokyo, the TNT 471-B site has yielded a comparable component (Tateno 1984; from strata dated by fission-track to about $49,000 \pm 5,000$ yr B.P. (Machida and Suzuki 1971). Further to the north in Miyagi Prefecture, several sites being dated about 40,000-45,000 yr B.P. have also yielded similar artifacts (Sekki Bunka Danwakai 1983; Tohoku Rekishi Shiryokan 1985). Like Ohira, none of these components shows any evidence of stone knapping at the site during the Paleolithic occupation.

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Archaeology and Paleoecology of the Broken Mammoth Site, Central Tanana Valley, Interior Alaska, USA

David R. Yesner, Charles E. Holmes, and Kristine J. Crossen

The Broken Mammoth site (49-XBD-131) and Mead site (XBD-071) are a pair of blufftop sites located near the confluence of Shaw creek and the Tanana River in east-central Alaska, ca. 30 km N of Delta Junction and 90 km SE of Fairbanks, Alaska. These multi-component sites contain materials ranging from ca. 3,000 to 12,000 yr B.P. in age, buried in loess deposits ca. 2 m in depth. During 1989, routine examination of gravel mining operations near the site by C. E. Holmes resulted in discovery of stone flakes, animal bones, mammothtusk fragments, and charcoal eroding out of the base of the loess cap overlying the 30-m bluff. Test excavations subsequently revealed the presence of intact paleosol sequences associated with cultural components containing wellpreserved faunal remains and additional mammoth-tusk fragments. An initial radiocarbon assay suggested that the lower unit of the site exceeded 10,000 years in age.

Based on this information, more extensive excavations were undertaken at the site during 1990 and 1991, as well as at the nearby Mead site, which had produced stone flakes in earlier test excavations as well as a mammoth tusk in a cut-bank exposure. Excavations at these sites during the past two years have provided evidence of at least five major periods of occupation: around 11,500, 10,000, 7,500, 4,000, and 3,000 years ago, respectively (Figure 1). These occupations are framed in discrete paleosols, which show no evidence of being affected by faulting cryoturbation, or other processes of geologic disturbance.

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The sediment matrix is a highly calcareous loess, which has preserved faunal remains, particularly in lower layers of the site.

The 3,000- and 4,000-year-old occupations of the site contain a microblade industry with wedge-shaped "Campus"-type cores. Deeper levels at the site do not contain microblades, however. Upper occupation units at the site are separated from the late-Pleistocene deposits by nearly a meter of sterile loess, bisected by a thin (<5 cm) sand unit that is local in its manifestation. The late-Pleistocene deposits contain a series of paleosols in a loess matrix, which have been designated as the Upper, Middle and Lower Paleosol complexes, respectively. The Upper Paleosol complex is poorly defined, consisting of numerous truncated stringers which do not crosscut the site area; it is culturally sterile. The Middle and Lower Paleosol complexes are thicker, with fewer, welldefined stringers, and contain abundant cultural materials and faunal remains. The Middle Paleosol complex at the site has a series of dates ranging from ca. 9,500 to 10,500 yr B.P. (Figure 1). The lithic assemblage from this unit includes two examples of basally thinned, subtriangular projectile points, as well as scrapers and both bifacially and unifacially trimmed flakes; this assemblage may be referable to the Nenana complex as defined by Powers and Hoffecker (1989) or the Chindadn complex as defined by Cook (1969). These items are associated with a series of features, including a large hearth measuring ca. $2 ext{ x}$ 2 m containing ash, flakes, and numerous bones and bone fragments. Faunal remains associated with this deposit range from poorly preserved antler(?) segments to very well-preserved materials. Both cranial and postcranial remains



Figure 1. Generalized stratigraphy, description, dates, and archaeological components for the Broken Mammoth site. are present of large ungulates, dominated by bison (cf. Bison priscus) but also containing elk or wapiti (Cervus elaphus). Dall sheep (ovis dalli) remains are also present. One distal humerus may represent a small camelid, possibly Hemiauchenia. One juvenile bison mandible suggests a late summer-fall occupation of the site on the basis of tooth emergence/wear patterns. Avian remains constitute ca. 20% of the bones from this level, as do small mammals (e.g., ground squirrel [Citellus sp.], marmot [Marmota flaviventiis], and hare [Lepus sp.]).

The Lower Paleosol complex at the Broken Mammoth site is variously separated from the Middle Paleosol complex by ca. 15 to 35 cm, and ranges from ca. 10 to 25 cm in thickness. Like the Middle Paleosol complex, it is comprised of a thicker central unit and smaller upper and lower stringers. It has provided a series of radiocarbon dates ranging from 11,000 to 11,800 yr B.P. Abundant artifacts and faunal remains are again associated with this complex. The artifactual assemblage contains a range of unifacial and bifacially worked materials and (predominantly) flakes similar to that of the Middle Paleosol complex. Faunal remains are at least as well preserved as in the Middle Paleosol complex. Elk appear to be somewhat better represented than bison in this unit, including both cranial and postcranial remains. Hind-limb elements are particularly frequent for both elk and bison. Small mammals are nearly as frequent as in the Middle Paleosol complex, but birds are considerably more abundant. Mammoth-tusk fragments have also been produced from this level, as well as from the lowest level at the nearby Mead site.

An important source of information on paleoenvironmental adaptations at the Broken Mammoth site is the sedimentary record. Initial occupation at the site (in the Lower Paleosol complex) is underlain by a 50-cm-thick sand deposit with ventifacts at its base, in turn overlying frost-shattered bedrock. This deposit is probably late Pleistocene in age, corresponding with sand deposition at the base of a pollen core taken from nearby Quartz Lake and the development of sand dunes in adjacent Shaw Creek Flats, suggesting a high-wind regime at that time, possibly associated with a late Pleistocene glacial advance. Subsequent recession of wind velocity was coupled with the establishment of stable occupation surfaces at the site, as glaciers receded and river bars became vegetated and stabilized. The Middle and Lower Paleosol complexes consist both of organics derived from pedogenic processes and anthropogenic charcoal and other debris. These stable occupation surfaces correlate with the latter part of the "Birch Period," as defined by Ager (1975), in which the late-Pleistocene steppe was replaced by an open shrubland including dwarf willow and birch. After ca. 9,000 yr. B.P., this shrubland gave way to a woodland including spruce and alder, immigrating from southern refugia. Red-squirrel and porcupine remains from the Middle Paleosol complex suggest that this process may have begun by 9,500 yr B.P. Shortly thereafter, windy conditions may have become reestablished, as loess accumulation appears to have accelerated until after 7,500 yr B.P. After that time, more modern conditions appear to have prevailed, with the modern forest soil established sometime after 2,500 yr B.P.

The faunal record from the Broken Mammoth site is perhaps its most unique feature. Both mammal and bird remains are well represented, particularly in

the bottom paleosol complexes. The birds were undoubtedly collected from the Tanana River flats, which today in late summer and early fall support hundreds of migrant waterfowl and cranes. The abundant evidence of waterfowl at the site, including Tundra Swans (*Cygnus columbianus*), Canada geese (*Branta canadensis*), *Anser* sp., and *Anas* sp., suggests that modern avian flyways through the Alaska Range had become reestablished by the time of initial occupation of the Broken Mammoth site (ca. 12,000 yr B.P. The prevalence of these forms in the Lower Paleosol complex suggests that they may have been a major factor attracting human populations to the site, during either the spring or fall seasons. Spring occupation is suggested by the frequent occurrence of eggshell fragments.

Large ungulate bones from the site are frequently (ca. 80%) spirally fractured, and the vast majority are unidentifiable. Identifiable remains, however, do suggest a domination of the large mammal faunal assemblage by bison and elk. This indicates that the "Birch Period" environment supported a fauna characteristic today of the northwestern Plains region, particularly semiforested regions in higher altitude environments. These herd animals would have represented a concentrated, storable biomass of resources available to late-Pleistocene hunters. The bison present in both paleosol complexes appear to represent the large Pleistocene Eurasian form (Bison priscus); size diminution had apparently not yet occurred. The elk are also quite large, with most remains being equivalent in size to large bull elk in current populations. Although elk (wapiti) are considered part of the Beringian fauna since pre-Wisconsin times (Guthrie 1966, 1968), they are not abundant in late-Pleistocene paleontological collections (Matthews 1984). The presence of a small camelid at the site would corroborate the notion of open-parkland conditions supporting aggregate herds. Finally, Arctic fox (Alopex lagopus) and ground squirrel are present in the late-Pleistocene paleosol units, but these species may be less sensitive indicators of environmental conditions (Guthrie 1983).

Mammoth-tusk fragments from the Broken Mammoth and Mead sites suggest that such material was available to terminal Pleistocene human populations in the region. Since no postcranial remains of mammoth have been found, it may be that the mammoth tusks were scavenged from the area, at least until more forested conditions set in after the "Birch Period." It is also possible that mammoth could have survived beyond the most recent dates of ca. 13,500 yr B.P. available from paleontological sites. At least one artifact from the Mead site—asmallivory point—seems to have been made from a mammothtusk tip segment. Other mammoth-ivory fragments contain cut marks made by stone tools, and one contains a remnant microchip in a groove channel.

The Broken Mammoth and Mead sites, like the Nenana Valley sites, are blufftop hunting camps, possibly seasonal in nature, reflecting a restricted suite of activities. Although they contain large, well-made hearths, no evidence of dwellings, burials, or other activities has yet come to light. It may be that such activities were practiced in valley-bottom locations, where late-Pleistocene/ early-Holocene sites have been obscured through meandering of glacial rivers. Such sites would be deeply buried and essentially nonretrievable. Thus, unless they were placed in relatively restricted channels where they may be discovered or exposed through downcutting of previous sediments, early sites with longerterm occupations may never be found.

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Physical Anthropology

A Multivariate Craniometric Analysis of North American Paleoindian Remains

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The question of the biological affinity and origin of the earliest Americans has been addressed by a number of scholars using a wide variety of techniques. Multivariate analyses of dental morphology and cranial shape have proven useful in documenting evolutionary relationships among late-Pleistocene fossil hominids in Europe, Asia, and the Americas (Corruccini 1992; Howells 1989; Kamminga and Wright 1988; Neves and Pucciarelli 1989, 1991; Steele and Powell n.d., 1992; Turner 1992; Turner and Bird 1981). In this study we collected craniometric data from the known sample of Paleoindian (8,500–12,000 yr B.P.) skeletons to more objectively determine the relationship between these individuals and more recent human populations.

Although there are at least 21 skeletons from 16 localities older than 8,500 yr B.P., only five of these were available and complete enough for statistical analysis. Our Paleoindian sample consisted of two adult females from Pelican Rapids, Minnesota (approximately 8,750 yr B.P.), and Gordon Creek, Colorado (9,700 \pm 250 yr B.P.), and three adult males from Browns Valley, Minnesota (8,700 \pm 110 yr B.P.), Sauk Valley, Minnesota (approximately 8,750 yr B.P.), and Horn Shelter, Texas (mean radiocarbon age 9,560 yr B.P.). A detailed discussion of these and other specimens can be found in Young (1986) and Steele and Powell (n.d., 1992).

Cranial dimensions were recorded for the Paleoindian samples following techniques described in Howells (1973). Because of the fragmentary nature of the Paleoindian crania, only eight craniofacial dimensions were available for analysis: maximum cranial length, maximum cranial breadth, upper facial height, bizygomatic diameter, nasal height and nasal breadth, orbital height, and orbital breadth. For comparison, we compiled data for 29 male and 26 female geographical samples of modern humans (see Steele and Powell 1992, table 2), along with late-Pleistocene fossils from Upper Cave, (Zhoukoudien)

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China (18,000 yr. B.P.) and Minatogawa, Okinawa (17,000 yr B.P.), and a middle-Holocene Jomon sample from Japan.

Because comparative data were compiled from published literature, analyses were conducted using sample means rather than individual observations, following Kamminga and Wright (1988) and Neves and Pucciarelli (1991), and standardized following Corruccini (1973). Separate analyses were conducted for males and females.

Samples were assigned to one of five major geographic groups based on a presumably common cultural and biological history: Europeans, northeast Asians, southern Pacific populations (including Australians, Tasmanians, and Melanesians), and American Indians. These *a priori* classes were entered into the canonical discriminant analysis in SAS (SAS Institute 1985), which attempts to best summarize the differences between classes and partition them through a linear combination of the variables. The Paleoindian, Upper Cave, Minatogawa, and middle-Holocene Jomon (Japan) populations were not assigned to a particular geographic group. Instead, these data were placed within the defined discriminant space by the program, so that their positions among modern populations could be better assessed. The results of the canonical discriminant analysis for males are presented in Figure 1.

The first three canonical axes account for 97.1% of the variance in males and 98.7% of the variance in females. The Paleoindian males are separated from the American Indians and move towards southern Pacific and Australian groups. Female Paleoindians are placed as an outlier, but are closer to the European populations than to any other group. When the fossil samples are considered, the close similarity of male Paleoindians and Jomon is apparent (Figure 1). For Paleoindian females, the closest fossil assemblage is the Upper Cave sample.

Previous investigations of the Paleoindian samples suggest that they were descendants of anatomically modern northern Asians that colonized the Americas (Hrdlička 1923, 1937; Neumann 1956; Protsch 1978; Smith 1976; Steele and Powell 1992; Stewart 1960, 1981; Young 1986, 1988). This does not preclude the possibility that the North American Paleoindian population differs from later Holocene populations in both the Americas and the Pacific Rim.

In general, our results, and those published elsewhere (Steele and Powell 1992), indicate that the earliest human populations in North America were distinct from their late-Holocene descendants in the New World. Previous univariate and bivariate analyses document that Paleoindians fall at one extreme of the American Indian range, away from northern Asians, and nearer to southern Asians and Europeans. The multivariate pattern that emerges is one where later Holocene northern Asians, and to a slightly lesser extent the American Indians, fall on one extreme in a suite of craniofacial features, while southern Pacific and European populations fall on the other, with Paleoindians between extremes. This more-central position of the earliest North American populations among those of the Pacific Rim also has been confirmed for early South American populations (Neves and Pucciarelli 1989, 1991), and is consistent with the view that the Asian ancestors to modern American Indians lacked the markedly broad face and cranium associated with modern northern

Asians (Kamminga and Wright 1988; Stringer and Andrews 1988) and North American Indians.

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Figure 1. Plot of Canonical Discriminant Scores for Males. Modern populations include Europeans (squares), northeast Asians (diamonds), southern Pacific and Australians (spheres), and Native Americans (crosses). Fossil samples include Minatogawa (flag), Jomon (cylinder), Upper Cave (cube) and Paleoindians (pyramid).

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Lithic Studies

Morphological and Distributional Characteristics of the Burnham Site Lithics

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Since 1986, periodic excavations at northwest Oklahoma's Burnham site have yielded lithic debitage and tool fragments in association with the bones of an extinct form of bison, *Bison cheneyi* or *B. alleni* (Wyckoff et al. 1990). Radiocarbon dates from the artifact- and fossil-bearing strata range from 26,820 \pm 350 yr B.P. (charcoal, AA-3838) to 40,900 \pm 1,500 (charcoal, AA-3840). Two dates on snail shells from the sediment containing the bison skull and artifacts gave results of 31,150 \pm 700 yr B.P. (Beta 23045) and 35,890 \pm 850 yr B.P. (AA-3837).

Approximately 23 m³ of sediment has been excavated, all of it waterscreened through 2-mm mesh. Lab workers sorting the residue were instructed to save all cryptocrystalline materials. These were examined under a stereoscopic zoom microscope. Using morphological characteristics widely accepted as indicative of man-made flakes (Crabtree 1972; Faulkner 1972; Fladmark 1982; Cotterell and Kaminga 1977, 1987), each item was classed as either of probable natural or man-made origin. These determinations were done "blind" with respect to provenience so as not to be influenced by possible associations or distributional patterns. Of the 174 items thus far classified, 120 are considered to be of natural origin and 53 are believed to be indicative of human-controlled flaking activities. Of the latter, 39 are flakes or flake fragments (two fragments refit and are counted as one), 11 are pieces of shatter, l is a possible flake tool and another is apparently an edge segment from a biface. The final item is a large (2.7k) chert cobble which shows two flake scars. It is considered a possible cultural item because of its direct association with the bison bone and because its size is in marked contrast with the fine-grained, ponded sediment in which it was found.

