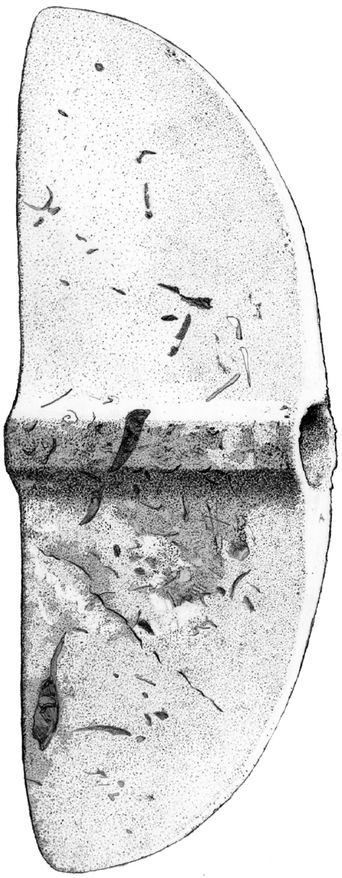
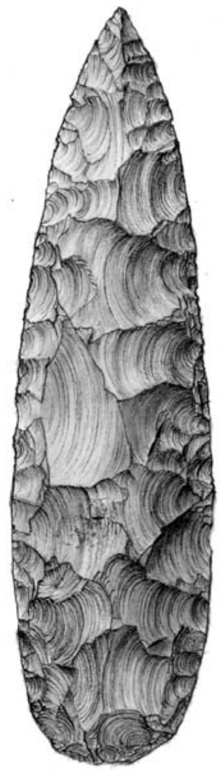
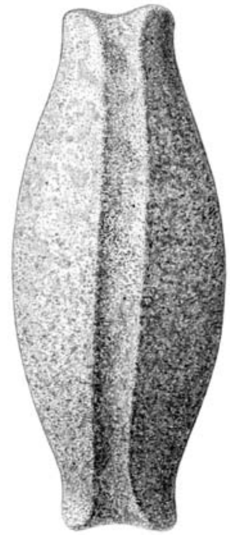
# Archaeology and Bioarchaeology of the Buckeye Knoll Site (41VT98), Victoria County, Texas







**Final Report**
**2012**

**Volume 3**
**(Appendices)**


**Prepared by:**

**Coastal Environments, Inc.**
**525 S. Carancahua Street**
**Corpus Christi, Texas 78401**

**Submitted to:**

**U.S. Army Corps of Engineers**
**Galveston District**



**Contract Nos.**

**DACW64-97-D-0003,**
**Delivery Orders 0006 and 0008**

**GS-10F-0445N, Order No.**
**DACW64-03-F-0073**

# ARCHAEOLOGY AND BIOARCHAEOLOGY OF THE BUCKEYE KNOLL SITE (41VT98), VICTORIA COUNTY, TEXAS


**Edited by:**

**Robert A. Ricklis**
**Richard A. Weinstein**
**Douglas C. Wells**

Contributing Authors:

Robert A. Ricklis
Glen H. Doran
Christopher Stojanowski
Susan L. Scott
Robert J. Hard
Noreen Tuross
Bruce M. Albert
Charles D. Frederick
Mark D. Bateman
Jason W. Barrett
Kathryn Puseman
Linda Scott Cummings
Collette Berbesque
Jon C. Lohse
Bruce Rothschild
Christine Rothschild
Tim Riley

Mortuary Artifact Illustrations by:

Alexander N. Cox


**Final Report**
**2012**

**Volume 3**
**(Appendices)**


Robert A. Ricklis
Principal Investigator

Coastal Environments, Inc.
525 S. Carancahua Street
Corpus Christi, Texas 78401



Submitted to:

U.S. Army Corps of Engineers,
Galveston District

Contract Nos.

DACW64-97-D-0003, Delivery Orders 0006 and 0008
GS-10F-0445N, Order No. DACW64-03-F-0073

**Cover Illustrations**

Drawings of Selected Mortuary Artifacts Recovered from Buckeye Knoll:
(Left) Limestone, Semi-Lunar, Winged Bannerstone, Burial 74;
(Center) Chert Biface, Burial 1-B;
(Right) Quartzite Grooved Stone, Burial 6.

Appendix A

# Geoarchaeological Investigations

**Charles D. Frederick**
**Mark D. Bateman**

### *Introduction*

This report presents the results of optical luminescence geochronological and other geoarchaeological investigations at the Buckeye Knoll Site (41VT98). The authors visited the site during April 2001, at which time three new trenches for our investigations were excavated by means of a backhoe, and the existing excavation units were examined, described, and sampled for physical characterization and optically stimulated luminescence (OSL) dating. The locations of these trenches are shown in Figure A-1, along with the approximate locations of the geoarchaeological profiles discussed in this appendix.

The goals of the investigations were to determine, as well as possible, the geologic history of the site, the age of the site deposits, and the manner in which human activity had modified the site deposits. The interpretation of the site history derives from the stratigraphic evidence and the luminescence dates. For this reason, the results of the luminescence dating are presented early in the report. An interpretation of the depositional history is presented next, and is, in turn, followed by the results of studies pertinent to the interpretation of the specific cultural features, namely, the site's middens.

### *Basic Stratigraphy*

The stratigraphic evidence revealed by the archaeological investigations was deceptively simple. Three major stratigraphic units were exposed: (1) the Beaumont Formation, (2) the Deweyville Formation, and (3) a series of unnamed Holocene deposits that rested unconformably upon both of the older units. The vast majority of the archaeological work was logically centered upon the Holocene unit, and the unravelling of this series of deposits was one of the main goals of our investigations. In the field, this deposit was separated into three basic units, named Zones 1, 2, and 3.

The youngest deposit, Zone 1, was between 40 and 90 cm thick, and was thinnest up slope (on the Knoll Top) and thickest downslope in the West Slope Excavation Block. This deposit appeared to be almost entirely enveloped by a weak A horizon, although on a depression in the Knoll Top Excavation, a relatively clean sand that was minimally altered by pedogenesis was present. This sand separated Zone 1 from Zone 2, and was termed Zone 1A. This unit (1A) was also present sporadically away from this depression.

Zone 2 was a very dark brown to black buried A horizon that was widely regarded in the field to be a midden on the basis of its color and elevated artifactual content. This deposit ranged from 30 to 60 cm thick, and the upper and lower boundaries appeared to have been altered by pedoturbation.

Beneath the midden was Zone 3, which was divided into two parts (3A and 3B) in the field. Zone 3A was, in many ways, similar to Zone 1 in that it exhibited a weak A horizon; whereas, Zone 3B

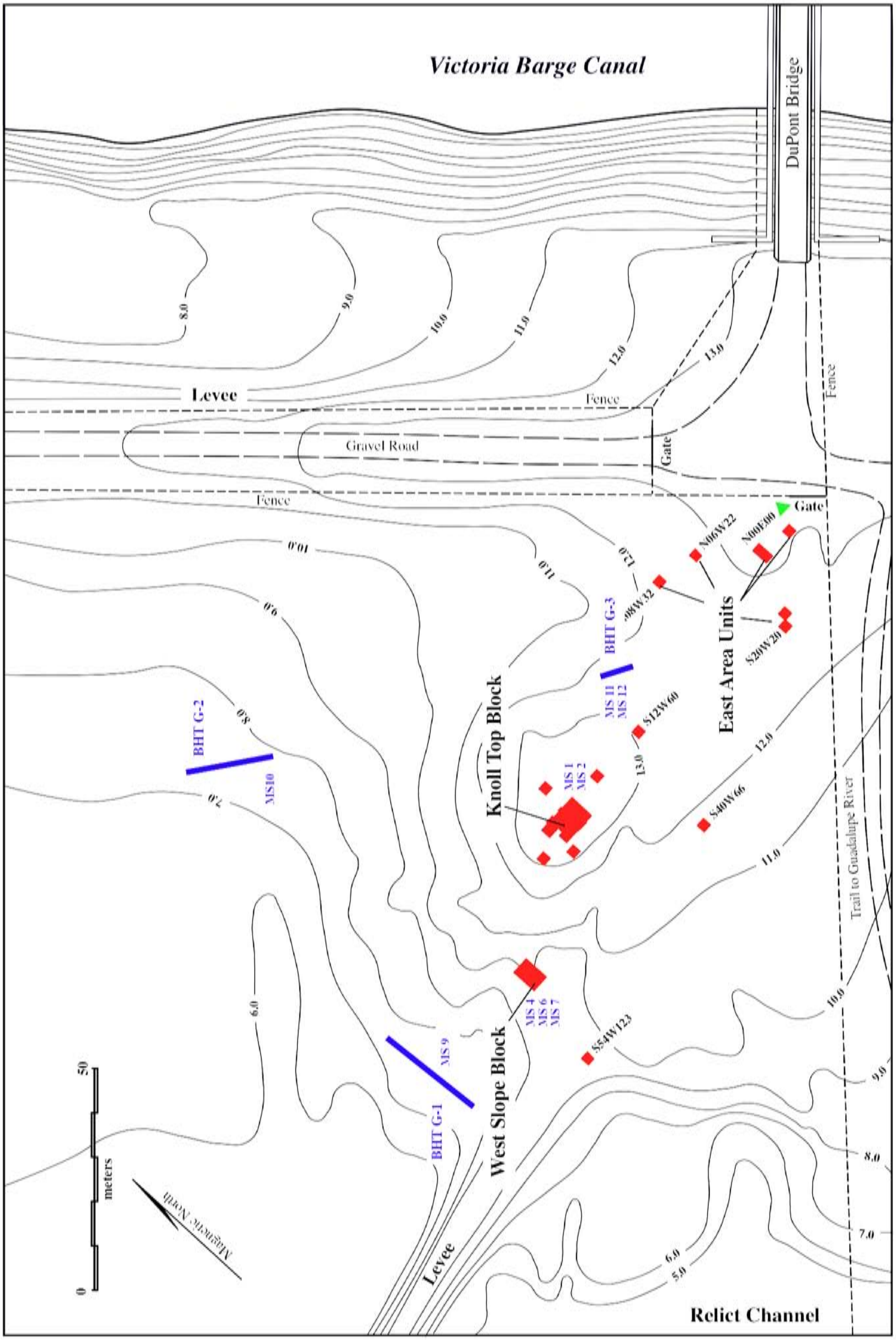



**Figure A-1.** A topographic map of the Buckeye Knoll site showing the locations of the geoarchaeological backhoe trenches (G-1 through G-3) and the associated profiles discussed in the text.