A number of characteristics are indicative of a human origin for these items. These include a high proportion of non-decortication debitage (86% n = 43), high proportion of flaked platforms (87% n = 20, based on complete flakes and proximal fragments), dorsal, platform-edge flaking (56% n = 13), and dorsal

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scars from previous flake removals (95% n = 37) (Figure 1: 1–5). Moreover, six flakes have platforms which appear to be edge remnants from bifaces (Figure 1: 2). The debitage does not show multi-generational flaking as is often (but not always) found on naturally flaked items. The sediments containing the debitage were deposited in a quiet, ponded environment, not likely to produce flakes by banging rocks together. Moreover, there is a paucity of suitable parent pieces in the deposits, and the debitage lacksedge rounding or other evidence of long-distance water transport. Finally, although the majority of the cultural items are either local Day Creek chert or as yet unidentified, at least one flake (Figure 1:5) is identified as Edwards chert, a non-local material. This identification is based on macroscopic, microscopic and ultra-violet light examinations.

There are two probable tool fragments, a flake tool and a segment of a biface edge (Figure 1: 6 and 7). The flake tool is broken by a bending-type break. The dorsal face shows a large hinge scar termination detached before the tool was broken. Small, bifacial flake scars are nearly continuous around the margin. Rounding of the edges and scar arrises is evident under the microscope, suggesting possible use wear. The biface-edge fragment shows three large flake scars on one face with more numerous, smaller scars on the opposite face. Minute, bifacial bending-flake scars are visible under 10x magnification. The fragment appears to have come from a biface produced by percussion with little, if any, deliberate pressure flaking of the edges.



Figure 1. Flakes and tool fragments in association with *Bison cheneyi* at the Burnham site, 34 Wo-73, Oklahoma. (1 and 2: flakes showing biface edge remnants; 3–5: flakes showing multiple dorsal flake scars; 6: flake-tool fragment; 7: biface-edge fragment).
The 120 lithic items judged to be of natural origin are markedly different from the debitage described above. They are slightly larger in clast size (most are less than 2 cm) and consist of small, rounded chert gravels or subangular, tabular pieces of chert. Their surfaces are heavily patinated, and weathered cortex is usually present. The majority are local Day Creek chert or unidentified chert gravels.

Horizontal and vertical distribution plots of the bison bone, debitage/tools and non-cultural lithics show an interesting pattern. The bison bone is concentrated in four squares, S1W22, S2W22, S2W23 and S2W24. The cultural lithics show a very similar pattern with 74% (n = 37) of the debitage plus the cobble concentrated in three of the same squares (S1W22, S2W22, S2W23). Adding the count from adjacent square S1W23 puts 92% (n=46) of the debitage in a 2-m² block among and adjacent to the bone concentration. Vertically, the bison bone ranges from level 97.0 below datum down to 96.2, a spread of 80 cm with the majority in levels 96.7 and 96.6. Ninety-four percent (n = 48) of the debitage as well as the tool fragments and cobble occur between levels 97.0 and 96.2 (the same as the bone) with 40% (n = 20) in level 96.7. Thus, the cultural lithics show a very tight association with the bison remains. The non-cultural lithics have a similar, if less marked, pattern. The bonebearing levels contain 78% (n = 94) of the natural lithics. The four squares containing the bulk of the bone account for 34% (n = 32) of this. The four squares having 94% of the cultural lithics have 57% (n = 54) of the non-cultural pieces. Vertically, the latter peak in level 96.4 with 23% (n = 22) as opposed to the cultural materials which peak in level 96.7 with 38% (n = 20).

While sharing areas of concentration, the natural lithics have a much wider dispersion both horizontally and vertically than do the cultural materials. Noncultural pieces have been recovered in nearly all excavated levels both above and below the bison bone. Only two flakes occurred above these levels (one each in 97.3 and 97.1), and none have been found below. Nonetheless, within the bone bed the bison remains, cultural and natural lithics show similar distribution patterns. A difference-of-percentages test (Leabo 1968) on the proportions of cultural vs. non-cultural lithics within these levels was significant at the .05 level, suggesting the difference is not due to chance. While it would be tempting to speculate that the nature of the cultural lithics and their close association with the bison remains reflects a butchering scenario with associated tool resharpening, it is more likely that the bone and both classes of lithics have been subjected to the same geomorphological processes. The high degree of concentration of the cultural lithics and the lack of edge rounding or water polish suggest they have been redeposited from a nearby source, perhaps within a few meters. The lack of cultural material from upper levels indicates horizontal rather than vertical displacement; there is no evidence that younger cultural materials have been displaced into the lower, older bison bone bed.

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Folsom Use of Alibates and Edwards Cherts: Raw Material Procurement and Technological Organization

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In their model of Paleoindian settlement and subsistence, Kelly and Todd (1988) assume that Paleoindians were highly mobile and relied on a costminimizing bifacial-core technology. High mobility is inferred in part from the common use of non-local raw materials for Paleoindian artifacts. Using data on Folsom use of Alibates and Edwards cherts, I address these two assumptions. Preliminary results indicate that Folsom people were utilizing a cost-minimizing bifacial core technology, and that Alibates chert may have been obtained by exchange, rather than directly procured.

To address the role of mobility in Folsom settlement, I examine the relationship between proportions of Alibates and Edwards cherts on sites with distance from the sources. Relative proportions (percents) of counts of raw material within assemblages are used. Least-cost-exchange models are described by log-normal curves (Hodder 1974:173; Renfrew 1977:74–75), such as the "E" curves (solid lines) in Figure 1. With movement from source A to source B, raw material from source A would be increasingly replaced with raw material from source B. But if Folsom groups were minimizing costs relative to raw-material transport, and were *directly procuring* their raw material, then the curve describing the distribution of raw materials should resemble the "D" curves (dotted lines) in Figure 1. With movement a gearing-up visit to a source, raw material A should represent a high proportion of the assemblage until other sources are visited.

Kelly and Todd emphasize the role of bifacial cores in Paleoindian technology.

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Figure 1. Comparison of hypothetical least-cost decay curves for raw material procured directly and by exchange.

Bifacial cores would have made possible the removal of flakes for a variety of informal and formal tools, including blanks for projectile-point manufacture; these cores would have maximized the number of potential tools per unit of rock transported (Kelly and Todd 1988:237). A corollary to this model is that because of uncertainty regarding bison-herd movement, and regarding the number and location of kill/butcheryevents relative to lithic-source locations, Folsom groups would have been very conservative in their use of raw material and would have curated usable tools (Binford 1977), especially projectile points (Hofman 1992:198).

To address the role of bifacial cores in Folsom technology, I partition Folsom assemblages into technological classes diagnostic of successive stages of reduction (Bradley 1982; Frison and Bradley 1980). Considering the high breakage rate during fluting (Flenniken 1978; Tunnell 1977), as much Folsom point manufacture as possible would have been completed at a quarry. In anticipation of a need to replace broken Folsom points away from the quarry after all pre-made points were used, bifacial cores, from which blanks could have been produced, would have been carried. Eventually the bifacial core itself would have become so reduced in size that flake production would no longer be feasible, and the biface would have been reduced to a Folsom point (Hofman 1992:201).

The result of this reduction sequence was that Folsom-point manufacture would have occurred at varying distances from the source, with resulting manufacturing debris being discarded at varying distances as well. But because of curation of Folsom points, and because of the use-life of bifacial cores with eventual reduction into projectile points, I expect Folsom points to be discarded at greater distances than any other class of artifact. Curation of Folsom points would have delayed manufacture of new points—one result being that channel flakes and preforms should also be discarded at mean distances similar to each other, but greater than other artifact classes except points.

I expect that the curves for the different technological classes will be similar in shape to one another but will differ in their relative locations on the graph. The placement and shapes of the curves should resemble the "E" curves in Figure 1 for an exchange situation, and the "D" curves for a direct procurement situation. The all-artifacts class includes all artifacts of Alibates or Edwards chert except channel flakes, preforms, and Folsom points. These patterns should be the same for both Alibates and Edwards.

I chose Alibates agatized dolomite and Edwards Formation chert for this analysis. Both Alibates and Edwards are cryptocrystalline silicates which are relatively localized in their occurrence, well known among researchers, and amenable to source identification. I have chosen the broadest possible geographic occurrence of the two materials (Banks 1984, 1990; Holliday and Welty 1981; Tunnell 1978). Preliminary results are based on analysis of 33 sites in Texas, New Mexico, Colorado, and Oklahoma, which have at least one of the two raw materials. Distance to source was measured as linear distance to nearest occurrence of specified raw material.

Curves fit to the Alibates distributions are shaped very much like the curves predicted for an exchange situation, while those for Edwards are shaped very much like those predicted for a direct-procurement situation. Thus, Alibates distributions may not reflect the scale of Folsom mobility.

In general, for both Alibates and Edwards, the relative placement of the different curves is patterned as expected. For Alibates, the all-artifacts curve is closest to the source, that for channelflakesisfartheraway, and that for Folsom points is farthest away. The preforms curve does not fit the expected pattern. Mean distances of discard generally pattern as expected (except for Folsom points) and are as follows: all artifacts, 232 km; channel flakes, 254 km; preforms, 264 km; and Folsom points, 192 km. Folsom points are found at the farthest maximum distance, however. For Edwards, the channel-flakes and preforms curves are very close to each other, but both lie at slightly greater distances than the Folsom-points curve. The all-artifacts class is not evaluated here due to small sample size (N=4 sites). Mean distances of discard pattern as expected and are as follows: channel flakes, 205 km; preforms, 263 km; and Folsom points, 415 km. These patterns agree with those expected for the Folsom reduction sequence and provide support for Kelly and Todd's model of the role of bifacial cores in Paleoindian technology.

In summary, raw-material distributions may not always reflect the scale of Folsom mobility, but those for Alibates and Edwards do seem to confirm the assumed role of bifacial cores in Paleoindian tool kits. A question for future research is why Alibates distributions resemble those expected for procurement by exchange, yet still confirm the role of bifacial cores in a highly mobile settlement system.

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Methods

Microclimate of Relic Steppes of the Northeast of Asia and Pleistocene Climate Reconstruction

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Steppe communities of northeast Asia, relics of the Pleistocene, have been studied in many respects, but thermic conditions of their existence remain obscure. The main alternative is the following: either steppe species of plants and animals have been preserved in the north owing to their ability to develop at low heat supply, or a specific microclimate forms in steppe biotopes, sharply different from that of northern taiga or tundra surrounding it and similar in thermic properties to southern steppes.

Researches of steppe thermic biotopes were conducted according to the gradient of continentality: the Oimyakon hollow (upper reaches of the Indigirka River; upper reaches of the Kolyma River; middle current of the Amguema River. As models, two sites were chosen on the Kolyma near "Aborigen" field station (Alfimov 1986) on 550 m a.s.l.: one on the steep north-facing slope in lichen-moss-larch light forest on cryobog soils with well-marked solifluction microrelief and maximum thawing up to 50 cm. Another one was located on a steep south-facing slope with project cover of grass and dwarf shrub 40% and thawing depth more than 3 m. Self-recorders registered temperatures of soil from the surface to 20 cm daily during the years 1983–1985. At key moments (snow melting, maximum warming up and the beginning of freezing) heat-balance measurements were conducted on the driest steppe areas.

The thermic differences in light forest soils of the north-facing slope and steppe biotopes appeared to be extremely great during the whole season (Figure 1), air temperature on the compared slopes being weakly connected with surface conditions, its sum totaling about 1350° C. Thawing of soil in steppe biotopes starts in late April and May due to radiation penetrating through snow, and after snow melt it makes up 65–70 cm by the middle of May at negative (-1 to -2° C) daily air temperature. On the north-facing slope at this moment even mounds thaw for 5–8 cm. In late June and July the soil temperature of steppe areas at a depth of 20 cm rise as much as $25-26^{\circ}$ C,

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Figure 1. Maximal (a) and mean daily (b) temperature for a decade in spring (the second decade of May), summer (thrid decade of June) and in autumn (first dec. of October) and the sums of mean daily temperature (S.D.D.) (c) in contrast to ecosystems. 1=soil surface, 2=depth of 5 cm, 3=depth of 20 cm.

amounting to $58-62^{\circ}$ C on the surface (average monthly $22-24^{\circ}$ C), upperlayer water content being not more than 6%. Heat expenditure to turbulent exchange and evaporation ratio here is approximately 14–15, compared with 0.3–0.5 on north-facing slopes, where thawing reaches 25–35 cm by this time, at surface temperatures of 19 to 20° C (average monthly temperature 10–12° C), and at a depth of 20 cm (i.e., near the permafrost table) up to 1–2° C, water content approaching 250–350%. In early October the temperature of the upper 20 cm of soil of steppe areas is still positive 1–2° C, whereas north-facing slopes freeze in the middle of September.

The seasons' sum of positive temperatures of the soil surface of steppe biotopes totals 2,500° C, but in light forest only 1,000° C (these sums for 20 cm are 2,150° C and 50° C accordingly), i.e., the difference is 2.5-fold on the surface, 3.6-fold at a depth of 5 cm, and 400-fold at 20 cm. These indices of steppe biotopes are similar to the south Siberia mountain steppes (e.g., Kosh-Agach meteorological station, 1,738 m a.s.l., which is situated 12–15° C farther south and in not so continental a climate).

So, similarity of thermic conditions is a result of convergence. On the contrary, the characteristics of north-facing slopes correspond to zonal tundra from Yamal to Chukotka (Reference book on the USSR Climate 1967). So, the real differences in heat supply are equivalent to the interval from tundra to steppes.

From the upper reaches of the Indigirka to the Amguema, the 1.7-fold decrease in air temperature sums reduces the heat supply of the warmest places 2.0- to 2.1-fold; a thermic contrast with the surrounding tundra biotopes decreases as well, and it favors the formation of tundra-steppe communities.

The fauna similarity of early-Pleistocene thermophilic insects (Kiselev 1981)

and of present relic steppes allows one to suppose that through all climate changes through the recent 2.5 million years there always remained biotopes in the upper reaches of the Indigirka, their thermic conditions being at least not worse than the present ones of the Oimyakon hollow (Berman 1983; Kiselev et al. 1986), which secured the survival of thermophilic species in this refugium as well as of steppe biota as a whole. Combined occurrences of tundra and steppe insects in a fossil state can be a result of taphonomic integration: the formation of deposits which include residues of inhabitants of the respective ecosystems, which existed within the same area but in contrasting micro-(nano-) climate conditions.

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The Paleozoology Laboratory (México) and Its Role in Quaternary Studies

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Since the outcome of the importance of animal remains studies for paleoenvironmental inferences in the 1950s, there has been an increased interest in the research of such remains all over the world. This has been the case for Latin America, and especially for México, where, in 1963, a Paleozoology Laboratory was created to attend the necessities of the archaeologists for identification and analysis of bone and shells obtained from their excavations, as well as the rescue of extinct specimens found in late-Pleistocene sediments and the repository for all of those materials (Alvarez, 1967). Unfortunately, few foreign researchers are aware of the function and proceedings of the laboratory, and little information has been printed in English regarding the studies done.

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In this paper we try to summarize briefly what the lab capacities are, and which materials (and from where) are available.

The Paleozoology Laboratory from Instituto Nacional de Antropología e Historia is composed by three areas: Preparation, Collections, and Research. The Collections area has been divided into four sections: Comparative Osteological, Molluscs Typological, Archaeozoological, and Paleontological. Also, there is a very complete library, encompassing most, if not all, the bibliographyregardingPleistocenefaunalstudiesin México and North America, as well as Archaeozoological studies and Molluscan Taxonomy.

The Osteological Collection was created for comparative purposes and initially included only one specimen by taxon of each of the vertebrate species known living in México; this is very important because traditionally there have been systematic collections containing skeletons for only one vertebrate class.

Moreover, recent osteological studies show the need of a larger specimen sample in order to consider the normal phenetic variation, and so presently we are depositing into the collection at least four specimens by taxon, female and male, young and adult; but we prefer series of about 15 specimens. For example, for mammals we have 1,026 specimens from 240 species from all over the country.

Also, we are now emphasizing collecting in areas under study to document the present faunal composition, which is important for paleontological and archaeozoological studies in order to compare the past and present faunas; this has been done recently for El Cedral, San Luis Potosí, and San Josecito Cave, Nuevo León.