was generally transitional to a C horizon and was minimally altered by pedogenesis. In the Knoll Top Block this deposit rested directly on top of the Beaumont Formation.

In the West Slope Block a fourth deposit (Zone 4), consisting of a yellowish sand, was situated beneath Zone 3 but above the Beaumont Formation. This deposit contained occasional freshwater mussel shell fragments and yielded few artifacts.

### *Analytical Methods*

Profiles examined in the field were described using standard soil description methods that noted the texture, Munsell color, structure, boundaries, consistency, and presence of specific pedogenic features. Profiles were described where samples were collected for optically stimulated luminescence dating (see below) and were designated MS1 to MS11. We also collected samples at 5-cm (or tighter) increments in 2.5-cm plastic cubes from each profile that we described to facilitate interpretation of the dating results. Additionally, a small number of samples were collected from the present-day floodplain, as well as a roadcut through a presumed dune formation to the east of the site, to provide reference material for sediment provenance. All these samples were used for a range of analytical procedures.

To supplement the OSL-derived chronology, independent dating control was provided by the recovered archaeological data and radiocarbon dating of associated bone and shell. Additionally, two burned-clay nodules from Profile MS7 were sent to Dr James Feathers, University of Washington, for thermoluminescence (TL) analysis. Their dose rates were determined by a combination of alpha and beta counting with flame photometry and field gamma spectrometry data. TL was measured on a Daybreak reader through a Corning 7-59 filter in a nitrogen atmosphere at 1°C/s to 450°C. A preheat of 240°C with no hold time preceded all measurements and artificial irradiation was given with $^{214}$Americium (Am) alpha and $^{90}$Strontium (Sr) beta sources. Final palaeodoses were determined using the Australian slide method and corrected for anomalous fading using the Huntley and Lamothe (2001) method. TL results have been used to compare artifactual antiquities to those of the sediment matrix.

In most cases the magnetic properties of the samples were first examined. In all cases this consisted of measuring the high- and low-frequency magnetic susceptibility. For three profiles, more advanced magnetic properties (ARM, IRM, HIRM, and SIRM) were measured at the "Gladys Dalby New" Magnetics Laboratory, Department of Geography, University of Liverpool (England).

Following the magnetic analysis, samples were split for a variety of other analyses. One split was used for granulometry, and these samples were analysed on a Cilas 940 Laser Particle Sizer at the Department of Geography, University of Sheffield. Prior to analysis, the samples were first digested in concentrated (~30 percent) hydrogen peroxide on a hot plate to remove organic material. When this digestion was completed (usually after boiling for 20-30 minutes) concentrated hydrochloric acid was added to remove carbonates. Microscopic analysis revealed these carbonates to be nearly all mollusc shell or reprecipitated mollusc shell carbonate. The results of these analyses are presented in Table A-1.

Samples from three prominent sedimentary units on the site and from the floodplain samples were analyzed by scanning electron microscope (SEM) to examine their grain surface textures to see if they could elucidate different sediment transportational pathways to the site. These samples were pretreated in hydrogen peroxide (30 percent) on a hot plate for 20 minutes to remove organic material; carbonate material was removed by adding hydrochloric acid. SEM analysis was carried out at the SEM facilities at the University of Sussex using a Leica streoscan 420 scanning electron microscope. Once mounted on aluminium stubs, quartz grains were identified on the basis on an EDAX scan, and only grains revealing nothing other than silica were analyzed.

Samples, both from the site and from the modern floodplain, were also submitted for heavy mineral analysis to ascertain sediment provenance. Samples for this were prepared by Robert Knox by sieving into a fine-sand fraction (62.5 to 125 microns) and separating out the heavy mineral fraction using bromoform (S.G. 2.9), and mounting in Canada Balsam on standard petrographic glass slides.

Splits of samples from two profiles (MS1 and MS4) were submitted to XRAL Laboratories (Canada) for elemental analysis by Inductively Coupled Plasma Spectrometry (ICP). This analysis was performed to examine the stratigraphic distribution of these elements commonly cited as those concentrated by human activity and was intended to permit discussion of midden formation processes. The procedures employed by XRAL are as follows: "A 0.25 gram sample

**Table A-1.** Results of the Granulometric Analysis at Buckeye Knoll.

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS1-1 | 0 | 10YR 2.5/1 | 2.08 | 3.51 | 3.03 | 1.89 | 1.98 | 0.75 | 0.77 | 0.82 | 2.12 | 79.50 | 17.91 | 2.59 |
| MS1-2 | 5 | 10YR 2.5/1 | 2.09 | 3.80 | 3.23 | 2.06 | 2.02 | 0.83 | 0.83 | 0.58 | 2.06 | 78.10 | 19.69 | 2.21 |
| MS1-3 | 10 | 10YR 2.5/1 | 2.24 | 3.89 | 3.34 | 2.14 | 2.10 | 0.77 | 0.78 | 0.59 | 1.61 | 75.81 | 21.36 | 2.83 |
| MS1-4 | 15 | 10YR 3/1 | 2.07 | 3.66 | 3.13 | 1.93 | 1.94 | 0.82 | 0.82 | 0.67 | 2.08 | 78.60 | 19.33 | 2.07 |
| MS1-5 | 20 | 10YR 3/1 | 2.10 | 3.76 | 3.20 | 2.01 | 1.98 | 0.83 | 0.82 | 0.61 | 1.94 | 77.34 | 20.49 | 2.17 |
| MS1-6 | 25 | 10YR 3/1 | 2.11 | 3.89 | 3.30 | 2.14 | 2.04 | 0.83 | 0.82 | 0.50 | 1.51 | 75.33 | 22.64 | 2.03 |
| MS1-7 | 30 | 10YR 3/1 | 2.10 | 3.75 | 3.20 | 2.01 | 1.98 | 0.83 | 0.82 | 0.60 | 1.90 | 77.52 | 20.40 | 2.08 |
| MS1-8 | 35 | 10YR 3/2 | 2.09 | 3.76 | 3.20 | 2.02 | 2.03 | 0.83 | 0.83 | 0.68 | 2.06 | 77.88 | 19.44 | 2.68 |
| MS1-9 | 40 | 10YR 3/2 | 2.15 | 3.90 | 3.32 | 2.23 | 2.16 | 0.78 | 0.78 | 0.54 | 1.31 | 74.01 | 23.35 | 2.64 |
| MS1-10 | 45 | 10YR 3/2 | 2.30 | 4.05 | 3.47 | 2.31 | 2.21 | 0.76 | 0.76 | 0.51 | 0.92 | 70.74 | 26.09 | 3.17 |
| MS1-11 | 50 | 10YR 3/1 | 2.10 | 3.80 | 3.23 | 2.18 | 2.10 | 0.78 | 0.78 | 0.54 | 1.21 | 73.72 | 23.98 | 2.30 |
| MS1-12 | 52.5 | 10YR 2/1 | 2.26 | 3.92 | 3.37 | 2.18 | 2.11 | 0.76 | 0.77 | 0.54 | 0.93 | 71.37 | 26.08 | 2.55 |
| MS1-13 | 55 | 10YR 2/1 | 2.23 | 3.80 | 3.28 | 2.06 | 2.06 | 0.76 | 0.78 | 0.65 | 1.58 | 75.58 | 21.67 | 2.75 |
| MS1-14 | 57.5 | 10YR 2/1 | 2.06 | 3.60 | 3.08 | 1.89 | 1.95 | 0.81 | 0.81 | 0.74 | 2.18 | 78.12 | 19.60 | 2.28 |
| MS1-15 | 60 | N 2/0 | 2.09 | 3.29 | 2.89 | 1.54 | 1.77 | 0.78 | 0.80 | 1.16 | 2.36 | 80.76 | 16.76 | 2.48 |
| MS1-16 | 65 | N 2/0 | 2.01 | 2.90 | 2.60 | 1.22 | 1.61 | 0.73 | 0.77 | 1.69 | 2.76 | 82.32 | 15.45 | 2.23 |
| MS1-18 | 70 | N 2/0 | 2.05 | 2.50 | 2.35 | 0.76 | 1.29 | 0.59 | 0.71 | 2.96 | 3.00 | 86.53 | 11.80 | 1.67 |
| MS1-19 | 75 | N 2/0 | 2.16 | 3.26 | 2.90 | 1.54 | 1.76 | 0.71 | 0.75 | 1.13 | 2.13 | 80.43 | 17.25 | 2.32 |
| MS1-20 | 77.5 | N 2/0 | 2.12 | 3.25 | 2.87 | 1.49 | 1.76 | 0.76 | 0.79 | 1.25 | 2.16 | 80.53 | 16.84 | 2.63 |
| MS1-21 | 80 | N 2/0 | 2.05 | 2.95 | 2.65 | 1.23 | 1.55 | 0.73 | 0.77 | 1.52 | 2.52 | 82.16 | 16.04 | 1.80 |
| MS1-22 | 82.5 | N 2/0 | 2.22 | 3.66 | 3.18 | 1.93 | 1.98 | 0.75 | 0.77 | 0.74 | 1.78 | 77.46 | 19.96 | 2.58 |

continued.

**Table A-1.** (continued)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS1-23 | 85 | N 2/0 | 2.26 | 3.17 | 2.86 | 1.40 | 1.71 | 0.65 | 0.72 | 1.39 | 2.05 | 80.72 | 16.65 | 2.63 |
| MS1-24 | 90 | N 2/0 | 2.25 | 3.26 | 2.93 | 1.50 | 1.76 | 0.68 | 0.73 | 1.23 | 2.02 | 80.30 | 17.14 | 2.56 |
| MS1-25 | 95 | N 2/0 | 2.26 | 3.46 | 3.06 | 1.70 | 1.87 | 0.71 | 0.75 | 0.97 | 1.89 | 78.71 | 18.63 | 2.66 |
| MS1-26 | 100 | 10YR 2/1 | 2.31 | 3.49 | 3.10 | 1.70 | 1.85 | 0.70 | 0.73 | 0.95 | 1.76 | 77.77 | 19.67 | 2.56 |
| MS1-27 | 105 | 10YR 2/1 | 2.22 | 3.13 | 2.83 | 1.38 | 1.68 | 0.66 | 0.72 | 1.36 | 2.00 | 80.70 | 16.97 | 2.33 |
| MS1-28 | 110 | 10YR 2/1 | 2.09 | 2.63 | 2.45 | 0.95 | 1.44 | 0.57 | 0.68 | 2.31 | 2.54 | 84.83 | 13.24 | 1.93 |
| MS1-29 | 115 | 10YR 2/1 | 2.03 | 2.59 | 2.40 | 0.98 | 1.45 | 0.58 | 0.69 | 2.25 | 2.81 | 84.27 | 13.85 | 1.88 |
| MS1-30 | 120 | 10YR 2/1 | 2.21 | 3.48 | 3.06 | 1.74 | 1.83 | 0.73 | 0.76 | 0.83 | 1.83 | 78.41 | 19.57 | 2.02 |
| MS1-31 | 122.5 | 10YR 3/1 | 2.12 | 3.11 | 2.78 | 1.43 | 1.66 | 0.70 | 0.73 | 1.18 | 2.08 | 81.08 | 17.15 | 1.77 |
| MS1-32 | 125 | 10YR 3/1.5 | 2.38 | 3.60 | 3.19 | 1.79 | 1.84 | 0.68 | 0.71 | 0.74 | 1.41 | 75.58 | 22.50 | 1.92 |
| MS1-33 | 130 | 10YR 3/2 | 2.27 | 3.43 | 3.04 | 1.66 | 1.77 | 0.70 | 0.73 | 0.87 | 1.69 | 78.46 | 19.64 | 1.90 |
| MS1-34 | 135 | 10YR 3/2 | 2.04 | 2.75 | 2.51 | 1.13 | 1.50 | 0.62 | 0.70 | 1.70 | 2.39 | 83.20 | 15.17 | 1.63 |
| MS1-35 | 140 | 10YR 3/2 | 2.14 | 3.28 | 2.90 | 1.61 | 1.73 | 0.71 | 0.73 | 0.90 | 1.81 | 80.01 | 18.35 | 1.64 |
| MS1-36 | 145 | 10YR 3/2 | 2.02 | 2.64 | 2.43 | 1.03 | 1.37 | 0.60 | 0.68 | 1.74 | 2.53 | 83.83 | 14.96 | 1.21 |
| MS1-37 | 150 | 10YR 5/2 | 2.25 | 3.42 | 3.03 | 1.68 | 1.77 | 0.70 | 0.73 | 0.84 | 1.71 | 79.09 | 19.11 | 1.80 |
| MS1-38 | 155 | 10YR 5/2 | 2.07 | 2.79 | 2.55 | 1.16 | 1.48 | 0.63 | 0.70 | 1.57 | 2.22 | 82.92 | 15.63 | 1.45 |
| MS4-05 | 5 | — | 1.98 | 2.45 | 2.29 | 0.89 | 1.37 | 0.53 | 0.66 | 2.43 | 2.71 | 85.84 | 12.56 | 1.60 |
| MS4-10 | 10 | — | 1.95 | 2.60 | 2.38 | 1.06 | 1.42 | 0.61 | 0.70 | 1.77 | 2.78 | 83.71 | 14.97 | 1.32 |
| MS4-15 | 15 | — | 2.21 | 3.59 | 3.13 | 1.86 | 1.87 | 0.74 | 0.76 | 0.67 | 1.61 | 76.87 | 21.36 | 1.77 |
| MS4-20 | 20 | — | 1.99 | 2.68 | 2.45 | 1.12 | 1.53 | 0.62 | 0.71 | 1.85 | 2.67 | 83.30 | 14.84 | 1.86 |
| MS4-25 | 25 | — | 2.06 | 2.78 | 2.54 | 1.05 | 1.47 | 0.69 | 0.75 | 1.99 | 2.56 | 83.40 | 14.71 | 1.89 |
| MS4-30 | 30 | — | 2.06 | 3.08 | 2.74 | 1.36 | 1.62 | 0.75 | 0.78 | 1.27 | 2.27 | 81.60 | 16.64 | 1.76 |

continued.

**Table A-1.** (continued)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS4-35 | 35 | — | 1.93 | 2.54 | 2.33 | 1.02 | 1.43 | 0.60 | 0.69 | 1.96 | 2.82 | 83.85 | 14.70 | 1.45 |
| MS4-40 | 40 | — | 2.11 | 2.94 | 2.66 | 1.19 | 1.51 | 0.70 | 0.76 | 1.55 | 2.13 | 82.23 | 16.06 | 1.71 |
| MS4-45 | 45 | — | 2.18 | 3.55 | 3.09 | 1.82 | 1.82 | 0.75 | 0.76 | 0.64 | 1.80 | 78.04 | 20.43 | 1.53 |
| MS4-50 | 50 | — | 2.11 | 3.26 | 2.88 | 1.65 | 1.76 | 0.70 | 0.73 | 0.87 | 1.75 | 79.70 | 18.68 | 1.62 |
| MS4-55 | 55 | — | 2.08 | 2.91 | 2.63 | 1.28 | 1.57 | 0.65 | 0.71 | 1.40 | 2.23 | 82.15 | 16.23 | 1.62 |
| MS4-60 | 60 | — | 2.09 | 2.82 | 2.57 | 1.07 | 1.47 | 0.68 | 0.75 | 1.88 | 2.36 | 83.30 | 14.89 | 1.81 |
| MS4-65 | 65 | — | 2.21 | 3.34 | 2.96 | 1.61 | 1.76 | 0.70 | 0.74 | 0.97 | 1.88 | 79.96 | 18.04 | 2.00 |
| MS4-70 | 70 | — | 2.08 | 3.45 | 2.99 | 1.74 | 1.83 | 0.79 | 0.79 | 0.81 | 1.97 | 79.44 | 18.69 | 1.87 |
| MS4-75 | 75 | — | 2.02 | 2.95 | 2.64 | 1.37 | 1.62 | 0.67 | 0.73 | 1.25 | 2.26 | 81.92 | 16.49 | 1.59 |
| MS4-80 | 80 | — | 2.06 | 2.74 | 2.52 | 1.02 | 1.45 | 0.67 | 0.74 | 2.01 | 2.45 | 83.91 | 14.28 | 1.81 |
| MS4-85 | 85 | — | 1.98 | 2.82 | 2.54 | 1.28 | 1.59 | 0.66 | 0.72 | 1.46 | 2.53 | 82.40 | 15.89 | 1.71 |
| MS4-90 | 90 | — | 2.01 | 3.26 | 2.84 | 1.69 | 1.79 | 0.74 | 0.76 | 0.84 | 2.16 | 80.69 | 17.66 | 1.65 |
| MS4-95 | 95 | — | 2.07 | 3.49 | 3.01 | 1.91 | 1.91 | 0.74 | 0.76 | 0.65 | 1.80 | 78.53 | 19.74 | 1.73 |
| MS4-100 | 100 | — | 1.98 | 3.35 | 2.89 | 1.83 | 1.85 | 0.75 | 0.77 | 0.70 | 2.07 | 80.13 | 18.30 | 1.57 |
| MS4-105 | 105 | — | 2.07 | 3.39 | 2.95 | 1.79 | 1.87 | 0.74 | 0.76 | 0.80 | 1.98 | 79.82 | 18.28 | 1.90 |
| MS4-110 | 110 | — | 1.98 | 3.03 | 2.68 | 1.50 | 1.71 | 0.70 | 0.75 | 1.11 | 2.29 | 81.52 | 16.75 | 1.73 |
| MS4-115 | 115 | — | 1.99 | 2.74 | 2.49 | 1.20 | 1.55 | 0.63 | 0.71 | 1.62 | 2.45 | 82.86 | 15.43 | 1.71 |
| MS4-120 | 120 | — | 2.00 | 2.62 | 2.42 | 1.06 | 1.48 | 0.59 | 0.69 | 1.94 | 2.48 | 84.09 | 14.18 | 1.73 |
| MS4-125 | 125 | — | 1.98 | 2.69 | 2.45 | 1.13 | 1.49 | 0.63 | 0.71 | 1.73 | 2.72 | 83.11 | 15.33 | 1.56 |
| MS4-130 | 130 | — | 2.12 | 3.44 | 3.00 | 1.80 | 1.86 | 0.74 | 0.75 | 0.77 | 1.83 | 79.18 | 18.98 | 1.84 |
| MS4-135 | 135 | — | 2.01 | 2.60 | 2.40 | 1.03 | 1.47 | 0.57 | 0.68 | 2.05 | 2.44 | 84.54 | 13.71 | 1.75 |
| MS4-140 | 140 | — | 2.12 | 3.40 | 2.97 | 1.75 | 1.84 | 0.73 | 0.75 | 0.82 | 1.94 | 79.86 | 18.29 | 1.85 |
| MS4-145 | 145 | — | 1.99 | 2.58 | 2.39 | 1.01 | 1.45 | 0.58 | 0.69 | 2.07 | 2.71 | 84.13 | 14.18 | 1.69 |