The Paleontological Collection is mainly formed by late-Pleistocene materials, with very few older specimens. Taxa are arranged phylogenetically and include Molluscs, Fishes, Amphibians, Reptiles, Birds, and Mammals. Presently the collection includes 4,517 catalogued unique specimens, and about 70% of the total number of specimens are uncatalogued. The collection is divided into two major parts: one part includes specimens of extinct taxa for comparative purposes, including seven holotypes; the other includes overall faunas from specific localities for preservation and study (Polaco and Arroyo-Cabrales, 1991).

Since the laboratory was created as part of a unit dedicated to the study of early-human sites in México, most of the paleontological materials proceed from those localities, including El Cedral; Tepexpan, Chimalhuacán, and Tlapacoya, México State; Hueyatlaco (Valsequillo), Puebla; Santa Martha, Los Grifos, and Aguacatenango, Chiapas; and, Loltún Cave, Yucatán, among others.

Presently, besides the identification stage, there is an increased interest in pursuing taphonomic and paleoenvironmental analyses with the materials, as well as searching for human-related bone marks, and bone technology. Because of these pursuits, taphonomical and modified bone collections have been initiated.

There are several projects undertaken in the different fields we are pursuing, such as: Paleontology (San Josecito Cave, El Cedral, and Loltún Cave); Archaeozoology (Teotihuacán, Templo Mayor, and Palenque); Taphonomy (recent experimentation); and Zoology (vertebrate and molluscs surveys from San Josecito, El Cedral, and Yaxchilán, Chiapas). The Paleozoology Laboratory has gained importance due to the recent approval of the law regarding federal control and management of archaeological and paleontological excavations by the Instituto Nacional de Antropología e Historia. Because of that, Lab personnel participate in the Advisory Committee for handling the requests of permits for paleontological excavations.

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Hair from Mammoth Meadow II, Southwestern Montana

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The First Americans multidisciplinary research program seeks to reconstruct the environmental and cultural history of the Everson Creek and Black Canyon area of southwestern Montana. This area is located between 2,060 and 2,100 m above sea level at the base of the Bitterroot Range (Figure 1). Since 1986, our research teams have mapped and tested three aboriginal quarries with finegrained cryptocrystalline rocks that were sought for the manufacture of flaked stone tools (MacWilliams 1992). Additionally, excavations at the stratified Mammoth Meadow workshop and habitation locality have exposed a significant archaeological record (Bonnichsen et al. 1991). The purpose of this note is to report a new cultural component found at the Mammoth Meadow II excavation, during the 1991 field season.

Figure 1 depicts a complex sequence of geologic deposits and soils. These include, from the base upward: alluvial gravel and sand (10C); subangular and rounded cobbles and stones in a clay matrix (9C1&2); a dark clay loam/clay paleosol (8Ab1&2) that includes the distinctive Cody level composed almost entirely of flakes and artifacts, clay and clay loam sediments and paleosol (strata

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Figure 1. Top right: map of Montana illustrating location of First Americans project at the South Fork of Everson Creek; top left, profile taken from north wall of Mammoth Meadow II excavation; and lower left: close-up showing relationship between subangular rocks and intrusion of cultural material (small squares) into bottom of Unit 9C2.

3C-7C inclusive) with intervening lenses of gravel (slopewash); and finally A1-2Bb inclusive) thick, black silty soil with abundant translocated clay in the Bt horizon. Elongate cobbles and stones (olivine basalt and quartzite) in strata 9C1&2 tend to have long axes oriented parallel to the 10% slope. This, the absence of gravel, low sand content and the distinctive chemical composition of the clayey matrix suggest that deposition was by mass movement downslope, under periglacial conditions, of local till deposits from upslope. The Cody level, like the cobble/clay horizon 9C below, is a distinctive marker across the entire site and has produced radiocarbon dates of 9,390 \pm 90 (TO-1976-AMS) and 8,226 \pm 84 (BX-16292-AMS). Both horizons of 9C and 10C are older than the dated Cody material.

The newly discovered archaeological component occurs at the contact between the water-rounded sand and gravel and subangular cobble/clay level (10C&9C). The site occupants apparently lived on the gravel bar surface. Archaeological remains from this buried surface include numerous cores and large flakes. This suggests that the gravel bar was a source for tool-making materials and served as a workshop site for the manufacture of flaked-stone artifacts. In addition to quarry debris, other archaeological remains include

blade-core preforms for the production of macroblades, large blade-like flakes, fragments of large carefully thinned bifaces, a spurred graver, and a grinding slab. Bone fragments are rare and poorly preserved.

Use of the flotation technique led to the recovery of a mammalian hair record. Hair remains occur in several of the upper levels; however, only specimens recovered from the lower level, which covers a 160-by-260-cm area, are reported here. C. W. Bolen's identification methodology combined the use of hair keys developed by Brauner and Coman (1974), Moore et al. (1974), and Steggerda (1941) as well as his personal hair-reference collection. Identifications were made by use of a light microscope at magnifications of 200x and 400x.

The hair record indicates the presence of a complex late-Pleistocene fauna. The hair reported here occurs at considerable depth in the phreatic-watertable zone just above the water table, where conditions are moist to wet. Taphonomic questions of whether humans or animals are responsible for the hair assemblage have yet to be considered. In total, 18 taxa have tentatively been identified from one or more surviving hair or hair fragments. The numbers of identified hairs per taxa (NIHPT) are enclosed in brackets. Lagomorphs are presented by a single rabbit [5] (Syvilagus sp.). Rodent hairs are from chipmunk [23] (Eutamias sp.), deer mouse [>5] (Peromyscus maniculatus), golden-mantled ground squirrel [>20] (Spermophilus lateralis), Richardson's ground squirrel [>25] (S. richardsonii), the northern pocket gopher [15] (Thomomys talpoides). Carnivores are well represented and include black bear [1] (Ursus americanus), wolverine [1] (Gulo gulo), badger [1] (Taxidea taxus), ermine [6] (Mustela erminea), long-tailed weasel [2] (M. frenata), and black-footed ferret [34] (M. nigripes). Artiodactyls include mule deer [2] (Odocoileus hemionus), bison [1] (Bison sp.), and caribou [1] (Rangifer sp.). The only extinct genera are horse [1] (Equussp.) and mammoth [1] (Mammuthussp.). But the most interesting specimen is a 32-cm-long human [1] (Homo sapiens sapiens) hair. A crosssection analysis of the hair compares favorably with mongoloid hair (Steggerda 1941) and does not match favorably with hair collected from crew members. Preliminary analysis of the follicle end of the hair by Mark Stoneking at Penn State University suggests that old DNA is still resident in the fossil hair sample.

Hair has previously been found at wet cave sites (Bolen 1983), in peat deposits (Sawtelle 1991), in permafrost (R. D. Guthrie, pers. comm. 1983) and dry cave sites (Agenbroad et al. 1983). Our work suggests that hair studies may have wider application for paleoecological and cultural reconstructions than commonly recognized. Although the lower component of the Mammoth meadow II has yet to be dated by ¹⁴C method, hair from extinct horse, mammoth, and caribou, which is no longer in the area, suggests the lower cultural component is of late-Pleistocene age.

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Preliminary Oxygen-Isotope Evidence for Late Pleistocene–Early Holocene Climatic Change

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Stable oxygen isotopes in late-Pleistocene and early-Holocene carbonate deposits provide preliminary evidence of climatic change from terrestrial sources in south Texas. Pedogenic carbonate nodules and a freshwater marl were sampled at two archaeological sites in Hidalgo and Willacy Counties. Both sites are situated on the edges of small blowout depressions. These blowouts are eroded into ancient infilled channels on the surface of abandoned Pleistocene delta deposits of the Rio Grande (Holz and Prewitt 1980). Below late-Holocene cumulic soils with archaeological materials are 50- to 150-cm-thick 2Bk horizons in the upper few meters of these delta deposits (Bousman et al. 1990). Outer and inner portions of two pedogenic carbonate nodules samples from site 41HG128, 3 km north of La Villa, provided four radiocarbon and stable oxygen isotope assays. A single marl sample from site 41WY112, 5 km east of Lyford, provided a fifth determination.

The influence of temperature on stable oxygen isotopes in meteoric water is well known (Dansgaard 1964), and recently Cerling (1984) demonstrated that oxygen isotopes in pedogenic carbonates can provide estimates of

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temperature change. It is assumed here that oxygen isotopes in the carbonate nodules and freshwater marl were in isotopic equilibrium with their coeval meteoric water. While no temperature estimates are offered, the increasing ¹⁸O/¹⁶O ratios of the pedogenic carbonate samples suggest rapid warming from 17,350 ± 150 yr B.P. (Beta-32204a ($\delta^{18}O = -4.2$)) to 16,330 ± 130 yr B.P. Beta-32205a ($\delta^{18}O = -3.4$)) and 15,010 ± 170 yr B.P. (Beta-32205b ($\delta^{18}O = -2.9$)). A lower $\delta^{18}O$ value dated to 12,780 ± 130 yr B.P. (Beta-32204b ($\delta^{18}O = -3.6$)) might be due to a reversion to cooler temperatures (Figure 1). Increased oxygen isotope ratios in the freshwater marl suggest warmer temperatures by 9,520 ± yr B.P. (Beta-32979 ($\delta^{18}O = -2.9$)).

These oxygen-isotope data support interpretations of early warming, based on declining spruce pollen at Boriack Bog in central Texas, soon after the Last Glacial Maximum (Bryant 1977; Holloway and Bryant 1984). The apparent drop in temperature indicated by the δ^{18} O value at ca. 12,800 yr B.P. could be synchronouswith a dramatic increase in grass versus arboreal pollen at Boriack Bog (Bousman 1991), and a Clovis-aged drought (Haynes 1991). All three events might be a response to a glacial meltwater surge down the Mississippi River (Fairbanks 1989; Overpeck et al. 1989). This meltwater surge appears to have reduced Gulf of Mexico sea-surface temperatures, and stimulated cooler and drier conditions in the region (Broecker et al. 1989). Clearly, additional isotopic data are needed to confirm this hypothesis of interrelated events.

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Figure 1. Chronological change of δ^{18} O values in south Texas pedogenic carbonates.

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Luminescence Dating of Eolian Deposits in the Mojave Desert—Initial Results

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A large amount of geologic evidence that includes sand dunes stabilized by soil formation and colluvial mantles, ventifacts covered with desert varnish, and dust mantles on lava flows shows that eolian processes have been more active than they are at present in the Mojave Desert of southern California during intervals of the late Quaternary (Smith 1967; Wells and McFadden 1987). These landforms and deposits have the potential to provide information on changes in wind directions and circulation patterns over time, as well as the duration and timing of periods of enhanced eolian sediment transport (Lancaster 1990). The precise timing and chronology of periods of past eolian

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activity is, however, generally poorly known and the response of eolian geomorphic systems to climatic changes uncertain, in part because the problems of obtaining absolute age estimates from eolian materials have hampered correlations with other sources of proxy palaeoclimatic data. Luminescence dating techniques (Wintle and Huntley 1982; Berger 1988) provide the means to directly assess the age of eolian sands and offer the promise of moderate-to high-resolution chronologies of eolian deposition on time scales of millennia to centuries, as well as enabling correlation of periods of eolian activity with other sources of palaeoclimatic data.

We are currently developing a history of eolian activity in the Mojave using a combination of stratigraphic studies and luminescence dating with the aim of reconstructing the climatic conditions, including winds and circulation patterns, that were associated with enhanced eolian action in this region. Our research to date has concentrated on Kelso dune field, as well as climbing and falling dunes in the Cronese Basin and Dale Lake areas.

Dating of sediments by thermoluminescence (TL) and optically stimulated luminescence (OSL) techniques measures the number of trapped electrons within a crystalline material (e.g., quartz or K-feldspar) resulting from its exposure to ionizing radiation derived from the decay of naturally occurring ⁴⁰K, U, and Th in the surrounding sediment (Wintle and Huntley 1982, Berger 1988). The luminescence signal is reduced to a residual value by heating to >500°C or exposure to sunlight; in sediments the event dated is therefore the last surface exposure. Measurement of the amount of luminescence and the rate of production per unit of radiation yields the amount of past radiation exposure or the equivalent dose (ED). The natural annual radiation dose is derived from independent measurements of radioactivity in the field or laboratory. The age of a sample is given by: Age = equivalent dose (ED) Grays/Dose rate (Grays/year). The electrons trapped in the crystal lattice can be evicted by heating the sample to 500°C (thermoluminescence), and the resulting photons can be detected as visible light via a photomultiplier. The same effect can also be generated in feldspars by exposure to infrared photons (infrared stimulated luminescence-IRSL) or in quartz by exposure to a green laser (optically stimulated luminescence-OSL).

Initial IRSL results from Kelso Dunes indicate three major periods of eolian deposition and/or dune reactivation in the past 5,000 years: 4,300–3,600 yr B.P., 1,300–1,700 yr B. P., and 400–870 yr B.P. Preliminary TL dates from Cat Dune and Dale Lake suggest that there is evidence for episodic eolian activity spanning the past 50,000 yr, with a well-defined period of eolian deposition in the period 15,000–9,500 yr B.P. Comparisons with the paleolake and alluvial fan records for the region (Wells and McFadden 1987, Enzel et al. 1989) suggest that periods of eolian activity in the region correlate well with intervals of low and/or fluctuating lake levels and aggrading alluvial fan systems may be a major control on the intensity of eolian processes in this region and thus an indirect link between the response of eolian processes to climatic change.

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Holocene Paleoclimatic Reconstruction in the Laguna de Babícora Basin, Chihuahua State, Northwest of Mexico

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The knowledge of fluctuations on the extent and depth of water levels in ancient lakes provides some of the most accepted evidence for climatic changes during late-Pleistocene and Holocene periods. Therefore, they are excellent indicators of variations in water balance.

The Laguna de Babícora Basin in Chihuahua State, northwestern Mexico, contains a lake at approximately 29° 15′ N and 108° 00′ W, and at 2,200 m altitude. The pre-Quaternary origin of the Laguna de Babícora Basin has been controlled, first, by extensional faulting related to the early-Tertiary compressive regional process of the Pacific coast margin, and second, to the distensive pattern during the late Tertiary.

In previous studies (Ortega 1985, 1990), it was postulated that the Laguna de Babícora Basin was affected by the paleoclimatic variations during Pleistocene/Holocene times. Additional evidence is presented here, including a new stratigraphic chronology which is based on six radiocarbon dates ranging from ca. 9,000 yr B.P. (8,120 ± 105 yr B.P. (INAH-810)) to ca. 2,800 yr B.P.

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 $(2,890 \pm 60 \text{ yr B.P.} (INAH-814))$. Sedimentological and mineralogical analyses of eight stratigraphic profiles are also presented. These new data enable us to interpret the history of the environmental fluctuations in the paleolake during the past 10,000 yr B.P.

The different graphical and statistical parameters that are currently in use, particularly the granulometric sampling of 99 samples from the stratigraphic profiles, provide insights into the transport type and the corresponding depositional environments of the sediments.

In addition, the stratigraphic correlation of the profiles, based mainly on principal components and cluster analyses, reveals that the northwest and southeast sides of the basin are characterized by sediments deposited within a closed aquatic environment, whereas the north and the northeast sides represent rather rhythmic fluvial deposits: swampy-lacustrine during the early Holocene; fluviatile and lacustrine-swampy during middle Holocene; and fluvial—short but intensive—during the late Holocene.

The oldest unit studied (early Holocene: ca. 10,000 to ca. 6,000 yr B.P.) is composed of laminated silts and clays with abundant ferric concretions, phytoliths, carbon, and diatoms, overlain by a veneer of fluvial sands and fine gravel. This unit is interpreted as hot, dry hydroclimatic conditions that arrived probably to a maximum to ca. 6,000 yr B.P. This previous information is in agreement with palynological studies in the following areas: Santa Barbara Basin, California, and the Guaymas Basin, Gulf of California (Heusser, 1978, 1982); the Great Lakes region (Benson et al., 1990); Arizona and Nevada (Van Devender, 1977); as well as in the West coast of U.S.A. (Curray, 1961).