continued.

**Table A-1.** (continued)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS4-145 | 150 | — | 1.99 | 2.58 | 2.39 | 1.01 | 1.45 | 0.58 | 0.69 | 2.07 | 2.71 | 84.13 | 14.18 | 1.69 |
| MS4-155 | 155 | — | 2.04 | 2.70 | 2.48 | 1.12 | 1.52 | 0.59 | 0.69 | 1.85 | 2.37 | 83.60 | 14.53 | 1.87 |
| MS4-160 | 160 | — | 1.97 | 2.59 | 2.38 | 1.03 | 1.43 | 0.59 | 0.69 | 1.93 | 2.67 | 83.94 | 14.58 | 1.48 |
| MS4-165 | 165 | — | 2.01 | 2.56 | 2.38 | 0.98 | 1.43 | 0.56 | 0.67 | 2.16 | 2.58 | 84.74 | 13.61 | 1.65 |
| MS4-170 | 170 | — | 2.02 | 2.71 | 2.48 | 1.13 | 1.51 | 0.61 | 0.69 | 1.74 | 2.39 | 83.32 | 15.04 | 1.64 |
| MS4-175 | 175 | — | 1.99 | 2.40 | 2.27 | 0.83 | 1.34 | 0.50 | 0.64 | 2.65 | 2.80 | 86.04 | 12.42 | 1.54 |
| MS4-180 | 180 | — | 1.94 | 2.43 | 2.27 | 0.91 | 1.38 | 0.54 | 0.66 | 2.35 | 2.84 | 84.76 | 13.76 | 1.48 |
| MS4-185 | 185 | — | 1.99 | 2.42 | 2.28 | 0.85 | 1.32 | 0.51 | 0.64 | 2.51 | 2.68 | 86.02 | 12.58 | 1.40 |
| MS4-190 | 190 | — | 1.98 | 2.49 | 2.32 | 0.93 | 1.36 | 0.55 | 0.66 | 2.15 | 2.58 | 84.86 | 13.83 | 1.31 |
| MS4-195 | 195 | — | 2.04 | 2.58 | 2.40 | 0.97 | 1.39 | 0.56 | 0.66 | 2.09 | 2.46 | 84.88 | 13.67 | 1.45 |
| MS4-200 | 200 | — | 2.02 | 3.19 | 2.80 | 1.63 | 1.77 | 0.72 | 0.75 | 0.93 | 2.25 | 81.20 | 17.10 | 1.70 |
| MS4-205 | 205 | — | 2.05 | 2.84 | 2.58 | 1.23 | 1.56 | 0.64 | 0.71 | 1.54 | 2.38 | 82.47 | 15.84 | 1.69 |
| MS4-210 | 210 | — | 2.06 | 2.76 | 2.52 | 1.14 | 1.51 | 0.61 | 0.69 | 1.72 | 2.32 | 83.02 | 15.31 | 1.67 |
| MS4-215 | 215 | — | 2.05 | 2.75 | 2.52 | 1.02 | 1.43 | 0.69 | 0.76 | 1.97 | 2.70 | 83.49 | 14.84 | 1.67 |
| MS4-220 | 220 | — | 2.01 | 3.00 | 2.67 | 1.42 | 1.67 | 0.69 | 0.74 | 1.24 | 2.44 | 81.74 | 16.51 | 1.75 |
| MS4-225 | 225 | — | 1.98 | 3.07 | 2.71 | 1.53 | 1.73 | 0.71 | 0.75 | 1.08 | 2.36 | 81.42 | 16.82 | 1.76 |
| MS4-230 | 230 | — | 2.06 | 3.32 | 2.90 | 1.72 | 1.86 | 0.73 | 0.76 | 0.92 | 2.27 | 80.80 | 17.09 | 2.11 |
| MS4-235 | 235 | — | 2.05 | 3.52 | 3.03 | 1.93 | 2.02 | 0.76 | 0.78 | 0.80 | 2.16 | 79.49 | 17.75 | 2.76 |
| MS4-240 | 240 | — | 2.32 | 4.39 | 3.70 | 2.83 | 2.56 | 0.73 | 0.73 | 0.33 | 0.69 | 60.04 | 35.43 | 4.53 |
| MS4-245 | 245 | — | 2.17 | 4.34 | 3.61 | 2.79 | 2.52 | 0.78 | 0.77 | 0.33 | 0.68 | 64.48 | 31.56 | 3.96 |
| MS4-250 | 250 | — | 6.56 | 7.38 | 7.10 | 1.84 | 1.66 | 0.45 | 0.42 | 0.32 | 0.72 | 0.00 | 80.27 | 19.73 |
| MS4-255 | 255 | — | 6.62 | 7.35 | 7.10 | 1.77 | 1.61 | 0.41 | 0.40 | 0.35 | 0.76 | 0.00 | 81.94 | 18.06 |

continued.