The middle-Holocene (ca. 6,000 to ca. 3,000 yr B.P.) sediments consist of two types of deposits: (1) lacustrine silts, fine sands and clays mixed with organic fragments and rhyzoconcretions, overlain by a unit of buried paleosol (eluvial horizon: Bt) dated ca. 3,000 yr B.P.; (2) fluvial sands and gravels deposits. From these deposits we can infer fairly variable hydroclimatic conditions that indicate mainly marsh and fluvial environments, ending in a dry interval represented by the paleosol.

During the late Holocene (over the past 3,000 yr B.P.) the hydroclimatic general trend was dry but included short wet intervals. At the top of these sediments there is an erosional surface dated ca. 2,000 yr B.P. which is overlaid by heterometric fluvial sand deposits with poor sorting which can be related to short humid periods.

We conclude that the Holocene paleoclimatic behavior at the "Laguna de Babícora" resembles middle-latitude paleoconditions such as those from the southwestern U.S.A. rather than lower latitudes as in central Mexico.

Although the cause of Pleistocene/Holocene paleoclimatic variations in the area is still under discussion, we suggest that the lake variations can be explained by the changes in the general atmospheric circulation related to the melting of the continental ice sheets. Another important point to stress is that at the base of the composite stratigraphic sequence, analyzed though not yet studied in detail, we hope to find older units that could correspond to Pleistocene times, and therefore would help to understand the early stages of genesis of the "Laguna de Babícora."

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Progress on Modeling Local Climate of the Southwest at 18 ka

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We have synthesized three models of separate aspects of paleoclimate to produce a more comprehensive representation. The basis model provides a computation of monthly temperature and precipitation for the time of the last glacial maximum. These solutions are used in a snowfall/snowpack model that computes mean monthly snowfall for a series of years using Monte Carlo methods. The third model computes stable-isotope ratios in precipitation, surface water and runoff using the monthly temperature and precipitation solutions and snowfall information.

The local climate model (LCM) simulates present (1980–84) and last-glacial (18ka) climate of the Southwest U. S. Measures of monthly temperature (TEMP) and precipitation (PREC) are computed using a canonical regression of predictor variables that represent the primary and interactive effects of terrain, sea-surface temperature, CO_2 , solar insolation and windfield. An energy-balance model (Pease 1987) is used to represent some of these interactions. Solutions are made at a 10-km spacing over an area that extends 220 km north, 330 km south, 800 km east and 360 km west of 116°W, 37°N. This

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area approximately extends from the Pacific coast to the Rocky Mountains and from the latitude of Lake Tahoe, NV, to the latitude of Los Angeles, CA.

Annual and seasonal TEMP and PREC are computed from solutions of monthly TEMP and PREC for comparison with proxy paleoclimate estimates. Departures (18ka minus present) in TEMP (°C) for the Southwest U.S. are: winter, -9.5; spring, -4.8; summer, +0.1; fall, -3.5. Average annual change in TEMP is -4.4°C. Departures in PREC (mm) are: winter, -13; spring, 53; summer, -46; fall, 28. Average annual change in PREC is +22 mm. Overall, most areas experienced increases (about 25 to 100 mm) in annual PREC. Larger increases in annual PREC are indicated for the Pacific coast, the southern Sierra Nevada, some inland ranges and the southern Rockies. However, decreases in PREC are indicated for the central Sierra Nevada and parts of the Colorado Plateau.

The detailed LCM solutions allow comparisons with proxy paleoclimate data. For example, Dohrenwent (1984) studied glacial landforms and cirque altitudes in the western Great Basin to estimate mean annual temperature and accumulation-season precipitation (ASP) during the full glacial. He computed a 5.5°C drop in mean annual temperature and a 370-mm increase in ASP, based on lapse rates of 6.7°C per 1000 m and 500 mm of ASP per 1000 m. Dohrenwend prefers a reconstruction for the full glacial with slight changes in ASP and mean annual temperatures 7°C lower. LCM solutions at the locations of alpine cirques and glaciated valley bottoms used by Dohrenwent (1984, Table 2) indicate a 5.3°C drop in annual TEMP, a 9.3°C drop in accumulation season TEMP (DJFM) and an 11-mm decrease in ASP (DJFM) at 18 ka.

The snow-simulation model calculates mean monthly snow accumulation, snow ablation, and snowpack-water equivalent for each month of a multi-year run within a gridded solution domain. Monthly temperature and precipitation value (normally and lognormally distributed, respectively) from the local climate model are perturbed in order to model their inherent temporal variability. Snowfall, that fraction of precipitation which falls below a critical temperature, is computed as the double integral of the bivariate normal distribution in standardized temperature and log precipitation space. Snow ablation is computed as an index of surface temperature (Martinec et al. 1983) and an areal-extent coefficient drawn from a beta distribution, and snowpackwater equivalent is computed as a function of extant snowpack, monthly accumulation, and monthly ablation.

A 34-year modern simulation (matching the length of record) at Donner Memorial State Park yields results for mean January snowfall within 7% of the observed value at that location. A 34-year LGM simulation at Donner Memorial State Park predicts mean January snowfall that is 330% of modern observed snowfall.

Rayleigh fractionation and distillation are included in the isotope computations which proceed along windflow paths computed by massconserving interpolation from a coarse grid of observations. The availability of the isotope results will allow a comparison to the geologic record of stable isotopes in the western U.S. Current research focuses on reconstructing the isotope signatures of water bodies within the drainage of the Truckee River. The isotope model has been tested for modern environments on a traverse across northern California.

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Paleoenvironments: Plants

Preliminary Pollen Analysis of Cores from the Northern Gulf of California

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Pollen analysis of continuously deposited sediments has become a particularly valuable complement to packrat-midden studies in the arid Southwest, because they record regional vegetation change on rapid (century to decade) time scales. Core AII 125 JPC 70, taken 24 April 1991 in 145 m water in the central northern Gulf of California, is 841 cm long and is dated 9,305 \pm 225 yr B.P. at 508 cm (accelerator date of microscopic charcoal). The Salina Grande core, taken from a raised spring mound on 9 November 1991, is 425 cm long, and is dated 3,690 \pm 50 yr B.P. at 390–400 cm on peat.

Core JPC 70 records the demise of Mojave Desert elements at 508 cm $(9,305 \pm 225 \text{ yr B.P.})$. Desert vegetation is indicated throughout: Larrea (creosote bush), Euphorbia (spurge), and Ephedra (joint fir). However, Ambrosia (bursage) and Ephedra percentages are higher above 508 cm, whereas Cupressaceae (juniper) is more abundant and Elaeagnaceae (cf. Shepherdia argentia, a Mojave Desert species) is consistently present below 508 cm (Figure 1). The demise of Elaeagnaceae is concurrent with the latest occurrence of Mojave Desert elements in the lower Colorado River Valley, as recorded in packrat middens (Van Devender 1990).

Preliminary 100-grain counts of eight samples of Salina Grande Marsh indicate increased spring discharge and lesser aridity from 180 to 360 cm. In that interval, the least-salt-tolerant taxa, cattail (*Typha-Sparganium*) and *Spirogyra* (a filamentous green alga), are more abundant; and lower *Ambrosia* percentages indicate reduced aridity in upland vegetation.

Core JPC 70 provides an important constraint on global atmospheric circulation. The COHMAP project (COHMAP Members 1988) concluded that the North American winter jet stream split into northern and southern limbs during the full glacial, with the southern arm displaced southward to about 30° N. The persistence of desert elements at JPC 70 prior to 9,300 yr B.P. fails

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Figure 1. Percentage pollen diagrams for cores from the northern central Gulf of California, and for a spring mound at Salina Grande, Sonora, Mexico. Curves without solidfill are types outside the pollen sum.

to support this contention. The vegetation changes are minor. If the continent's primary storm track had been displaced to this latitude, the desert should have been replaced by grassland or more mesic vegetation.

The core of Salina Grande Marsh appears to record an early-Neoglacial wet period indicated at Pecks Lake, Arizona (1,500–3,000 yr B.P.; Davis and Turner 1986), and San Joaquin Marsh, California (2,800–2,300 yr B.P.; Davis 1992). Its basal age is contemporaneous with earliest sediment accumulation at Pecks Lake (Davis and Turner 1986) and Hassayampa Marsh (Davis 1990); and with the transition to late-Holocene vegetation in the Sonoran Desert (Van Devender 1990).

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Preliminary Results of a Nonsiliceous Algae Record from Cloquet Lake, Lake County, Minnesota, USA

James K. Huber

Nonsiliceous algae associated with a pollen sequence from Cloquet Lake, Lake County, Minnesota, indicate several apparent fluctuations in the trophic status of the lake. Cloquet Lake, the headwaters of the Cloquet River, is associated with the Highland Moraine and is located approximately 90 km north of Duluth, MN (91° 30'N, 47° 30'W). Analysis of the pollen sequence indicates that the vegetation progressed from a tundra-like environment to a mixed conifer-hardwood forest following glacial retreat, approximately 14,700 yr B.P. (Wright 1972). Paleoecological investigations of the Cloquet Lake sediments were undertaken to aid in the understanding of Paleoindian occupation of the area.

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A 438-cm core was extracted near the center of the lake. The core is composed of two distinct lithologic units separated by a 3-cm-thick gravel layer. The upper 397 cm consists of detrital gyttya; below the gravel layer (400–438 cm) is silty gray clay.

Zone CLA-1 (Figure 1) represents the initial period of algal colonization in the lake. Algal concentrations are very low, 700–1,100 coenobia/cm³ of wet sediment, and only eight different taxa are present. Dinoflagellate cysts (dormant, thick-walled cells) were also observed in their greatest abundance in CLA-1 (Figure 1); however, their paleoecological significance has not yet been determined.

After the initial period of colonization, *Scenedesmus*, a colonial green algae (Chlorophycophyta) indicative of elevated nutrient levels (Cronberg 1982), is the predominant taxon. *Scenedesmus* maxima in the sequence indicate that Cloquet Lake has undergone five cycles of nutrient enrichment. In the upper portion of the sequence, *Scenedesmus* abundance decreases significantly (Figure 1).

Blue green algae (Cyanochloronta) of *Gloeotrichia*-type, a nitrogen-fixing algae (Van Geel et al. 1989), is consistently a minor component in zones CLA-2 through CLA-6 after its initial appearance. In zone CLA-7, *Gloeotrichia*-type decreases to trace amounts before disappearing completely. *Pediastrum Boryanum*, an indicator of lake eutrophication (Cronberg 1982), is present in



Figure 1. Algae percentage diagram of selected taxa from Cloquet Lake, Lake County, Minnesota.

trace amounts in CLA-1 and occurs as the second-most-important taxon throughout the rest of the sequence. Zygnema-type and/or *Spirogyra*-type resting spores, which are present in all zones, indicate stagnant, shallow, and generally mesotrophic conditions (Van Geel 1978).

Scenedesmus and/or Pediastrum maxima associated with the late-glacial spruce zone (Crisman 1978; Huber 1988, 1989; Huber and Overstreet 1990) have been documented at sites in Minnesota and Wisconsin. These maxima have been interpreted as indicating periods of increased productivity. The five cycles of nutrient enrichment indicated by the Scenedesmus maxima suggest that Cloquet Lake has been a productive lake throughout most of its history. The oscillations in Scenedesmus abundance may result from changing environmental and/or limnologic conditions after the lake basin was formed. Further investigations of nonsiliceous algae should aid in the understanding of changing watershed conditions following glacial retreat.

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Reexamination of the Cool/Mesic Interpretation of the "Altithermal"Mud Creek Local Fossil Biota, Eastern Iowa

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Kramer (1972), identified fossil plants, molluscs and vertebrates from seven sites along a 3.7-km segment of Mud Creek. One site produced a date of 6,220 ± 110 yr B.P. (I-6228); another, 6,310 ± 75 yr B.P. (Wis-580). Both dates placed the Mud Creek biota within the "altithermal" period. Paleoenvironmental analysis of these sites, however, resulted in an enigmatic paleoclimatic interpretation: a cool/moist rather than an expected warm/arid "altithermal" in eastern Iowa (Kramer 1972). This interpretation contrasts with the interpretation of warm, dry conditions for the same time period in northwestern Iowa (Semken 1980; Baker and Van Zant 1980). The discrepancy led Semken (1980, 1983) to predict an increased climatic gradient across Iowa during the "altithermal." However, the assumption that the seven sites were contemporaneous is probably false since recent work has shown that cutbank exposures along Mud Creek vary significantly in age (Autin and Bettis 1991). The interpretation of a more mesic "altithermal" could therefore be challenged on the grounds that some paleoecologically critical specimens did not come from "altithermal" age deposits. Recently, Autin and Bettis (1991) systematically described the Holocene sedimentology, stratigraphy and soils of the Deforest formation along Mud Creek. One cut bank, the Lilienthal section (NE 1/4, NE 1/4 Sec 12 T79N, R1W, Cedar County, Iowa), exhibits sediments from all three members of the Deforest formation (Figure 1): the Camp Creek member, dated less than 240 yr B.P., the Roberts Creek member at (240-4,000? yr B.P.) and the Gunder member at (5,350-9,310 yr B.P.) (Autin and Bettis 1991). Thus, reexamination of Mud Creek fossil assemblages within a firm stratigraphic framework is now possible.

Preliminary analysis of the Lilienthal section indicates that the Gunder Member represents a point bar deposit that was hydrodynamically influenced by an overturned tree stump. Wood from the top, middle and bottom portions of the Gunder member produced radiocarbon ages of $6,240 \pm 50$ yr B.P. (Beta-46211), $6,300 \pm 80$ yr B.P. (Beta-41170), and $5,920 \pm 60$ yr B.P. (Beta-46212), respectively (Figure 1). Analysis of associated plant macrofossils suggests that during the "altithermal" period the area around this site was dominated by an upland deciduous forest containing sugar maple (*Acer saccharum*), basswood (*Tilia americana*), white oak (*Quercus alba*), bitternut hickory (*Carya cordiformis*), hazel (*Corylus*) and American elm (*ulmus americana*). Riparian elements including willow (*Salix*) and green ash (*Fraxinum pennsylvanica*) were also noted; no prairie species have yet been recovered. This plant macrofossil assemblage confirms the presence of a more humid climate in eastern Iowa as

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originally suggested by Kramer (1972) and subsequently by Chumbley et al. (1990) from a biostratigraphic sequence along Roberts Creek. Analysis of vertebrate remains is in progress.



Figure 1. Generalized Holocene section at the Lilienthal Site, Mud Creek, Cedar County, Iowa.

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Paleoenvironments: Vertebrates

A New Late Wisconsinan Record of Wolverine from Southwestern Nebraska

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Fossil wolverines (*Gulo gulo*) are rare in North American Pleistocene deposits: only three sites in the central Great Plains have yielded remains of this animal (Corner and Voorhies 1987), and all are located in Nebraska. I present the fourth Nebraska locality with an occurrence of *G. gulo* and a new southernmost record.

A right partial wolverine mandible (Figure 1) was found on the beach of Harlan Co. reservoir in 1990 by a local collector, Paul Prettyman. Although not found in situ, the specimen is encrusted with caliche and cemented loess and displays rootlet etching, both indicative of burial. The cutbank along the shore in this area is in situ Peoria Loess of late-Wisconsinan age, and proboscidean remains have been found in the immediate vicinity (Steven Holen, pers. comm.). Therefore, a late-Wisconsinan age for the specimen is likely, and it marks the southernmost known occurrence of fossil wolverine in North America. The nearest historic record of *Gulo* is from Scotts Bluff Co., NE, in 1887 (Jones 1962), approximately 400 km to the northwest of Harlan Co. Reservoir and 610 m higher in elevation. If the Harlan Co. specimen were Holocene in age, it would still be the southernmost record of *Gulo* in the Great Plains.