**Table A-1.** (continued)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS10-05 | 5 | 10YR 4/1 | 2.02 | 2.56 | 2.38 | 0.98 | 1.45 | 0.56 | 0.67 | 2.25 | 2.62 | 85.48 | 12.66 | 1.86 |
| MS10-10 | 10 | 10YR 4/1 | 2.04 | 2.53 | 2.36 | 0.92 | 1.41 | 0.53 | 0.66 | 2.42 | 2.63 | 86.28 | 11.92 | 1.80 |
| MS10-15 | 15 | 10YR 4/1 | 2.02 | 2.63 | 2.42 | 1.04 | 1.50 | 0.59 | 0.69 | 2.09 | 2.65 | 84.32 | 13.76 | 1.92 |
| MS10-20 | 20 | 10YR 4/1 | 1.95 | 2.20 | 2.12 | 0.66 | 1.15 | 0.38 | 0.57 | 3.12 | 3.08 | 89.78 | 8.97 | 1.25 |
| MS10-25 | 25 | 10YR 4/1 | 2.01 | 2.37 | 2.25 | 0.76 | 1.24 | 0.47 | 0.62 | 2.71 | 2.83 | 88.26 | 10.42 | 1.32 |
| MS10-30 | 30 | 10YR 3/1 | 1.99 | 2.32 | 2.21 | 0.73 | 1.21 | 0.45 | 0.61 | 2.82 | 2.90 | 89.03 | 9.65 | 1.32 |
| MS10-35 | 35 | 10YR 3/1 | 2.00 | 2.34 | 2.23 | 0.74 | 1.22 | 0.46 | 0.61 | 2.81 | 2.88 | 88.78 | 9.90 | 1.32 |
| MS10-40 | 40 | 10YR 3/1 | 1.96 | 2.27 | 2.17 | 0.71 | 1.24 | 0.43 | 0.61 | 3.11 | 3.22 | 87.78 | 10.88 | 1.34 |
| MS10-45 | 45 | 10YR 3/1 | 2.04 | 2.51 | 2.35 | 0.88 | 1.34 | 0.53 | 0.66 | 2.37 | 2.68 | 86.07 | 12.46 | 1.47 |
| MS10-50 | 50 | 10YR 3/1 | 2.04 | 2.59 | 2.40 | 0.86 | 1.31 | 0.63 | 0.72 | 2.34 | 2.67 | 85.60 | 12.97 | 1.43 |
| MS10-55 | 55 | 10YR 3/1 | 1.99 | 2.48 | 2.31 | 0.91 | 1.35 | 0.54 | 0.66 | 2.24 | 2.74 | 85.59 | 13.05 | 1.36 |
| MS10-60 | 60 | 10YR 2/1 | 2.02 | 2.79 | 2.54 | 1.18 | 1.54 | 0.65 | 0.72 | 1.64 | 2.59 | 82.74 | 15.55 | 1.71 |
| MS10-65 | 65 | 10YR 2/1 | 1.98 | 2.56 | 2.37 | 0.99 | 1.48 | 0.59 | 0.70 | 2.26 | 3.09 | 84.13 | 13.88 | 1.99 |
| MS10-70 | 70 | 10YR 3/1 | 2.06 | 3.66 | 3.13 | 2.05 | 2.04 | 0.78 | 0.79 | 0.63 | 1.98 | 77.40 | 20.36 | 2.24 |
| MS10-75 | 75 | 10YR 3/1 | 1.99 | 2.43 | 2.28 | 0.85 | 1.44 | 0.52 | 0.66 | 2.95 | 3.29 | 85.39 | 12.27 | 2.34 |
| MS10-80 | 80 | 10YR 3/1 | 2.01 | 3.35 | 2.91 | 1.77 | 1.93 | 0.76 | 0.78 | 0.95 | 2.68 | 80.40 | 16.94 | 2.66 |
| MS10-85 | 85 | 10YR 3/1 | 2.10 | 3.69 | 3.16 | 2.07 | 2.09 | 0.77 | 0.78 | 0.69 | 1.67 | 76.15 | 21.00 | 2.85 |
| MS10-90 | 90 | 10YR 2.5/1 | 2.05 | 3.41 | 2.96 | 1.81 | 1.94 | 0.76 | 0.78 | 0.90 | 2.42 | 79.83 | 17.56 | 2.61 |
| MS10-95 | 95 | 10YR 3/1 | 2.00 | 2.75 | 2.50 | 1.17 | 1.61 | 0.64 | 0.72 | 1.90 | 2.91 | 82.91 | 14.63 | 2.46 |
| MS10-100 | 100 | 10YR 3/1 | 2.01 | 2.77 | 2.51 | 1.19 | 1.61 | 0.64 | 0.72 | 1.83 | 2.77 | 82.79 | 14.86 | 2.35 |
| MS10-105 | 105 | 10YR 3/1 | 2.09 | 3.58 | 3.08 | 1.93 | 1.98 | 0.78 | 0.78 | 0.74 | 2.06 | 77.84 | 19.80 | 2.36 |
| MS10-110 | 110 | 10YR 3/1 | 2.03 | 3.45 | 2.98 | 1.87 | 1.92 | 0.76 | 0.77 | 0.75 | 2.16 | 78.62 | 19.35 | 2.03 |
| MS10-115 | 115 | 10YR 3/1.5 | 2.03 | 2.79 | 2.54 | 1.19 | 1.59 | 0.65 | 0.72 | 1.77 | 2.71 | 82.68 | 15.19 | 2.13 |

continued.

**Table A-1.** (continued)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS10-120 | 120 | 10YR 3/2 | 2.03 | 2.66 | 2.45 | 0.95 | 1.44 | 0.66 | 0.74 | 2.39 | 3.05 | 84.23 | 13.69 | 2.08 |
| MS10-125 | 125 | 10YR 3/2 | 2.06 | 3.04 | 2.72 | 1.31 | 1.61 | 0.75 | 0.79 | 1.41 | 2.53 | 81.68 | 16.36 | 1.96 |
| MS10-130 | 130 | 10YR 3/2 | 2.06 | 3.10 | 2.75 | 1.38 | 1.67 | 0.76 | 0.79 | 1.34 | 2.49 | 81.42 | 16.45 | 2.13 |
| MS10-135 | 135 | 10YR 3/2 | 2.06 | 2.78 | 2.54 | 1.05 | 1.50 | 0.69 | 0.76 | 2.08 | 2.79 | 83.26 | 14.58 | 2.16 |
| MS10-140 | 140 | 10YR 3/2 | 2.07 | 2.70 | 2.49 | 0.95 | 1.47 | 0.66 | 0.75 | 2.46 | 2.87 | 84.50 | 13.09 | 2.41 |
| MS10-145 | 145 | 10YR 3/1 | 2.06 | 3.25 | 2.85 | 1.51 | 1.75 | 0.78 | 0.81 | 1.17 | 2.51 | 80.99 | 16.68 | 2.33 |
| MS10-150 | 150 | 10YR 3/1 | 2.01 | 2.79 | 2.53 | 1.20 | 1.64 | 0.65 | 0.73 | 1.85 | 2.80 | 82.64 | 14.79 | 2.57 |
| MS10-155 | 155 | 10YR 3/1 | 1.99 | 2.55 | 2.36 | 0.98 | 1.52 | 0.58 | 0.69 | 2.49 | 3.21 | 84.44 | 13.07 | 2.49 |
| MS10-160 | 160 | 10YR 3/1 | 2.04 | 3.42 | 2.96 | 1.82 | 1.92 | 0.76 | 0.78 | 0.83 | 2.36 | 79.40 | 18.38 | 2.22 |
| MS10-165 | 165 | 10YR 3/1 | 2.21 | 3.70 | 3.21 | 1.97 | 2.02 | 0.76 | 0.77 | 0.74 | 1.74 | 77.15 | 19.97 | 2.88 |
| MS10-170 | 170 | 10YR 3/1 | 2.02 | 3.12 | 2.75 | 1.54 | 1.79 | 0.72 | 0.76 | 1.18 | 2.66 | 81.40 | 16.28 | 2.32 |
| MS10-175 | 175 | 10YR 3/2 | 2.06 | 3.42 | 2.97 | 1.70 | 1.83 | 0.80 | 0.81 | 0.91 | 2.47 | 80.21 | 17.59 | 2.20 |
| MS10-180 | 180 | 10YR 3/2 | 2.05 | 3.36 | 2.93 | 1.61 | 1.76 | 0.81 | 0.82 | 0.94 | 2.70 | 81.01 | 17.06 | 1.93 |
| MS10-185 | 185 | 10YR 3/2 | 2.06 | 3.07 | 2.74 | 1.33 | 1.64 | 0.76 | 0.79 | 1.42 | 2.58 | 81.58 | 16.25 | 2.17 |
| MS10-190 | 190 | 10YR 3/2 | 2.03 | 2.90 | 2.61 | 1.21 | 1.59 | 0.73 | 0.77 | 1.70 | 2.82 | 82.37 | 15.45 | 2.18 |
| MS10-195 | 195 | 10YR 4/2 | 2.05 | 2.65 | 2.45 | 0.91 | 1.43 | 0.66 | 0.75 | 2.54 | 2.96 | 84.81 | 13.02 | 2.17 |
| MS10-200 | 200 | 10YR 4/2 | 2.02 | 2.60 | 2.41 | 0.90 | 1.43 | 0.64 | 0.73 | 2.57 | 3.12 | 84.84 | 13.07 | 2.09 |
| MS10-205 | 205 | 10YR 4/2 | 2.02 | 2.58 | 2.40 | 0.88 | 1.41 | 0.64 | 0.74 | 2.65 | 3.35 | 84.69 | 13.23 | 2.08 |
| MS10-210 | 210 | 10YR 4/2 | 2.09 | 3.54 | 3.05 | 1.79 | 1.85 | 0.81 | 0.81 | 0.76 | 2.04 | 78.80 | 19.24 | 1.96 |
| MS10-215 | 215 | 10YR 4/2 | 2.05 | 3.32 | 2.90 | 1.70 | 1.87 | 0.74 | 0.77 | 0.97 | 2.41 | 80.76 | 16.89 | 2.35 |
| MS10-220 | 220 | 10YR 4/2 | 2.02 | 3.43 | 2.96 | 1.85 | 1.95 | 0.76 | 0.78 | 0.82 | 2.42 | 80.19 | 17.49 | 2.32 |
| MS10-225 | 225 | 10YR 4/2 | 2.04 | 2.78 | 2.53 | 1.17 | 1.59 | 0.63 | 0.71 | 1.85 | 2.60 | 82.89 | 14.85 | 2.26 |
| MS10-230 | 230 | 10YR 4/2 | 2.11 | 3.90 | 3.30 | 2.26 | 2.18 | 0.79 | 0.79 | 0.53 | 1.39 | 74.46 | 22.85 | 2.69 |

continued.

**Table A-1.** (concluded)

| Profile | Depth | Color (D) | median (Md) | mean (Mphi) | graphic mean (Mz) | std. dev. | incl. std. dev. | skewness | incl. skewness | incl. kurtosis (sd) | incl. kurtosis (75-25) | % sand | % silt | % clay |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MS10-235 | 235 | 10YR 4/2 | 2.04 | 3.75 | 3.18 | 2.17 | 2.12 | 0.79 | 0.79 | 0.57 | 1.90 | 76.50 | 21.00 | 2.50 |
| MS10-240 | 240 | 10YR 4/2 | 3.02 | 4.69 | 4.13 | 2.96 | 2.63 | 0.56 | 0.57 | 0.29 | 0.63 | 52.86 | 41.66 | 5.48 |
| MS10-245 | 245 | 7.5YR 5/3 | 5.77 | 4.71 | 5.06 | 2.95 | 2.61 | -0.36 | -0.24 | 0.27 | 0.61 | 36.36 | 58.34 | 5.30 |
| MS10-245 | 250 | 7.5YR 6/4 | 2.74 | 4.41 | 3.85 | 2.71 | 2.45 | 0.61 | 0.64 | 0.33 | 0.65 | 51.72 | 44.32 | 3.96 |
| MS10-250 | 255 | 7.5YR 5/2 | 6.33 | 5.13 | 5.53 | 2.86 | 2.57 | -0.42 | -0.32 | 0.31 | 1.09 | 22.61 | 70.61 | 6.78 |
| MS10-260 | 260 | 7.5YR 5/4 | 2.67 | 4.81 | 4.10 | 3.18 | 2.78 | 0.68 | 0.67 | 0.24 | 0.59 | 54.41 | 38.64 | 6.95 |
| MS10-265 | 265 | 7.5YR 6/4 | 2.58 | 4.48 | 3.85 | 2.82 | 2.53 | 0.67 | 0.67 | 0.31 | 0.63 | 55.77 | 40.13 | 4.10 |
| MS10-270 | 270 | 7.5YR 6/4 | 5.82 | 4.71 | 5.08 | 2.96 | 2.61 | -0.38 | -0.26 | 0.26 | 0.60 | 38.65 | 56.14 | 5.21 |
| MS10-275 | 275 | 7.5YR 6/6 | 2.03 | 3.70 | 3.14 | 2.11 | 2.18 | 0.79 | 0.80 | 0.76 | 2.56 | 78.12 | 17.72 | 4.16 |
| MS10-280 | 280 | 7.5YR6/4 | 2.12 | 4.52 | 3.72 | 2.89 | 2.61 | 0.83 | 0.82 | 0.32 | 1.08 | 72.29 | 22.38 | 5.33 |
| MS10-285 | 285 | 10YR 7/3 | 2.10 | 2.46 | 2.34 | 0.74 | 1.26 | 0.49 | 0.64 | 2.97 | 2.94 | 88.50 | 9.87 | 1.63 |
| MS10-290 | 290 | 10YR 7/4 | 2.11 | 2.47 | 2.35 | 0.75 | 1.21 | 0.49 | 0.64 | 2.70 | 2.69 | 87.93 | 10.80 | 1.27 |
| MS10-295 | 295 | 10YR 7/4 | 1.96 | 2.16 | 2.09 | 0.48 | 0.96 | 0.42 | 0.60 | 3.99 | 4.64 | 90.72 | 8.50 | 0.78 |
| MS10-300 | 300 | 10YR 7/4 | 2.00 | 2.28 | 2.18 | 0.55 | 0.95 | 0.51 | 0.65 | 3.08 | 3.77 | 90.82 | 8.30 | 0.88 |
| MS10-305 | 305 | 10YR 8/4 | 2.10 | 2.49 | 2.36 | 0.78 | 1.22 | 0.51 | 0.64 | 2.54 | 2.69 | 87.00 | 11.81 | 1.19 |
| MS10-310 | 310 | 10YR 7/4 | 2.00 | 2.31 | 2.21 | 0.59 | 1.06 | 0.53 | 0.67 | 3.27 | 4.02 | 89.47 | 9.52 | 1.01 |
| MS10-315 | 315 | 10YR 8/4.5 | 1.99 | 2.22 | 2.14 | 0.50 | 0.81 | 0.46 | 0.60 | 2.67 | 3.29 | 91.56 | 7.64 | 0.80 |
| MS10-320 | 320 | 10YR 8/4.5 | 1.87 | 1.95 | 1.92 | 0.44 | 0.63 | 0.17 | 0.37 | 2.01 | 2.07 | 93.51 | 5.99 | 0.50 |

is digested in a Teflon dish with 5 mls 12M $HNO_3$, 5 mls 28M HF and 3 mls 12M $HCLO_4$. Heat until dry, cool, add 5 mls 12M HCL, 10 mls $H_2O$ and heat to dissolve salts. Transfer into a 15 ml test tube and dilute to 15 mls with distilled $H_2O$. Transfer 5 mls of the solution into test tube for ICPMS analysis and retain remaining solution for analysis by ICP-ES. ICP-ES—samples are analyzed on ARL 3560 or Optima (3000 or 4300). The calibration stds. are made up of a blank, a 5 ppm std., a 50 ppm std., Fe at 1000 ppm and Ag at 1 ppm. Drift check solution is also used to monitor drift. ICP-MS—samples are analyzed on either a PQ2, PQ3 or Elan6100. Calibration stds are made up of a blank, 10 and 50 ppb stds. Re and Rh are used as internal standards" (XRAL n.d.). The results of these analyses are presented in Table A-2.

Another split was sent to the Stable Isotope/Soil Biology Laboratory, Institute of Ecology, University of Georgia, for the determination of stable carbon isotopic composition of soil organic matter, as well as total organic carbon. The methods employed by this laboratory are not described in detail here but can be obtained on the following website: (http://www. uga. edu/~sisbl/ratio.html#intro).

### *OSL Dating*

To derive an optically stimulated luminescence (OSL) age, both the palaeodose (ED or De—the amount of absorbed dose since the sample was buried) and the dose rate (the estimated radiation flux for the sedimentary bodies) have to be determined. A detailed explanation of both these parameters is given by Aitken (1998). To calculate an age, the palaeodose (expressed in Grays) is divided by the annual dose rate (Grays/yr.). An inherent assumption in these age calculations is that the sediment was fully reset, or "bleached," by exposure to sunlight during the last transport event or whilst *in situ* prior to burial. As part of this investigation, efforts have been made to establish if these sediments have been bleached.

The samples collected by the authors in April 2001 (Tables A-3 and A-4) are assumed not to have been exposed to sunlight during sampling or transportation to the laboratory. Upon arrival, each sample was allocated a Sheffield laboratory number.

#### *Dose Rate Analysis*

Naturally-occurring potassium (K), thorium (Th), and uranium (U) are the main contributors of dose to sedimentary quartz. The concentrations of these elements were determined in the field using an EG & G micronomad portable gamma spectrometer. Conversion from elemental concentrations to effective dose rates made use of the coefficients given by Aitken (1998), incorporating attenuation factors relating to sediment grain sizes used, density, and a palaeomoisture value based on those measured at present. The contributions to dose rates from cosmic sources were calculated using the expression published in Prescott and Hutton (1994).

The dose rates calculated are based on analyses of the sediments at the present day. This assumption is only valid if no movement and/or reprecipitation of the three key elements has taken place since sediment burial and the sources of ionizing radiation are in equilibrium. Analysis carried out by Dr. James Feathers at the University of Washington as part of thermoluminescence dating of burned-clay nodules (see below) suggested this may not be the case for the clay nodules. Ten splits of the OSL samples were submitted to Dr. Edward McGee of the Environmental Radiation Research Laboratory, University College Dublin (Eire), for high-resolution gamma spectrometry. Unfortunately, the samples were only just above the detection limits, although the data yielded no evidence to suggest that the samples are not in secular equilibrium.

#### *Palaeodose Determination*

The samples were prepared under subdued red lighting following the procedure to extract and clean quartz outlined in Bateman and Catt (1996). Prepared aliquots of the samples were taken from a size range within 90-250 $\mu$m limits, with the exact size fraction used depending on the dominant grain size within each sample. The purity of the quartz extract was checked using infra-red stimulated luminescence and no feldspar contamination was seen. All OSL measurements were carried out using an upgraded DA-12 Risø luminescence reader fitted with a 150-W filtered (GG-420) halogen lamp. Samples were dosed using a calibrated $^{90}Sr$ beta source. Samples were analyzed using the Single Aliquot Regenerative (SAR) approach (Murray and Wintle 2000), in which an interpolative growth curve is constructed using data derived from repeated measurements of a single aliquot that had been given various laboratory irradiations. A five-point SAR protocol was used, with three of the points to bracket the naturally acquired OSL value, a fourth point (a zero dose), was to correct for recuperation, while the fifth point was to repeat the first dose point. Sensitivity changes induced by the repeated measurement of the same aliquot were made using the OSL response to a