Bryant (1987) states that late-Pleistocene wolverines of both North America and Europe were larger than extant populations, and that the largest specimens in North America come from Fairbanks, Alaska (Anderson 1977), and Chimney Rock Animal Trap, Colorado (Hager 1972). The latter is approximately 560 km to the northwest of Harlan Co., NE, and nearly 1800 m higher in elevation. Measurements taken of the Harlan Co. specimen (after Von Den Driesch 1976) include: a tooth-row length C-M/2 of 67.8 mm; depth of ramus between M/1-2 of 27.2 mm; length of P/4 of 12.5 mm; width of P/4 of 7.8 mm; length of M/1 of 22.6 mm; and width of M/1 of 10.6 mm. The Harlan Co. specimen was compared with published data (Anderson 1977; Hager 1972; Bryant 1987; Kurten and Anderson 1972), another Nebraska specimen (Crappie Hole

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locality, George Corner, pers. comm.), and the Natural Trap Cave collection from Wyoming measured by the author (unpublished). The tooth-row length and depth of ramus for the Harlan Co. specimen are the second- and thirdlargest (respectively) recorded dimensions for these measurements in fossil *Gulo*. The length-to-width ratio of the P/4 falls into the "narrow" category described by Bryant (1987) as occurring more commonly in fossil rather than in extant populations. Both the large size and more narrow P/4 support a late-Pleistocene age for the specimen. The Harlan Co. wolverine gives further evidence for boreal habitat and a widespread distribution of *Gulo* in the central Great Plains during the late Wisconsinan.



Figure 1. A. Map showing late Wisconsinan localities yielding fossil wolverine (*Gulo gulo*) in North America (triangle marks Harlan Co. Reservoir locality). B. Right ramus of *G. gulo* found at Harlan Co. Reservoir.

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Preliminary Report on the Fossil Bears of El Capitan Cave, Prince of Wales Island, Alaska

Timothy H. Heaton and Frederick Grady

For the last five years officials of Tongass National Forest and cavers of the National Speleological Society have joined forces to find and survey caves in the extensive limestone exposures of Prince of Wales Island, one of the largest islands of the Alexander Archipelago. During the 1990 field season, an important and unexpected paleontological site was discovered by expedition leader Kevin Allred. In a remote high passageway of El Capitan Cave, Alaska's largest known cave, Allred found the complete skeleton of a black bear (*Ursus americanus*) in nearly perfect condition, parts of at least two other black bears, and fragments of a second species of bear that is much larger. Together with these were piles of small ground fish bones that appear to be remnants of the bears' excreta.

It is virtually impossible that bears could have entered this passage by the treacherous route the cavers used. Allred discovered, however, that the bone deposit was close to the surface, and after some digging in a high rubble pile at the end of the passage he was able to see daylight through a now-sealed entrance. Thus the passage containing the bones was presumably used as a den by bears before this entrance became choked with rocks and soil.

Together with Allred we conducted a preliminary survey of the site in 1991. The passage containing the bear remains ranges from 1 to 3 m in width and

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height and extends 20 m between a pool and the choked entrance. This part of the cave is very wet and stays at a temperature near 40° F. The complete blackbear skeleton lies near the lake on flat bedrock, clean rock rubble, and shallow clay. The bone is clean and in excellent condition, and it has taken on a deep reddish color. Bones of the other black bears are in good to fair condition but are more widely scattered. Some are buried in shallow clay; others are under water when the pool is high. Bones of the large bear are highly fragmented and are mixed with soil and rock rubble that has come in through the sealed entrance. Also found were the complete skull and jaws of an ermine (*Mustela erminea*) and bones of several bats. Sediments may be too thin near the pool and too disturbed near the sealed entrance to provide a stratigraphic relationship between the skeletons.

The two black bears represented by skulls are young adults with fully erupted teeth, but some bone epiphyses are not fully fused. Five humeri measured (probably from three individuals) have lengths ranging from 28 to 33 cm, which spans the upper size range for modern black bears.

The identification of the large bear remains unresolved. Parts found thus far include a partial right maxilla with P4, an upper left canine, the distal end of a left humerus, the distal end of a left femur, the shaft of a left tibia, and a partial pelvis, all presumably from the same individual. The P4 measures 20.5 mm in length compared with 13.6 and 13.7 mm for the black bears. In size, the large species closely matches the extinct giant short-faced bear (*Arctodus simus*) as reported by Merriam and Stock (1925), Kurten (1967), and Emslie and Czaplewski (1985). However, the distal humerus, though somewhat eroded, appears to lack the entepicondylar foramen diagnostic of *Arctodus*, suggesting that the large bear is some species of *Ursus*. The diastema is too short and P4 too wide for polar bear (*Ursus maritimus*), so what we may have is an exceptionally large grizzly bear (*Ursus arctos*). Since only black bears now inhabit Prince of Wales Island, the large bear is significant regardless of its identification.

Samples of the complete black bear and the large bear were removed for radiocarbon dating by accelerator mass spectrometry (AMS) to obtain an approximate minimum and maximum age for the deposit, respectively. Unexpectedly the black bear turned out to be older at $10,745 \pm 75$ yr B.P. (AA-7793). We suspect that the other black bears will yield even older dates. The large bear dated at $9,760 \pm 75$ yr B.P. (AA-7794). Thus the age of the deposit falls near the end of the Wisconsin glacial, and the two species of bears must have been early post-glacial inhabitants of Prince of Wales Island. Since El Capitan Cave is located in a deeply eroded glacial valley, the bears provide a terminal date for substantial deglaciation. During the 1991 field season, we surveyed the location of the bear entrance and established voice contact between the cave and the surface.

During the 1992 field season we plan to remove the large log and rocks that block this entrance and reopen it in order to make a complete excavation more practical. We believe that more material of the large species can be recovered from the deep fill that has fallen in from the surface, and we hope this additional material will allow us to make a full analysis of this enigmatic bear. We thank Kevin Allred for taking us to the site, Julie Heaton for helping locate the bear entrance on the surface, Jim Baichtal and Cat Woods of Tongass National Forest for providing housing and food during our stay and for funding the radiocarbon dates, and to the University of South Dakota for providing partial travel funds.

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A Reinvestigation of the Burntwood Creek Bison Bone Bed

Matthew E. Hill, Jr., Jack L. Hofman, and Larry D. Martin

Research of the late-Pleistocene/early-Holocene cultural occupation of the North American Great Plains region has emphasized the importance of bison (*Bison*) bone beds (Frison 1991). Bone beds are key sources of information on aspects of economy, ecology, and taphonomy of the Plains region (e.g., Frison and Todd 1987; Todd 1987a; 1991; Wheat 1972). Until now, however, only a single such site, 12 Mile Creek, has been recognized for the entire western-Kansas region (Rogers and Martin 1984; Williston 1902). Our recent inventory of a paleontological collection of bison remains from western Kansas has documented a previously overlooked early-Holocene bison bone bed.

In 1924, H. T. Martin published notice of a rich deposit of large bison, which had apparently been known to local ranchers for some 40 years. The site is located in Rawlins County, Kansas, along a small stream called Burntwood Creek, which is tributary to the Republican River. Two seasons (1922 and 1923) were spent at the site resulting in the recovery of numerous elements from mostly disarticulated animals. E. R. Hall (1923:7–9) describes the deposit as follows:

The bison lay directly upon early Pleistocene stratum of blue clay two feet in thickness, strongly contrasted with the loose red Pleistocene soil which covered them.... Slightly north of the center the bed dips noticeably and

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in this region there is greater disarticulation between parts of the skeletons.

Not only were the bones disarticulated, but they were broken and chewed up. In other areas the bones were several layers deep (Hall 1923:9). Martin describes the assemblage as being poorly preserved and highly fractured. The remains were considered by Martin to be comparable to the 12 Mile Creek bison and identified as *Bison occidentalis*. The 12 Mile Creek site in Logan Co., Kansas, approximately 80 km south of Burntwood Creek, is the only other early-Holocene-age bison bone bed documented in Kansas and has been dated to about 10,200 yr B.P. (Rogers and Martin 1984). The age of the Burntwood Creek deposit is undetermined, but bone analysis is being conducted to determine the feasibility of obtaining a reliable AMS date on the bone from the site.

Inventory of the Burntwood Creek collection, curated at the Museum of Natural History at the University of Kansas, suggests that it may be an early-Holocene archaeological site. Martin (1924) discusses the site as a paleonto-logical quarry and with no comment of the possibility of a cultural origin. However, Hall (1923:8) comments that "on the north edge of the bed, the bones are blackened and charred." Although no artifacts are documented from the deposit, the site setting and the presence of numerous carbonized bone (ca. 4%, n=59) opens the possibility that a bison kill is represented.

Metric analyses of the radii, humeri (RD 9 and HM 11 of Todd 1987b), and metapodials (M1: maximum length of Bedord 1974) from Burntwood Creek suggest that the bison from this site are similar in size to the bison found at other early-Holocene kill sites and substantially larger than modern bison (*Bison bison*) samples (Todd 1987b). Burntwood Creek bison are smaller than the large bison from the Lipscomb site (Todd et al. 1992: Figure 10), but are of similar size to bison from the Casper and Olsen-Chubbuck sites (Todd 1987b; Bedord 1974: Table 8.18). Several researchers have suggested that the size of early-Holocene bison has progressively decreased. If this trend is accurate, then the size of the Burntwood Creek bison would tentatively date the site to the late-Paleoindian period.

Martin (1924:278) estimated "the number of animals that perished here could not have been less than 150." The actual basis for Martin's estimate is unknown, but our inventory documents a minimum of 31 individuals (based on right astragali). It is possible that Martin's estimate is based on 1) material observed in the field but not collected, or 2) an extrapolation based on material recovered in relation to total extent of the deposit.

Skeletal-element frequency is not uniform. Lower-limb elements, such as carpals, tarsals, and phalanges, are well represented, whereas upper-limb and axial elements are sparse. Cultural destruction or transport may partially explain this pattern, though it is likely that differential preservation of elements is largely responsible. The most numerous elements in the Burntwood Creek collection, e.g., astragali (MAU=31) and carpals, are very dense; and the least-represented elements, such as ribs (MAU=0.3), femora (MAU=1), and skulls (MAU=5), are structurally weak (Lyman 1984). Fluvial transport may have played an active role in the formation of this site, given its alluvial setting and because Martin (1924:278) attributes disturbance at the deposit to stream

erosion. Hall (1923: 8) notes that "cutting in of the stream had carried away several feet of the bed."

Evidence for unequivocal cultural breakage of the bones is absent. All breakage appears to be dry-bone breaks, and surface modifications to the bones is limited to subareal weathering, root etching, and a metacarpal with signs of carnivore gnawing. While morphological evidence for carnivore action is scarce, there is a slight difference in the ratio of proximal ends to distal ends for long bones (ratio = 1:1.2). The difference between the quantity of proximal (n=1) and distal ends (n=5) of humeri at the site is greater, which might suggest carnivore modification of the faunal assemblage (Binford 1981). Todd and Rapson (1991) state that a significant difference between the quantity of first phalanges to third phalanges can indicate carnivore action or other destructive forces on ungulate carcasses. At Burntwood Creek, both first phalanges (ratio MAU = 77.8%) and third phalanges (ratio MAU = 63.7%) are well represented, and this implies that carnivores may not have been important taphonomic agents in the formation of the site.

The most prevalent taphonomic modification to the assemblage is subareal weathering (Behrensmeyer 1978). All long bones were examined (n=57) for evidence of weathering. Approximately 75% (n=43) have evidence of extensive weathering, comparable to Behrensmeyer's Stage 3 or above. The side opposite the area of maximum weathering was also examined for evidence of weathering, identified as minimum weathering. Most of the elements were extensively weathered on both sides, and 43 (ca. 75%) of the long bones had no difference or a difference of only one weathering stage between the two sides. This equality of weathering on both sides of these bones suggests that the surface exposure of these bones was unstable.

Teeth are a common element from Burntwood Creek. A minimum of 24 individuals (MNI=23 right and MNI=24 left) are represented by $M_{g}s$. With only ten separate mandible fragments, most of the teeth are loose. Therefore analysis of seasonality is limited primarily to loose $M_{g}s$. No calf mandibles are present, and only two mandibles have lower dentitions not in full wear. Sixteen $M_{g}s$ are in partial wear, and they represent two distinct age groups, comparable to dental-age groups 4 and 5 from the Scottsbluff site (Todd et al. 1990). The lack of wear on some Group 4 $M_{g}s$ and on the hypoconulids of Group 5 $M_{g}s$ suggests that the season of death for the Burntwood Creek bison may have been slightly earlier than for the Scottsbluff assemblage (ca. 3.1–3.2 and 4.1–4.2 years). This degree of wear has been interpreted to place the season of death at late spring to early summer.

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The M_1 in *Panthera leo atrox*, an Indicator of Sexual Dimorphism and Ontogenetic Age

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The Rancho La Brea (RLB) collections provide the largest single sample of *Panthera leo atrox* (American lion) remains. Skeletal elements of over 80 individuals have been recovered from the asphaltic deposits that range in age

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from 32,000 to 12,000 yr B.P. (Marcus and Berger 1984). The total available samples of femora (n=25) and M_1 (n=49) from RLB are used to estimate body size/mass and to document sexual dimorphism in *P. l. atrox*, permitting a comparison of the sexual and ontogenetic age structure of modern African and extinct American lion populations. Although RLB provides the largest sample of *P. l. atrox*, the sample is still statistically very small and subject to taphonomic biases that are not yet fully understood.

Estimates of body size/mass based on adult femoral size (Alexander et al. 1979; Anderson et al. 1985) are probably more accurate than those calculated from dental parameters. Tooth size may be subject to adaptive selection, related more to feeding function than body size. Body size/mass estimates calculated from M_1 dimensions, APD (Van Valkenburgh 1990) or APD x LLD (Legendre and Roth 1988) exhibit consistently larger means and greater ranges in comparison with estimates based on femoral size. However, dental wear provides a precise estimate of ontogenetic age throughout the life of the individual, whereas relative femoral development is applicable only to younger animals.

In the felid dentition, the size of the M1 is the best gauge of body size/mass (Legendre and Roth 1988; Van Valkenburgh 1990). Bivariate distribution of the antero-posterior length (APD) plotted against the lingua-labial width (LLD) for the M_1 s of *Panthera leo atrox* clearly distinguishes large and small specimens which are referable to male (n=31, 63%) and female (n=18, 37%) individuals.

Legendre and Roth (1988) estimate body size/mass using the crown area of M_1 (APD x LLD). The mean M_1 crown area of RLB *Panthera leo atrox* males is 494.19 mm² (range = 440.44 to 581.75 mm²). These measures indicate a mean mass of 266.2 kg (range = 223.2 to 343.0 kg). Calculated body mass for females (mean M_1 crown area 387.50 mm², range 313.77 to 442.32 mm²) results in a mean of 183.1 kg (range = 132.2 to 224.7 kg). In contrast, body size/mass estimates based on adult femoral size (Gingrich 1990) for male (n=14) and female (n=11) *P. 1. atrox* are 235 kg (range = 286 to 199 kg) and 175 kg (range = 210 to 151 kg) respectively. Male *P. 1. atrox* were between 26% (femoral estimates) and 31% (dental estimates) larger than the females, compared with about 15% in *P. l. leo* (Schaller 1972) and >40% in *P. tigris* (Neff 1982).

Schaller (1972) employed the diameter of the occlusal wear facet on the P^2 as an estimate of ontogenetic age in east African *Panthera leo leo* individuals. However, because anterior premolars may be used inconsistently during feeding, wear on these teeth is highly variable and does not closely reflect that of the carnassials. Wear on the anterior premolars is not an accurate age estimate. Furthermore, wear-stage categories that are based upon full dentitions produce relatively long (2 to 3 years) ontogenetic age sets (Smuts et al. 1978) and are difficult to recognize with incomplete fossil specimens. Therefore, the carnassial teeth of *P. l. atrox* were examined for an occlusal wear pattern that could be consistently measured. It was found that, with increasing ontogenetic age, the wear facet on the anterior shear blade of the M₁ enlarges dorso-ventrally, and the antero-ventral margin of this facet remains parallel to the blade crest during moderate through severe wear. The dorso-ventral

height of the facet (WFH) was measured below the antero-posterior mid-point of the blade crest (Figure 1) as a gauge of relative individual age.

Given the fact that M,s in Panthera leo atrox are separable into male and female sets, the sex of individual teeth in progressive stages of occlusal wear can be determined (WFH cannot be measured in all sexed specimens). Assuming the amount of wear in teeth reflects ontogenetic age (a specific age in years cannot presently be assigned to wear stage levels), the age distribution of RLB male and female individuals can be compared with the observed age pattern in P. l. leo. Schaller's data (1972, table 26) reflect a living population with a distinctive ontogenetic age structure with more adult females than males. Nearly equal numbers of P. l. atrox male and female M,s are distributed uniformly through the RLB sample from the dentally very young to old adult. Unlike P. l. leo, neither sex predominated any ontogenetic stage (equal level of wear on M₁), and a higher mortality of young adult males was not reflected. M,s with measurable WFH yield a population that is 47% adult male and 37% adult female. Juvenile individuals with M, unerupted and/or without wear make up 16% of the population. Using the age classification of Smuts et al. (1978), these small cubs are one year old or less.

Panthera leo leo (Africanlion) populations in east Africa have a male:female:cub ratio of about 74:100:48 (Makacha and Schaller 1969; Schaller 1972). Pride behavior in these animals directly affects ontogenetic age structure and favors the survival of females (Schaller 1972). Ratios of 129:100:42, based on sexed/ aged M_1 s, and 127:100:272, determined from femoral dimensions, are exhibited by the RLB population. It is, therefore, highly improbable that *P. l. atrox* lived in African lion-like prides or cooperatively hunted in social groups. As



Guthrie (1990) proposed for European and Alaskan P. l. spelaea, P. l. atrox may have hunted in pairs or alone (Akersten 1985).

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Positional and Ordinal Identification of the Teeth of *Mammut Americanum*

Richard S. Laub

Mammut americanum (American mastodon) is among the more common Pleistocene fossil mammals. In situations where the bones of several individuals are found interspersed, teeth can be useful guides for determining minimum number of individuals present, provided homologous teeth can be recognized. Earlier workers have offered criteria helpful in such recognition

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(e.g., Saunders 1977; Simpson and Paula Couto 1957; Skeels 1962; and especially Hay 1914). The following system combines these criteria with additional observations, allowing the identification of isolated cheek teeth as to jaw quadrant, and order within a battery (from anterior to posterior: dP2 [deciduous premolar 2], dP3, dP4, M1 [molar 1], M2 and M3). It has been used to unambiguously categorize all but one of a collection of more than 30 teeth from a single site.

I. Distinguishing upper vs. lower teeth: It is first necessary to recognize the anterior face of the tooth. In lateral view, the anterior sides of the lophs are generally steeper than the posterior (Figure 1a).

The posterior upper teeth have two roots extending across the front face (Figure 1b). These resemble two legs, the wider one stepping slightly farther forward than the narrower. I have observed this condition in upper M1–M3, and it is reported in upper dP4 by Hay (1914) and Saunders (1977). Hay indicates, however, that it does not occur in dP2 and dP3. Palates of juvenile *Cuvieronius* (gomphothere; Florida Mus. Nat. Hist. specimens 22585, 131985) also lack split anterior roots in dP2 and dP3, and its absence in a dP4 suggests that this condition may prove not to be ubiquitous in *M. americanum* upper dP4's. In contrast with the upper teeth, all lowers have one continuous root across the front (Figure 1c).

Also, the lophs of upper teeth cross the long axis of the tooth at nearly right angles (Figure 1d, h). Those of lower teeth cross with a distinct slant (Figure 1e). Here again the upper dP2s vary from the rule, the lophs displaying a moderate slant (fide G. T. Jefferson, pers. comm., based on LACMHC 1264). The upper dP2s, however, are more squared in crown view (widths of protoand metalophs being more nearly equal, ratio 26/28 mm [N=1]; Figure 1f) than are the lowers (ratio approximately 20/25 mm [N=3]; Figure 1g).

II. Distinguishing left vs. right teeth: In upper teeth, the double anterior roots are diagnostic, as the root that is wider and more anterior ("stepping out") is buccal (Figure 1b).

Where roots are lacking, or in lower teeth and anterior uppers where the "step-out" feature does not occur, the positions of the pre-trite and post-trite cusps of each loph can be used. The post-trite cusps are buccal in upper teeth, and lingual in the lowers. In crowns showing little wear, the post-trite cusp almost always stands higher and has a steeper free edge than the pre-trite. Figure 1b has the post-trite side on the left (the supplementary line marks its slope) and the pre-trite on the right. In Figure 1c, pre-trite is on the left, post-trite on the right. In extensively worn crowns, the pre-trite on right side). This reflects the ramp-like "cristae" that slope from the summit of the pre-trite cusps down toward the midline of the tooth, wearing into a characteristic "trefoil" pattern.

Finally, in lower teeth, the lophs slant posteriorly toward the buccal side (Figure 1e).

III. Distinguishing the ordinal position of teeth: Determining left/right and up/down establishes the mouth quadrant of a tooth. A sequence of six

teeth of increasing size advances toward the front of the jaw during the individual's lifetime. These six fall into three classes: 1) dP2 and dP3 each have two complete lophs (Figure 1f, g; dP3 may have a weakly developed third loph); 2) dP4, M1 and M2 each have three complete lophs (Figure 1a, h); 3) M3 has four or more complete lophs and a posterior incipient loph (Figure 1d, e).













f



Figure 1. Teeth of Mammul americanum.

- a: Upper M2, lateral view, showing general inclination of lophs toward the anterior (in this case, to the right).
- b: Upper M3, anterior view, showing double anterior root. Left side is buccal.
- c: Lower M3, anterior view, showing single anterior root. Left side is buccal.
- d: Upper M3, crown view. Anterior toward top of page. Lophs cross tooth long axis at right angles.
- e: Lower M3, crown view. Anterior toward top of page. Lophs slant across long axis, inclining back toward buccal side (to the right in this case).
- f: Right upper dP2, crown view, based on unpainted cast of Los Angeles County Museum HC 1264. Anterior toward top of page.
- g: Left lower dP2, crown view. Anterior toward top of page.
- h: Left upper M2, crown view. Anterior toward bottom of page. Same tooth as in a.

Supplementary marks are explained in the text. Illustrations are not shown to same scale.

M3 is unique and readily recognized. For the others, size is used to distinguish teeth within a class. The following measurements (maximum length and width in cm just above the base of the crown, indicated by dashes in Figure 1a, d, g), are of teeth still in the jaws and are thus identified objectively. Specimens are from New York, Pennsylvania, Michigan, Indiana, Florida and California, and include both males and females. "N" refers to number of teeth measured rather than number of individual animals. Where both sides of an individual's jaw were available, the left and right teeth were included in the data.

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Lower teeth:
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dP2 length 2.8-3.0 (N = 3), width 2.4-2.5 (N = 3) dP3 length 4.2-4.3 (N = 3), width 3.2-3.5 (N = 3) dP4 length 6.7-7.5 (N = 5), width 5.0-5.9 (N = 4) M1 length 8.0-9.5 (N = 7), width 6.0-7.9 (N = 7) M2 length 9.5-12.0 (N = 18), width 7.8-9.5 (N = 18) M3 length 16.0-19.0 (N = 13), width 9.0-10.5 (N = 12) Upper teeth: dP2 length 2.7-2.8 (N = 2), width 2.8 (N = 2) dP3 length 4.1-4.2 (N = 2), width 3.5 (N = 2) dP4 length 7.0-7.5 (N = 4), width 6.0-6.5 (N = 4) M1 length 8.0-9.8 (N = 6), width 6.0-8.0 (N = 5) M2 length 10.0-12.5 (N = 9), width 8.0-9.0 (N = 8) M3 length 15.6-17.6 (N = 8), width 9.3-10.5 (N = 8)

While there is some overlap in the class widths, there is virtually none in length. Length is thus the principal aid in distinguishing teeth within loph classes, while width may be used as a "tie-breaker" for ambiguous measurements.

These measurements do not differ greatly from those published elsewhere (e.g., Hay 1914; Saunders 1977; Skeels 1962). Nevertheless, in view of intraspecific variation and the subjectivity inherent in measuring irregular objects, it is advisable to use measurements of objectively identified teeth from the site in question, or its environs, as a basis for ordinal identification of isolated teeth.

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Skeletal Remains of a Juvenile *Bison* sp. (Extinct Bison) from the Page Museum Salvage, Rancho La Brea

Pamela R. Owen

Preparation of vertebrate remains recovered from the Page Museum Salvage deposit has allowed researchers to investigate the taphonomic history of several individual Rancho La Brea animals. The Page Museum Salvage is a thin tabular asphaltic deposit discovered during the construction of the George C. Page Museum in Hancock Park, Los Angeles (Duque and Barnes 1975; Jefferson and Cos 1986). It is considered to represent an accumulation of relatively short duration (Jefferson and Cox 1986; Scott 1989).

Fifty-five isolated skeletal elements of a juvenile *Bison* sp. (extinct bison, most likely *Bison antiquus*) were recovered from a block removed from the lower, less asphaltic portion of the deposit (Jefferson and Cox 1986). The remains of two juvenile *Equus* sp. cf. *E. occidentalis* (extinct western horse), and one juvenile and one adult *Canis latrans* (coyote) were recovered along with the *Bison* material (Jefferson and Cox 1986).

Cranial elements are few, comprising solely an unworn deciduous lower incisor, tooth fragments and an occipital fragment. Seventy-eight percent of the remains are vertebral and rib elements. Other postcranial elements include the left stylohyal, diaphysis of the left humerus, left patella, and phalanges.

The remains of the juvenile *Bison* show clear evidence of carnivore modification. Carnivore-modified assemblages are characterized by high frequencies of vertebral and rib elements (Behrensmeyer and Dechant-Boaz 1980). Two thoracic vertebrae (LACMPMS 401 and LACMPMS 403) exhibit single puncture marks. Each puncture is found on the right lateral surface of each centrum. The diaphysis of the left humerus is shattered; this is a fresh break, not post-depositional, and is indicative of marrow processing (Behrensmeyer and Dechant-Boaz 1980).

The preponderance of material is from the left side of the bison's body. This appears to indicate that the animal was lying on its left side at time of death and deposition. Since the carnivore punctures are on the right side of the vertebrae, an argument can be made for scavenging activity.

The remains are poorly preserved and weathered, probably a result of subaerial exposure before burial (Behrensmeyer 1978). The probable site of deposition for the juvenile *Bison*, as well as the other animals, was in sediments near or within an ephemeral stream or pond (Lamb and Jefferson 1988; Scott 1989).

Adult female bison with calves and juveniles were seasonally present in the

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Rancho La Brea area during the late spring (Jefferson and Goldin 1989). Cool spring and winter weather increases the viscosity of the asphalt (Shaw and Quinn 1986). Owing to the weathered nature of the fossils, the asphalt impregnation, although slight, may have been secondary to disarticulation and deposition of this juvenile. Thus, it seems reasonable to conclude that asphalt entrapment is not likely to be the cause of death for this juvenile *Bison*, which probably died soon after birth.

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Diddly Cave: A New Late Quaternary Vertebrate Fauna from New York State

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Diddly Cave (town of New Scotland, Albany County, New York; Clarksville quad., 42° 35'N, 73° 58'W, elev. 240 m) is a solution cavity developed in the middle-Devonian Onondaga limestone. The narrow entrance of the cave, at the base of a small escarpment, was covered by talus until exposed by cavers in 1990. The first room of Diddly Cave, which measures 11.5 m north-south and 7.2 m east-west, is covered by fossiliferous sediments at least 1.5 m thick.

Ongoing test excavations in 1991–92 have revealed at least three major stratigraphic units in the sediments from the first room of this relatively dry cave. The uppermost unit (Layer I) is clayey pebble-cobble-boulder breccia.

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The clasts are dominated by angular to subangular limestone roof spall. In the lower half of Layer I the density and mean size of the roof spall are reduced. The middle stratum (Layer II) is a medium to coarse pebbly clay. Layer II is better stratified than Layer I, and contains more rounded pebbles of allochthonous rocks. The lower stratum (Layer III) is a medium pebbly clay, with fewer rounded allochthonous pebbles.

Layer I is particularly rich in bones, charcoal, plant macrofossils, and landsnails. Using screens as fine as 0.6 mm, we have recovered from 10 to 100 identifiable bones from each of 14 sediment samples of 2.5 to 5.0 liters from Layer I. Bones are scarcer in Layers II and III (5 to 20 identifiable bones per sample, based on three samples of 2.2 to 3.0 liters each). We believe that most of the Diddly Cave fauna represents bones accumulated in an ancient carnivore den. The carnivores involved are difficult to determine at this point; some combination of mustelids, procyonids, canids, ursids, and felids may have been involved. Thus far we have found no prehistoric cultural evidence in Diddly Cave.

Preliminary examination of the bones from Diddly Cave yields these taxa: frogs (Rana sp.), toads (Bufo sp.), salamanders, snakes (Colubridae sp., Crotalus horridus), birds (Bonasaumbellus, Ectopistes migratorius), shrews (Blarina brevicauda, Sorex sp.), bats (Eptesicus fuscus, Myotis sp.), lagomorphs (Lepus americanus), rodents (Erethizon dorsatum, Sciurus sp., Tamias sp., Tamiasciurus sp., Synaptomys sp., Microtus sp., Neotoma magister, Peromyscus sp.), carnivores (Mustela vison), and artiodactyls (Odocoileus virginianus). Among these are at least three locally or regionally extirpated species (timber rattlesnake Crotalus horridus, passenger pigeon Ectopistes migratorius, and Allegheny woodrat Neotoma magister).

Rounded pebbles and cobbles of allochthonous rock types, some of which are covered secondarily with flowstone, occur in all three strata. In the karst landscape around Diddly Cave, the availability, transport, and deposition of this type of sediment cannot be accounted for in a Holocene hydrologic regime, but require the greatly increased availability of water associated with glacial conditions. This suggests deposition of the fossil assemblage in the late Pleistocene rather than Holocene. In the Diddly Cave sediments excavated thus far, the preservation of pollen is too poor to help characterize the age or habitat type represented by the deposits (C. Chumley and D. Royall, pers. comm.). The age of the bone deposits in Diddly Cave will be determined through AMS ¹⁴C dating of XAD-2 purified gelatin hydrolyzate from identified bones, using methodologies detailed in Stafford et al. (1991).

All previous records of late-Pleistocene mammals from New York involve only large species, while the Holocene record includes mammals of all sizes (Steadman and Funk 1987; Steadman and Miller 1987; Steadman 1988; Steadman et al. in press; Laub 1990). If the AMS dating of bones from Diddly Cave yields late-Pleistocene rather than Holocene age determinations, this site will provide our first look at New York State's late-Pleistocene small mammal fauna.

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Stable Carbon Isotope Ratios of *Equus* sp. and *Bison Antiquus* from the Late Pleistocene Deposits at Hall's Cave, Kerr County, Texas

Rickard S. Toomey, Jeffery A. Huebner, and Thomas W. Boutton

Hall's cave (TMM41229), located on the Edwards Plateau in Kerr County, Texas, contains a sequence of sediments which exhibit abundant vertebrate remains (Toomey 1989, 1990, in prep). Eleven ¹⁴C assays indicate that the deposition occurred over the last 15,000 years. The vertebrate remains include over 50 mammalian taxa. Extinct megafauna include *Bison antiquus, Equus sp.*, *Panthera atrox* or *P. onca augusta, Platygonus compressus, Dasypus bellus*, and *Hemiauchenia* sp. Both the mammalian megafauna and microfauna indicate an open grassland environment (Toomey 1989). The presence of both *Geomys* sp. and *Cynomys* sp. probably indicates a mixed-grass assemblage. Analysis of the Hall's cave deposits and fauna is continuing (Toomey in prep).

Stable carbon isotope ratios were measured for samples of two taxa. Portions of a *Bison antiquus* metatarsal (TMM41229-1362) from a depth of 210–215 cm

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in Pit 1C and an *Equus* sp. (large species) mandible (TMM41229-10795) from a depth of 209.5–212 cm in Pit 1d/E were analyzed. Both specimens were well preserved.

The ages of these materials are well constrained. A ¹⁴C determination of $15,420 \pm 170$ yr B.P. (TX-7430, bone apatite) at 230-235 cm in Pit 1d/E occurs below the sample material. From above the samples at a depth of 190-195 cm in Pit 1B, a travertine stringer yielded a ¹⁴C age of $12,470 \pm 160$ yr B.P. (TX-6069). Assuming constant sedimentation rates, the analyzed materials occurred between 13,250 and 14,000 yr B.P. This period is interpreted to have had greater effective moisture than modern conditions. However, the period may have been drier than that prior to 15,000 yr B.P., or around 10,500 yr B.P. (Toomey 1992; in prep).