**Table A-2 .** Element concentration for Profile MS 1, Knoll Top Block Excavation, Buckeye Knoll.

| Sample Identification | Ti | Zr | P | Pb | Ca | Mg | Cu | Mn | Al | Zn | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Analysis Unit | % | ppm | % | ppm | % | % | ppm | ppm | % | ppm | ppm |
| Detection Limit | 0.01 | 0.5 | 0.01 | 2 | 0.01 | 0.01 | 0.5 | 2 | 0.01 | 0.5 | 0.5 |
| MS1-1 | 0.12 | 51.5 | 0.14 | 8 | 0.89 | 0.13 | 33.6 | 280 | 1.48 | 35.4 | 53 |
| MS1-2 | 0.1 | 36.2 | 0.14 | 9 | 1.08 | 0.13 | 20.3 | 175 | 1.45 | 33.7 | 63.7 |
| MS1-3 | 0.1 | 42.9 | 0.13 | 7 | 0.54 | 0.11 | 28.5 | 229 | 1.37 | 28.2 | 44.2 |
| MS1-4 | 0.1 | 34.4 | 0.13 | 8 | 0.64 | 0.11 | 17.7 | 173 | 1.47 | 29.2 | 51.1 |
| MS1-5 | 0.1 | 42.9 | 0.11 | 8 | 0.46 | 0.11 | 26.3 | 224 | 1.41 | 28.4 | 42.3 |
| MS1-6 | 0.08 | 28.2 | 0.07 | 7 | 0.37 | 0.1 | 14.5 | 142 | 1.29 | 24.1 | 37.9 |
| MS1-7 | 0.1 | 41.7 | 0.13 | 7 | 0.48 | 0.11 | 23.2 | 212 | 1.35 | 26.1 | 42.3 |
| MS1-8 | 0.09 | 26.8 | 0.09 | 9 | 0.42 | 0.12 | 13.3 | 125 | 1.49 | 26.9 | 41.5 |
| MS1-9 | 0.1 | 36.3 | 0.3 | 7 | 0.89 | 0.12 | 19.8 | 174 | 1.47 | 28.3 | 46.7 |
| MS1-10 | 0.1 | 33.1 | 0.15 | 7 | 0.56 | 0.13 | 11.6 | 123 | 1.6 | 39.4 | 45.9 |
| MS1-11 | 0.12 | 39.5 | 0.15 | 7 | 0.58 | 0.14 | 21 | 176 | 1.67 | 27.8 | 48.2 |
| MS1-12 | 0.11 | 32.4 | 0.17 | 7 | 0.58 | 0.12 | 13.2 | 125 | 1.5 | 29.2 | 45.2 |
| MS1-13 | 0.1 | 35.1 | 0.18 | 7 | 0.6 | 0.12 | 21.1 | 190 | 1.4 | 30.9 | 47.1 |
| MS1-14 | 0.09 | 29.7 | 0.19 | 6 | 0.63 | 0.11 | 12.5 | 129 | 1.38 | 28.8 | 45.3 |
| MS1-15 | 0.1 | 31.7 | 0.23 | 6 | 0.78 | 0.11 | 22.9 | 208 | 1.3 | 31.7 | 47.7 |
| MS1-16 | 0.09 | 29.2 | 0.22 | 6 | 0.72 | 0.11 | 17 | 161 | 1.35 | 31.7 | 49.9 |
| MS1-17 | 0.09 | 31.3 | 0.23 | 6 | 0.75 | 0.11 | 23 | 211 | 1.29 | 31.1 | 49.9 |
| MS1-18 | 0.09 | 30.3 | 0.29 | 6 | 0.92 | 0.11 | 15.8 | 172 | 1.26 | 32.8 | 53.5 |
| MS1-19 | 0.1 | 30.6 | 0.24 | 6 | 0.77 | 0.11 | 24.9 | 221 | 1.31 | 30.5 | 48.7 |
| MS1-20 | 0.09 | 25.7 | 0.27 | 7 | 0.9 | 0.11 | 16.1 | 168 | 1.31 | 31.3 | 55.2 |
| MS1-21 | 0.09 | 31 | 0.34 | 6 | 1.02 | 0.1 | 21.3 | 202 | 1.16 | 29.3 | 54.8 |
| MS1-22 | 0.09 | 23.9 | 0.29 | 6 | 0.93 | 0.1 | 15.9 | 162 | 1.21 | 28.7 | 53.7 |
| MS1-23 | 0.09 | 29.9 | 0.24 | 5 | 0.76 | 0.1 | 18.6 | 160 | 1.24 | 25.8 | 48.1 |
| MS1-24 | 0.09 | 26.9 | 0.23 | 7 | 0.75 | 0.11 | 14.6 | 136 | 1.25 | 30 | 51.1 |
| MS1-25 | 0.1 | 35.7 | 0.22 | 6 | 0.72 | 0.11 | 21.9 | 173 | 1.37 | 27 | 49.1 |
| MS1-26 | 0.1 | 27.4 | 0.25 | 8 | 0.77 | 0.11 | 16.5 | 124 | 1.35 | 26.5 | 50.3 |
| MS1-27 | 0.1 | 33.2 | 0.25 | 6 | 0.77 | 0.11 | 21 | 164 | 1.32 | 25.8 | 49.6 |
| MS1-28 | 0.08 | 25.3 | 0.27 | 6 | 0.78 | 0.1 | 13.8 | 106 | 1.14 | 22.2 | 45.7 |
| MS1-29 | 0.1 | 30.9 | 0.26 | 7 | 0.78 | 0.11 | 20.5 | 168 | 1.36 | 28.8 | 50.5 |
| MS1-30 | 0.09 | 26.7 | 0.24 | 7 | 0.73 | 0.1 | 12.7 | 108 | 1.28 | 24.2 | 50.3 |
| MS1-31 | 0.09 | 26.8 | 0.24 | 6 | 0.76 | 0.09 | 19.6 | 142 | 1.2 | 21.9 | 48.5 |
| MS1-32 | 0.1 | 27.9 | 0.27 | 6 | 0.81 | 0.09 | 13.5 | 97 | 1.23 | 21.3 | 51.8 |
| MS1-33 | 0.09 | 32.1 | 0.25 | 5 | 0.74 | 0.08 | 19.9 | 140 | 1.19 | 19.7 | 47.5 |
| MS1-34 | 0.08 | 27.1 | 0.21 | 6 | 0.68 | 0.08 | 11.5 | 94 | 1.12 | 19 | 45.8 |
| MS1-35 | 0.09 | 26.5 | 0.23 | 6 | 0.74 | 0.08 | 17.9 | 141 | 1.14 | 19.3 | 51.5 |
| MS1-36 | 0.1 | 33 | 0.2 | 6 | 0.63 | 0.07 | 15.2 | 123 | 1.12 | 15.1 | 47.2 |
| MS1-37 | 0.1 | 33.7 | 0.24 | 6 | 0.69 | 0.07 | 18.1 | 142 | 1.18 | 16.8 | 47.4 |
| MS1-38 | 0.1 | 33.1 | 0.23 | 6 | 0.66 | 0.07 | 12.3 | 120 | 1.13 | 14.4 | 46.2 |
| MS4-1 | 0.1 | 37.3 | 0.12 | 7 | 0.44 | 0.09 | 19.2 | 159 | 1.27 | 21.6 | 42.5 |
| MS4-2 | 0.1 | 34.5 | 0.13 | 7 | 0.48 | 0.1 | 15.3 | 160 | 1.32 | 22.2 | 43.9 |
| MS4-3 | 0.09 | 28.5 | 0.15 | 6 | 0.51 | 0.1 | 17 | 150 | 1.28 | 24.2 | 43.4 |
| MS4-4 | 0.1 | 33.8 | 0.18 | 6 | 0.6 | 0.1 | 15.7 | 154 | 1.34 | 25 | 46.5 |
| MS4-5 | 0.08 | 27.7 | 0.23 | 6 | 0.78 | 0.09 | 16.5 | 159 | 1.23 | 25.9 | 47.3 |
| MS4-6 | 0.08 | 28.8 | 0.27 | 6 | 0.85 | 0.09 | 16.1 | 151 | 1.29 | 26.2 | 50.2 |
| MS4-7 | 0.08 | 32.5 | 0.17 | 6 | 0.62 | 0.09 | 15.8 | 148 | 1.26 | 24.8 | 46.2 |
| MS4-8 | 0.09 | 26.9 | 0.16 | 6 | 0.64 | 0.09 | 16 | 151 | 1.23 | 23.7 | 47.2 |

continued.