Samples for isotopic analysis were removed from the bone with a saw. Bone samples were cleaned in distilled water, crushed, and collagen extracted following the method of Boutton et al. (1984). Following combustion, the resultant CO_2 was measured with a VG-903 isotope ratio mass spectrometer. Results are reported in δ notation relative to PDB, where:

$$\delta^{13}C = [[({}^{13}C/{}^{12}C)_{sample} / ({}^{13}C/{}^{12}C)_{standard}] -1] \times 1,000 \%.$$

Analytical precision of measurement was ± 0.1 ‰. Atomic C:N ratios were measured with a Carlo Erba NA-1500 elemental analyzer; precision was 0.015% for carbon and 0.0015 for nitrogen.

Stable carbon isotope ratios of -10.0 ‰ (C:N 3.25) were obtained for *Bison* antiquus, and -16.3 ‰ (C:N 3.18) for *Equus* sp. Atomic C:N ratios indicate the bone collagen of both samples retained their *in vivo* isotopic signatures according to the criteria of De Niro (1985). Using the modern δ^{13} C ratios for C₃ and C₄ plants, -26.5 ‰ and -12.5 ‰, respectively, bison diet was 82% C₄ and horse diet was 37% C₄.

Feeding ecology research by Schwartz and Ellis (1981) shows that bison are non-selective grazers (eat grass species in proportion to their abundance). Horse, as represented by *Equus burchelli* (zebra), exhibit a higher selectivity (Stewart and Stewart 1971). For this reason, we consider the bison diet to be more representative of the ratio of C_8 and C_4 grasses available to these grazers.

The δ^{15} C ratio of extinct bison compares well with those of the modern species during the late Archaic (ca. 2,000 yr B.P.) -10.0 ± 0.77 ‰ (n=6), and late Prehistoric (750–300 yr B.P.) -9.3 ± 0.77 ‰ (n=10) on the Edwards Plateau (Huebner and Boutton, unpublished data).

Our findings differ from those of Stafford (1984) for Pleistocene-age bison. Samples from Stratum l at Lubbock Lake (ca.11,100–12,500 yr B.P.) yielded δ^{1S} C ratios of -16 to -17 ‰, indicative of a greater C₃ plant component in the High Plains diet relative to our data.

The significant conclusions include the following:

- 1. C_4 grasses constituted a significant portion of the grasses available on the central Edwards Plateau ca. 13,000–14,000 yr B.P.
- 2. Isotopically, the diet of *Bison antiquus* on the Edwards Plateau during the period ca. 13,000–14,000 yr B.P. was very similar to the diet of *Bison bison* during the late-Archaic and late-Prehistoric periods.

- 3. *Bison* and *Equus*, although both primarily grazers, selected for different grass species and thus would have competed with each other only to a limited extent.
- 4. Either the grassland composition or the behavior of *Bison antiquus* differed between the Central Edwards Plateau and the High Plains.

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Mastodon Digesta from North Florida

S. David Webb, James Dunbar, and Lee Newsom

Late-Pleistocene strata near the base of the Page/Ladson site produce remarkably rich concentrations of cut twigs and occasional seeds in an organic clay matrix. Other paleontological and archaeological aspects of this underwater excavation in the lower Aucilla River of north Florida have been reported in Dunbar et al. (1990).

Our preliminary analyses of the plant remains in sedimentary and stratigraphic context point toward the following five conclusions: 1) the plant material was ingested and masticated by some species of large herbivore; 2) the

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plant remains represent summer browse; 3) the plant remains were transported to the site of deposition by the large herbivores; 4) the ages of these strata straddle dates of about 12,500 yr B.P.; and 5) the large herbivore species was probably *Mammut americanum* (American Mastodon).

The plant material under discussion extends abundantly through six fine clastic strata (levels 16 through 20B in Test F) with a combined thickness of about 1.2 m. The proven horizontal extent includes two squaremeters in Test C and an equal area in adjacent Test F, but its real extent is surely greater. The depositional context, discussed in the reference above, was a small sinkhole pond at the foot of a well-wooded limestone bluff at least 12 m tall.

The plant material consists of small woody pieces, of which most exhibit a ragged cut at one end. As depicted in Figure 1, the modal twig length is 8–10 mm and the histogram of lengths is strongly peaked in the range from 4 to 14 mm. Maximum fragment length observed to date is 40 mm, but this is based only on the 667 specimens measured in sample 131 collected from Test C in 1988. Many of these twigs are apical pieces less than 2 years old. The physical condition and strongly modal length distribution indicate mastication by a large herbivore. One can see spheroidal clumps among the in-place sediments, as recorded in a photograph of Test F, level 18 taken in 1991, but the weakly consolidated sediments cannot maintain the integrity of such possible fecal masses.

The commonest plant taxon in these sediments is *Taxodium* sp. (bald cypress). Other abundant woody taxa are *Cephalanthus occidentalis* (buttonbush), *Salix* sp. (willow), and *Pinus* sp. (pine). *Vitis* (grape) tendrils are fairly common also. Although seeds are much less common, the following five taxa have been recognized: *Vitis* sp. (wild grape), *Phytolacca americana* (pokeweed), *Argemone* sp. (Mexican poppy), and *Cucurbita pepo* (wild gourd). These plants,



with the exception of grape and gourd, generally live in open savannas, disturbed thickets and margins of woods, and seem incompatible with the mesic bluff habitat immediately bordering the site. Transport, presumably by a large herbivore, is implied. These seeds all ripen in the late summer, and thus indicate the season of harvest and deposition.

Two TAMS radiocarbon dates were run on specimens in sample 131 from Test C about 10 m below the river surface by the Isotope Geochemistry Laboratory at the University of Arizona. The result from sample number AA-7453, a twig of *Cephalanthus*, was $12,375 \pm 75$; and AA-7452, a *Vitis* seed, was $12,545 \pm 80$ radiocarbon yr B.P. Twig accumulations occur both above and below this dated horizon and will be constrained by more dates.

Several medium-sized herbivore genera and two megaherbivore taxa occur in the late Pleistocene at Page/Ladson, and also in several similar sites in the lower Aucilla River (Webb, 1974). Medium herbivores include *Megalonyx* (megalonychid sloth), *Paramylodon*, (mylodont sloth), *Equus* (horse), *Tapirus* (tapir), *Hemiauchenia* (extinctllama), and *Bison* (bison), and the megaherbivores are *Mammuthus columbi* (mammoth) and *Mammut americanum* (mastodon). The latter proboscidea are represented in the lower Aucilla by about a dozen partial to complete skeletons, some of which give evidence of butchering. Webb et al. (1984) described a *Bison* kill site in the adjacent Wacissa River.

We hypothesize that *Mammut americanum* masticated and transported the concentration of segmented twigs described here. Mead et al. (1986) analyzed the herbivore dung in Western dry caves, and Laub (pers. comm.) described segmented spruce twigs at the Hiscock site in New York. *Mammuthus columbi* samples were recognized in the former and *Mammut americanum* in the latter. The modal length of the Florida sample is comparable to both of the above samples and probably indicates mastication by a proboscidean. The heavy emphasis on browse suggests *Mammut* rather than *Mammuthus*, which is expected to be a grazer. If correctly attributed, the Aucilla River vegetation indicates a considerably different diet for American Mastodon in Florida than for other regions of eastern North America.

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Paleoenvironments: Invertebrates

Fossil Molluscs from Pre-Illinoian Sediments of the Buried Mahomet Valley, Central Illinois

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Five species of molluscs have been identified from cuttings and splitspoon samples recovered from near the base of the Mahomet Sand Member of the Banner Formation near the base of two wells drilled for the De Witt County Well Field, and from a test hole (36-3) near the city of Decatur, Illinois.

The fossils include two unionid clams, cf. *Pleurobema cordatum pyramidatum*, and *Elliptio dilatatus*; and three gastropod taxa, *Pleurocera canaliculatum*, *Lithasia armigera*, and Campeloma cf. *C. decisum*. These represent the first fossils reported from the deeply buried sediments of the Mahomet Valley.

One specimen of *P. C. pyramidatum* was identified from a portion of a left valve containing a thick, heavy beak and pseudocardinal teeth that are usually characteristic of individuals found in large rivers. This form appears tolerant of sand-mud or gravel-mud substrates and lives at depths of 1–3 m ((Parmalee 1967).

A single thick valve of *E. dilitatus*, which is characteristic of specimens from large rivers, was collected in association with *P. C. pyramidatum*. The species was once commonly abundant locally in large rivers such as the Illinois, Wabash, Ohio, Mississippi and Rock (Parmalee 1967).

Two of the gastropods, *P. canaliculatum*, and *L. armigera*, are river species that now occur in the Ohio River drainage (LaRocque 1968:417). The third gastropod species, *C.* cf. *C. decisum*, is represented by two corroded immature shells from the splitspoon sample. The species is broadly distributed throughout much of eastern North America and is "found in rivers and creeks, on a

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bottom of sand, mud, gravel and sand, or clay; in shallow water 30 cm or more deep; generally more abundant in rapid current, but not in riffles or rapids" (LaRocque 1968:374). The molluscan assemblage indicates a medium to large river. Most of the shells show some evidence of abrasion and breakage that probably occurred prior to burial. The preponderance of thick-shelled forms suggests that considerable attrition may have occurred before burial.

Alloisoleucine/Isoleucine (aIle/Ile) ratios from *Pleurocera* shell protein recovered from a fine sand at a depth of 74.7–75.1 m, near the base of test hole 36-3, provide a method for evaluating the age of the fill in the Mahomet Valley at this locality. Subsamples from this collection were analyzed at the University of Massachusetts Amino Acid Geochronology Laboratory (AGL) and at the MemphisState UniversityAmino Acid Geochronology Laboratory (MSUAGL). The peak-height alle/Ile ratios in the total hydrolyzate fraction for these analyses are (AGL 1323) 0.52 ± 0.05 (n=3) and (MSUAGL 91062) 0.48 ± 0.04 (n=2). These values are similar to those obtained from other taxa analyzed from magnetically reversed silts associated with the West Lebanon Till in west central Indiana (Miller et al. 1987). The amino-acid data support the age interpretation suggested by Kempton et al. (1991) that some of the sediments in the Mahomet Valley are older than 730,000 yr. B.P.

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Paleoenvironments: Geosciences

Late Quaternary Sedimentation and Geoarchaeology of Palo Duro Creek, Hansford County, Texas

Charles D. Frederick and J. Michael Quigg

Recent CRM investigations in Palo Duro Creek valley, Hansford County, Texas, provide a late-Quaternary sedimentation record spanning the last 14,000 years. Flowing northeast across the Texas Panhandle, where it is incised into the Blackwater Draw and Ogallala formations, Palo Duro Creek joins the North Canadian River in the Oklahoma Panhandle 30 km north of the project area. Building upon a geomorphic analysis conducted in association with archaeological testing (Caran 1991), a detailed stratigraphic reconnaissance and dating program of the valley's late-Quaternary deposits during 1991 resulted in the identification of seven informally defined alloformations, five of which are alluvial fill deposits (Quigg et al. 1992). Approximately 82 radiocarbon ages of bulk sediment humates, in addition to a few soil humate, bone and charcoal samples, confine the stratigraphic sequence (Figure 1).

Noteworthy is the alternation of marsh and fluvial conditions throughout the Holocene, which contrasts with other alluvial sequences to the south (e.g., Holliday et al. 1985; Blum et al. in press) and two erosional events during the middle Holocene. Periodic eolian and colluvial deposition identified may be under-represented due to emphasis upon alluvial sediments. Archaeological excavations focused upon three sites dating to the transitional-Archaic and late-Prehistoric periods. At 41HF5 campsite occupations were excavated below two surfaces: a late-Holocene terrace and an eolian mantled ridge. Two components buried within the first terrace fill were targeted for excavation. This deposit is less than 3,900 years old and yielded a transitional-Archaic occupation(s) at a depth of 250 cm bgs, which was associated with arrow and dart points and a radiocarbon age of $3,470 \pm 180$ yr B.P. (Tx-7039; charcoal, d13C corrected). A late-Prehistoric component associated with a buried A horizon 50–80 cm bgs dated to ca. 1,100 yr B.P. This point-bar setting formed

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in conjunction with high-magnitude but relatively infrequent floods that initially interrupted widespread, seasonal marshes which were common upon portions of the valley floor until approximately 1,700 yr B.P.

Two brief, late-Prehistoric (ca. 400 yr B.P.) single-event bison (*Bison*) processing components were excavated from the same late-Holocene fill within a distal floodplain facies at 41HF8. A transitional-Archaic (ca. 1,900 yr B.P.) single-event bison-processing station site was also discovered and tested within late-Holocene colluvial deposits burying the second terrace of Palo Duro Creek at 41HF128.

Project results clearly indicate that dynamic sedimentation in a variety of depositional environments (floodplain, eolian uplands, and distal colluvial slopes) throughout the Holocene, and specifically during the last 3,900 years, resulted in the burial of even relatively recent archaeological sites and significantly reduced their visibility throughout the basin.



Figure 1. Temporal trends of late Quaternary sedimentation within the Palo Duro Creek valley, Hansford Co., Texas.

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Geoarchaeological Investigations in the Vicinity of the Little River Paleoindian Site Complex: 1991 Season

Andrea K. L. Freeman and Edward E. Smith, Jr.

During the summer of 1991, geoarchaeological investigations continued in Trigg and Christian counties of western Kentucky in the vicinity of the Little River Paleoindian site complex (Smith and Freeman 1991). The purpose of this research was to ascertain the nature and extent of the Paleoindian utilization of the area, and the presence of additional sites with chronostratigraphic potential.

In an effort to gain insight into Paleoindian utilization of the karst topography of the area and its abundant local chert resources, survey was conducted along the lower portion of the Little River and its tributary streams. This portion of the river extends westward from Christian County into adjoining TriggCounty. Using a combination of collector interviews and geoarchaeological assessment, approximately 20 new sites were discovered, some of which appear to have Paleoindian or early-Archaic components. Stratigraphic profiling of extant exposures of Holocene alluvium provided useful information about some of these newly discovered sites and their relationship to the previously discovered Boyd site (15 Ch 236). Although the deposits at these newly discovered sites appear younger than those at the Boyd site, radiometric dates are needed to confirm this hypothesis.

Chronostratigraphic information from preliminary profiling conducted at the Boyd site during the summer of 1990 (Smith and Freeman 1991) revealed

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an extensive deposit of Holocene alluvium lying adjacent to the Pleistocene terrace on which the site is located. Previous definition of the terrace sequence (Leach n.d.) makes us believe that the site rests atop the late-Pleistocene Pickneyville Terrace (15,000–11,000 yrs. old). Our first augering transect began with a core 5.25 m in depth. This auger core as well as subsequent cores bottomed out in gravel deposits. The other cores presumably represent point-bar deposits impenetrable by the use of hand equipment.

Given that the depth of limestone bedrock in the present-day river channel is at approximately the same depth as the extent of the first auger core, this core is presumed to have bottomed out in basal gravel. An accelerator date (TAMS) on a piece of charcoal derived from the bottom of the first auger core returned a date of 13,029 \pm 120 yr B.P. (AA-7097) (Figure 1). This date is believed to date the basal-gravel level. Given minimal disturbance of the site by subsequent fluvial processes, this date suggests the presence of a depositional sequence which may reveal intact stratigraphy that could then be linked to the adjacent Paleoindian site on the terrace surface.

These investigations were conducted jointly by the Glenn A. Black Laboratory of Archaeology, Indiana University, and the Department of Anthropology, University of Arizona, and were sponsored by the Kentucky Heritage Council. The accelerator date from the Boyd site was paid for by NSF grant #EAR-8820395 awarded to C. Vance Haynes.



Figure 1. Preliminary stratigraphic profile, 15 Ch 236 augering transect 1.

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The Study of Fractured Rock in Alluvial Deposits

Leland W. Patterson

Toth (1991:58-59) has given some rather simplistic comments on avoiding the study of lithic collections from "high-energy" geological deposits. He made little distinction between natural fracture processes in widely differing situations, such as alluvial fan formation, ocean-beach storm conditions, and freefall of rocks from cliffs. Studies of man-made versus natural fracture processes should account for the specific types of possible natural fracture processes, however, at each selected study location. This article gives comments on considerations that should be made by investigators in judging if man-made lithic specimens are present at an alluvial deposit location. In the study of fractured-rock collections from alluvial deposits, both specific natural fracture processes and the location of fracture events should be considered. An alluvial deposit is not necessarily a poor scenario to document human presence, as stated by Toth (1991:59). Since many early-prehistoric sites are likely to be located near a water source where alluvial deposit action can occur, it is especially important to be able to study fractured-rock specimens at this type of location. Otherwise, significant amounts of potential data for the study of primitive lithic industries can be ignored. As Butzer (1991:140) has noted, Paleoindian sites are located in a variety of sedimentary contexts, ranging from "high-energy fluvial beds to spring deposits and shallow lake sediments in the case of open-air sites."

Mud and water-flow conditions that form alluvial deposits would be expected to fracture rocks mainly by pressure, as viscous liquids and slurries inhibit highvelocity percussion interaction of transported rocks. It can be demonstrated that percussive-type flaking, such as used by early man, gives different lithic attributes than pressure-type flaking, such as produced by mechanical gravel crushers (Patterson 1983:306). I have never had problems in distinguishing between a collection of percussion-made chert flakes produced with a hammerstone and a collection of pressure-made flakes produced by a mechanical crusher, especially for flake sizes above 15 mm square. Pressure-made flakes tend to lack bulbs of force and residual striking platforms. Also, a significant proportion of pressure-made flakes will have very flat ventral surfaces, as opposed to some curvature on ventral faces of most percussionmade flakes. In judging whether or not natural fracture processes have produced lithic specimens, the concentration of fractured specimens is important. As noted previously (Patterson et al. 1987:96), there is no documented situation where natural forces have produced large concentrations of percussion-made flakes such as found in human lithic-manufacturing activities.

It should be noted that the so-called "high-energy" action of alluvial deposition does not always act as a gravel crusher to cause large-scale fracturing of transported rocks. It is common to encounter alluvial deposits where few

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pieces of brittle siliceous minerals have fracture scars, and there are no flakes present to represent by-products of fracture events. An alluvial deposit may be a high- or low-energy event, depending on the rate of deposition.

The location of fracture events in an alluvial deposit is of prime importance in the study of possible human lithic-manufacturing activities. Man-made lithic materials can be produced at a location and then covered by alluvial deposition without further redeposition of the lithics. In contrast, lithic materials that have been fractured during the alluvial transport process and then redeposited should have attributes that demonstrate this scenario. Lithic flakes that have been transported in an abrasive medium would usually have some edge rounding rather than sharp edges, and redeposited lithic flakes would not be expected to have the same type of flake-size distribution pattern as that from human lithic manufacturing at the original location (Patterson et al. 1987:101).

In summary, there is no reason to avoid the study of lithic materials in alluvial deposits to determine human presence, as suggested by Toth (1991:59). For example, the Calico site lithic collection from an alluvial fan has thousands of flakes with the attributes of man-made percussive flaking, and no evidence of transport in the alluvial deposition process (Patterson et al. 1987). If the Calico site lithic collection was actually produced by natural fracture processes, the nature of the fracture processes remains to be explained. Whether or not the large collection of fractured siliceous materials from the Calico Site was produced by human activities remains an important question, regardless of whether the answer is positive or negative for human presence. If nature can mimic the products of human flaking activities on a large scale, this should be determined as a question of world-wide importance to archeological studies.

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Optical Dating of Independently Dated Late Quaternary Eolian Deposits from the Southern High Plains

Stephen Stokes

Accurate age control of both sediment and artifacts is crucial to the development of a comprehensive or regional late-Quaternary history. As with many arid and semi-arid regions, generally poor preservation on uncontaminated carbon for radiocarbon dating, a lack of temporally wide-ranging diagnostic taxa, and a widespread lack of materials suitable for other radiometric dating methods have to a large degree limited the development of a widespread regional chronostratigraphy for late-Quaternary deposits of the Southern High Plains. This is particularly the case for eolian sediments. Optical dating is a recently developed technique, closely related to thermoluminescence (TL) dating, which allows the direct dating of a wide range of late-Quaternary terrestrial sedimentary deposits and may provide a means of improving the chronology of the area.

As part of the initial phases of a more widespread project applying optical dating to late-Quaternary eolian deposits of the arid Southwest of the United States, a series of three well-dated sites from the Southern High Plains were selected for analysis whose chronologies are constrained by radiocarbon dating and archaeological inference. Successful application of optical dating at these sites is considered to provide some empirical degree of assurance for dates generated subsequently from other undated localities.

Optical dating is a radiation-exposure-based chronometric dating method developed over the past few years (Aitken 1991; Huntley et al. 1985; Smith et al. 1986, 1991). The method is closely related in both principle and practice to TL. The techniques differ primarily in the type of excitation source utilized to stimulate the dating signal. In conventional TL dating heat is employed. The optical method uses one of a variety of filtered light sources. The key advantage of optical dating over TL is that in the former only the light-sensitive portion of the total luminescence (termed optically stimulated luminescence is rapidly reset at deposition.

Both methods are based on the determination of both a total accumulated dose of radiation (termed the equivalent dose (ED) and measured in grays (Gy)) within detrital mineral grains since they were last exposed to daylight during sedimentary transportation and deposition, and an annual dose of radiation (termed the annual dose) which is caused by the alpha- and betaparticle and gamma-ray emissions from the radioactive decay of K, U and Th from the sedimentary matrix surrounding the given sample, and a cosmic ray

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contribution. Division of the total accumulated radiation, or equivalent dose (ED), by the annual radiation dose yields the sample age. A detailed discussion of the method, and approaches to sample preparation and analysis, are beyond the scope of this discussion; readers are referred to Rhodes (1990), Stokes (1992) and the references listed above for details of the methodology and limitations of the technique.

The three sites from which samples were collected and are reported here were selected as they contain some of the best age-constrained, stratified eolian deposits on the Southern High Plains. They are: the Mustang Springs site (Meltzer 1991), near Stanton, Texas; the Lubbock Lake site, Lubbock; and the Blackwater Draw Locality (BWD#1) near Portales, New Mexico. All samples were collected for dating from relatively homogeneous sandy strata. Specific details of sample treatment will be provided elsewhere.

A total of seven strata were sampled for optical dating, varying in age from approximately 600 to 10,000 yrs. The optical dates were generated using an argon-ion laser (λ =514 nm) excitation source, and alpha counting and flame photometry for the analysis of uranium and thorium, and potassium, respectively. Errors calculated for the dates incorporate random and systematic errors in ED and annual-dose evaluation. The resulting optical dates are displayed and directly compared with the inferred or directly measured ages for the strata based on other methods in Figure 1. All seven optical dates presented are both stratigraphically consistent and generally agree with the independent radiocarbon stratigraphies.

The possible small degree of age underestimation for the Mustang Springs samples is most likely related to the high silt and clay content of the strata (whose water-holding, and, correspondingly, radiation-attenuating, capacity is considerably greater than for more sandy deposits), coupled with uncertainty regarding the average moisture conditions of the samples during antiquity. The presence of lacustrine deposits with the sequence is indicative of saturated conditions, while biotic stratigraphic and archaeological data (Hill and Meltzer 1987; Meltzer 1991) suggested periods of extreme drought. Hence, the current moisture status of the deposits is not considered representative.

Most radiocarbon-based chronostratigraphic investigations at BWD#1 have concentrated on the lower, Paleoindian-associated deposits (Haynes and Agogino 1966; Haynes et al. in press), due both to the primary focuses of the previous studies and to the general paucity of radiocarbon-datable material in units of F & G. Haynes et al. (in press) rejected the ca. 6,200 yr age for the F/E boundary, favoring an older date of 8,830 yr B.P. (AA-1413); the depositional time range of unit E spanning approximately 9,000–10,500 years is based both on radiocarbon dates and associated Cody complex artifacts (C. V. Haynes pers. comm.). The 8,830 yr B.P. date for this boundary forces the abandonment of a number of previous radiocarbon dates from within unit E. (Haynes et al. in press, table 4). Whichever of the two ages is accepted, the stratigraphically overlying optical dateof5,950 ± 600yr B.P. (OX_{ob}819/1) supports a5,000–6,000 yr B.P. depositional time span for unit F, casting further doubts on the 8,230 ± 140 yr B.P. (AA-1643) date presented with some reservation by Haynes et al. (in press). Acceptance of the latter would imply a major hiatus in

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deposition at BWD#1 spanning up to 7,000 years following the deposition of unit F and prior to deposition of unit G.

The age of 850–900 years for the commencement of sedimentation of stratum 5 at Lubbock Lake was inferred by Holliday et al. (1983) based on a number of radiocarbon determinations on soils formed upon the underlying stratum 4. Radiocarbon dates for stratum 4 at Lubbock Lake ranged from 870 to 5,550 yr B.P. (Holliday et al. 1983) although a number of these dates were derived from buried A horizons and other post-depositional sediment fractions. A depositional-age range of 4,500 to 5,500 yr B.P. for deposition of stratum 4 at Lubbock Lake was suggested by Holliday (1983).

The three latest Holocene dates (spanning approximately 500–900 yrs) for the Blackwater Draw and Lubbock Lake sites suggest that widespread eolian reactivation (including both sand-sheet and lunette deposition) took place on the Southern High Plains at this time. Similar eolian reactivation in a number of adjacent areas (Stokes et al. 1991; Stokes unpublished data) during the latest



Figure 1. Schematic partial stratigraphic sections for the sites investigated in this study. Informal stratigraphic subdivisions and radiocarbon-based chronostratigraphies (rhs columns) are after Meltzer (1991) (Mustang Springs); Haynes and Agogino (1966); Haynes et al. (in press) (BWD#1); Haas et al. (1986); Holliday (1983); and Holliday et al. (1983) (Lubbock Lake). Only those radiocarbon dates which are from, or adjacent to, strata sampled for optical dates are presented (see text for a discussion of additional related radiocarbon determinations). All radiocarbon dates are uncalibrated and were generated using bone organics, burnt bone and various sediment organic fractions (see original sources for discussion). Crosses on the columns depict the relative position from which the optical dating samples were collected. No chrono- or litho-stratigraphic relationship is implied for units between sites displayed on the diagram at the same relative vertical position. The material stratigraphically overlyingunit G at BWD#1 is disturbed landfill. Radiocarbon sample (0-157 (BWD#1)) may actually be from a higher stratigraphic position at the G/F boundary or actually within the basal portion of unit G (C. V. Haynes, pers. comm.).

Holocene (ca. 500–1,000 yrs) may indicate one or more major regional paleoclimatic shifts resulting in a phase, or phases, of aridity whose widespread significance are yet to be fully realized.

The good correlation between the optical and radiocarbon chronostratigraphies, coupled with additional empirical investigations of independently dated sequences (e.g., Smith et al. 1991; Stokes 1991) and the sound theoretical basis of the optical-dating method (e.g., Aitken 1992; Rhodes 1990), indicates that the technique may be applied with confidence either in the absence of other dating strategies, or in a supplemental role. In doing so, it is envisaged that considerable new information may be generated with implications for chronostratigraphy and regional correlation, archaeology and soil chronosequence studies.

Added in proof

It has been brought to the attention of the author by Dr. V. T. Holliday, that sample OX_{op}827/2 may in fact be derived from stratum 4B. If this is the case, the most proximal radiocarbon-age determination for the unit would be that of 880 \pm 70 radiocarbon yr B.P. (SI-4169). It is hoped that this possible discrepancy will be resolved by a subsequent visit to the site. I am grateful to Dr. Holliday for pointing this out.

Drs. D. J. Meltzer (SMU), C. C. Reeves, Jr. (Texas Tech) and F. E. Green, and Mr. S. Stadleman (Texas Tech) are thanked for assistance in collection of the samples from the Mustang Springs, Blackwater Draw, and Lubbock Lake localities, respectively. Drs. A. Allsop, (RLAHA, Oxford), C. V. Haynes (University of Arizona), V. T. Holliday (University of Wisconsin, Madison), and D. J. Meltzer are thanked for reading a draft of this article. It is a pleasure to acknowledge the ongoing support, encouragement and enthusiasm of Drs. M. Collins (University of Texas, Austin), D. J. Meltzer, and C. C. Reeves, Jr. in respect of my investigations on the sediments of the Southern High Plains.

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Information for Contributors

GENERAL INFORMATION

Categories of notes will be: 1) Archaeology, 2) Physical Anthropology, 3) Lithic Studies, 4) Taphonomy–Bone Modification, 5) Methods, 6) Paleoenvironments (which includes the subsections: Plants, Invertebrates, Vertebrates, and Geosciences), and 7) Special focus. The last category is reserved for a preselected topic; articles are submitted by authors at the request of the Center. Usually 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.

Manuscripts should be of note length, no greater than 1000 words, or 400 words with one figure and caption, plus references. They should be current, original, not be or have been submitted to another journal, and may cover any aspect of the above-mentioned categories. All notes will be published in English. Authors submitting manuscripts in a language other than English may either submit their manuscript also in English or request the editorial staff to provide a translation (final decision will be left to the editorial board). In either case, both accepted manuscripts will be published. Manuscripts submitted in a language other than English should be typed double-spaced throughout and be legible. If a manuscript requires extensive editing or if a meaning is unclear, the author will be contacted—this could delay the printing of the manuscript.

Manuscripts are first read by the editorial staff to ensure the minimum requirements are met, as outlined above. All manuscripts are edited for style and general grammar. Because one of the practical goals of the journal is to provide quick turnaround time for the printing of manuscripts, authors do not review galley or page proofs. The editorial staff compares the submitted manuscripts with the style-edited page proofs. Thus it is imperative that authors carefully proof their manuscripts for content, journal style, and grammar. It is suggested that all manuscripts be reviewed by a colleague of the author prior to submission. All manuscripts receive peer reviews.

FORM AND STYLE

Manuscripts should be concise but detailed enough to permit critical appraisal.

They must be typed and DOUBLE-SPACED THROUGHOUT (i.e., entire manuscript, references, and figure caption) on one side of 22 by 28 cm (8-1/2 by 11 inch) paper with no less than 4 cm (1-1/2 inch) margins.

If a word processor is used, use the following specifications in preparing and printing your manuscript. Use letter quality or near letter quality printing. Align text to the left margin only—do not justify. Underline any words that should be italicized in the final typeset galleys. DO NOT hyphenate words at the right margin. Manuscripts should be submitted both in printed form and on computer disk. (Macintosh, MS DOS/IBM, or Apple II format). In addition to the original word-processing document, the disk also contain an ASCII version. The computer will probably be able to translate the text and formatting from the original document, but if it cannot translate the original, it will at least be able to read the ASCII file. Manuacripts that conform to these specifications will allow us to fully utilize the technology we have available in preparing manuscripts for publication and will help hold down both the turnaround time and the cost of the journal.

Space will not permit the inclusion of tables. Materials that normally would be placed in a small table should be placed in the text [e.g., "There are five radiocarbon dates from this site $(15,000 \pm 100 \text{ yr B.P. } (A-000), \ldots 11,000 \pm 100 \text{ yr B.P. } (A-0000))$ "]. One figure is permitted; the caption should be typed on a separate page using all the above-mentioned specifications for text preparation. All pages should be numbered consecutively starting with the first page of text. The title page should include an informative title, author(s), affiliation(s), and complete mailing address(es), which must contain your zip code or postal district, when applicable. It would help to include your telephone number and your BITNET number, if possible, on your cover letter, should there be any questions by the editor. Avoid titles with interrogative form, abbreviations, and formulae. Submit three (3) copies of each manuscript and at lease one PMT or glossy print of the figure, if one is included. Authors should keep original art.

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Metric units should be used throughout and be abbreviated when appropriate. Examples of the abbreviation style used include: i.e.; e.g.; cf.; cm; m; km; ha; yr B.P.; and sp. Numbers will be written out when they start a sentence or when they are the numbers one through nine (exception: "... 20 choppers, 10 burins, and 2 knives were recovered."); numbers greater than nine are written as numerals (e.g., 10, 11, 1,000). All numbers greater than 999, including radiocarbon ages, should use a comma (22,200 \pm 1,210 yr B.P.; 1,000 years ago; 12,000 mollusks).

Radiocarbon dates should be expressed in ¹⁴C years before present (yr B.P.) and should include the standard error and the laboratory number (e.g., 11,000 \pm 140 yr B.P. (A-1026)). International notation should be employed in all cases of chemical notations.

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