**Table A-2.** (concluded)

| Sample Identification | Ti | Zr | P | Pb | Ca | Mg | Cu | Mn | Al | Zn | Sr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Analysis Unit | % | ppm | % | ppm | % | % | ppm | ppm | % | ppm | ppm |
| Detection Limit | 0.01 | 0.5 | 0.01 | 2 | 0.01 | 0.01 | 0.5 | 2 | 0.01 | 0.5 | 0.5 |
| MS4-9 | 0.09 | 33.2 | 0.13 | 6 | 0.52 | 0.09 | 16.1 | 153 | 1.21 | 22.7 | 42.1 |
| MS4-10 | 0.08 | 32 | 0.13 | 6 | 0.49 | 0.08 | 16.3 | 140 | 1.18 | 21.5 | 41.9 |
| MS4-11 | 0.08 | 30.6 | 0.16 | 6 | 0.54 | 0.08 | 15.1 | 126 | 1.16 | 21.9 | 41.5 |
| MS4-12 | 0.08 | 29.5 | 0.14 | 6 | 0.49 | 0.09 | 13.6 | 128 | 1.21 | 21.3 | 42.9 |
| MS4-13 | 0.09 | 33.3 | 0.16 | 6 | 0.53 | 0.08 | 15.4 | 130 | 1.15 | 23 | 43.7 |
| MS4-14 | 0.09 | 33.2 | 0.18 | 6 | 0.61 | 0.09 | 17.9 | 157 | 1.21 | 28.1 | 45.2 |
| MS4-15 | 0.09 | 33.4 | 0.18 | 6 | 0.6 | 0.09 | 15.6 | 153 | 1.19 | 28 | 44.5 |
| MS4-16 | 0.09 | 30.6 | 0.18 | 6 | 0.58 | 0.09 | 15.2 | 141 | 1.21 | 24.1 | 43.7 |
| MS4-17 | 0.08 | 32.4 | 0.17 | 6 | 0.59 | 0.09 | 13.7 | 130 | 1.18 | 23.2 | 44.4 |
| MS4-18 | 0.09 | 30.6 | 0.16 | 6 | 0.57 | 0.09 | 14.7 | 136 | 1.26 | 23.7 | 45.6 |
| MS4-19 | 0.09 | 31.9 | 0.19 | 6 | 0.65 | 0.09 | 14.6 | 140 | 1.26 | 23.6 | 45.7 |
| MS4-20 | 0.09 | 34.8 | 0.17 | 6 | 0.61 | 0.09 | 18.3 | 141 | 1.2 | 23 | 44.1 |
| MS4-21 | 0.09 | 32.6 | 0.25 | 6 | 0.92 | 0.1 | 15.5 | 148 | 1.29 | 26.5 | 54.2 |
| MS4-22 | 0.09 | 30.3 | 0.27 | 6 | 1.14 | 0.1 | 15.1 | 135 | 1.23 | 22.9 | 58.2 |
| MS4-23 | 0.09 | 26.1 | 0.26 | 6 | 1.13 | 0.1 | 16.3 | 135 | 1.26 | 22.3 | 58.3 |
| MS4-24 | 0.11 | 36.1 | 0.25 | 6 | 1.15 | 0.1 | 14.1 | 133 | 1.29 | 27.7 | 58.4 |
| MS4-25 | 0.1 | 36.2 | 0.19 | 6 | 0.9 | 0.1 | 13.8 | 120 | 1.27 | 24.4 | 52.2 |
| MS4-26 | 0.1 | 34.3 | 0.22 | 6 | 0.92 | 0.1 | 13.3 | 128 | 1.26 | 23.2 | 54 |
| MS4-27 | 0.09 | 31.6 | 0.18 | 6 | 0.87 | 0.09 | 14.4 | 134 | 1.18 | 21.4 | 51.4 |
| MS4-28 | 0.09 | 33 | 0.18 | 6 | 0.87 | 0.09 | 15.2 | 136 | 1.2 | 21 | 51.4 |
| MS4-29 | 0.08 | 29.7 | 0.18 | 6 | 0.85 | 0.09 | 13.6 | 125 | 1.21 | 20.3 | 52.1 |
| MS4-31-68 | 0.09 | 30.9 | 0.21 | 6 | 1.06 | 0.1 | 15.6 | 127 | 1.29 | 21.1 | 56.9 |
| MS4-31-69 | 0.08 | 26.6 | 0.18 | 6 | 0.83 | 0.08 | 12.4 | 103 | 1.14 | 19.3 | 48.5 |
| MS4-33-70 | 0.09 | 31.4 | 0.16 | 6 | 0.81 | 0.09 | 12.1 | 125 | 1.22 | 21.4 | 50.1 |
| MS4-33-71 | 0.08 | 29.6 | 0.14 | 6 | 0.75 | 0.08 | 13.3 | 118 | 1.16 | 20.3 | 46.2 |
| MS4-34 | 0.09 | 31.8 | 0.16 | 6 | 0.91 | 0.08 | 13.7 | 128 | 1.21 | 21.1 | 52.1 |
| MS4-35 | 0.09 | 27.9 | 0.18 | 6 | 1.02 | 0.08 | 12.7 | 130 | 1.15 | 20 | 51.9 |
| MS4-36 | 0.1 | 31.1 | 0.13 | 6 | 0.88 | 0.08 | 12.6 | 121 | 1.21 | 17.9 | 50.4 |
| MS4-37 | 0.09 | 29.9 | 0.09 | 6 | 0.67 | 0.07 | 12.9 | 118 | 1.15 | 15.2 | 45.6 |
| MS4-38 | 0.08 | 27.8 | 0.09 | 6 | 1 | 0.07 | 11.7 | 110 | 1.13 | 15.6 | 49.4 |
| MS4-39 | 0.09 | 29 | 0.07 | 6 | 0.76 | 0.07 | 12.6 | 114 | 1.15 | 14.2 | 46.3 |
| MS4-40 | 0.08 | 26.3 | 0.11 | 5 | 0.96 | 0.08 | 11.8 | 109 | 1.15 | 15.6 | 48.9 |
| MS4-41 | 0.08 | 28.3 | 0.1 | 5 | 1.39 | 0.08 | 11.8 | 105 | 1.13 | 28.5 | 54.1 |
| MS4-42 | 0.09 | 27.7 | 0.11 | 5 | 2.36 | 0.09 | 10.9 | 98 | 1.15 | 14.3 | 64.8 |
| MS4-43 | 0.09 | 29.4 | 0.1 | 5 | 1.72 | 0.09 | 11.9 | 96 | 1.17 | 14.2 | 60.1 |
| MS4-44 | 0.1 | 31.1 | 0.14 | 6 | 2.08 | 0.1 | 10.7 | 97 | 1.34 | 15.9 | 69.1 |
| MS4-46-83 | 0.09 | 33.3 | 0.13 | 6 | 1.42 | 0.09 | 13.5 | 103 | 1.27 | 18.8 | 56.3 |
| MS4-46-84 | 0.09 | 32.1 | 0.16 | 6 | 1.72 | 0.09 | 11.8 | 101 | 1.35 | 15.8 | 62.5 |
| MS4-47 | 0.1 | 31.5 | 0.14 | 6 | 1.5 | 0.11 | 12.4 | 103 | 1.4 | 18.6 | 59.5 |
| MS4-48 | 0.11 | 40.1 | 0.24 | 7 | 1.55 | 0.17 | 9.9 | 96 | 2 | 22.2 | 63 |
| MS4-49 | 0.1 | 36 | 0.24 | 6 | 1.06 | 0.15 | 11.6 | 79 | 1.81 | 19.9 | 58.5 |
| MS4-50 | 0.29 | 88.6 | 0.19 | 12 | 1 | 0.66 | 12.7 | 329 | 5.83 | 63.5 | 88.4 |
| MS4-51 | 0.26 | 75.6 | 0.13 | 11 | 0.87 | 0.54 | 11.5 | 316 | 5.2 | 52.7 | 74.3 |

**Table A-3.** Summary of OSL Results: Radioactivity and Dosimetry Data.

| Sample | Radioactivity Data | | | Dosimetry Data | | | Moisture (%) |
|---|---|---|---|---|---|---|---|
| | U (PPM) | Th (PPM) | K (%) | $D_{\alpha+\beta}$ ($\mu$Gy/a$^{-1}$) | $D_{\gamma}$ ($\mu$Gy/a$^{-1}$) | $D_{cosmic}$ + ($\mu$Gy/a$^{-1}$) | |
| Shfd01013 | 1.28 | 3.45 | 0.67 | 609 ± 78 | 418 ± 34 | 145 ± 7 | 12.7 |
| Shfd01014 | 0.87 | 2.21 | 0.58 | 537 ± 78 | 332 ± 32 | 150 ± 8 | 5.7 |
| Shfd01015 | 0.95 | 2.76 | 0.66 | 603 ± 84 | 381 ± 35 | 155 ± 8 | 6.6 |
| Shfd01016 | 0.93 | 3.02 | 0.70 | 658 ± 108 | 415 ± 51 | 159 ± 8 | 3.7 |
| Shfd01017 | 0.94 | 3.08 | 0.74 | 685 ± 94 | 426 ± 37 | 164 ± 8 | 4.1 |
| Shfd01018 | 0.87 | 3.04 | 0.74 | 681 ± 94 | 419 ± 37 | 166 ± 8 | 3.6 |
| Shfd01019 | 0.72 | 3.15 | 0.73 | 664 ± 95 | 408 ± 37 | 171 ± 9 | 3.0 |
| Shfd01020 | 0.95 | 3.04 | 0.71 | 675 ± 95 | 424 ± 38 | 178 ± 9 | 2.8 |
| Shfd01021 | 1.00 | 2.84 | 0.67 | 651 ± 89 | 405 ± 36 | 165 ± 8 | 2.6 |
| Shfd01022 | 0.96 | 2.95 | 0.69 | 657 ± 88 | 414 ± 37 | 172 ± 9 | 3.3 |
| Shfd01023 | 0.76 | 3.35 | 0.69 | 652 ± 89 | 418 ± 36 | 181 ± 9 | 2.1 |
| Shfd01024 | 0.88 | 3.05 | 0.68 | 642 ± 88 | 408 ± 36 | 158 ± 8 | 3.3 |
| Shfd01025 | 0.95 | 2.92 | 0.72 | 673 ± 94 | 416 ± 37 | 166 ± 8 | 3.6 |
| Shfd01026 | 1.09 | 2.78 | 0.69 | 669 ± 88 | 420 ± 37 | 173 ± 9 | 3.1 |
| Shfd01027 | 0.96 | 3.17 | 0.74 | 698 ± 95 | 437 ± 38 | 178 ± 9 | 3.2 |
| Shfd01028 | 1.03 | 3.24 | 0.73 | 702 ± 95 | 447 ± 39 | 183 ± 9 | 3.0 |
| Shfd01029 | 1.11 | 4.33 | 0.74 | 720 ± 93 | 500 ± 39 | 156 ± 8 | 5.1 |
| Shfd01030 | 1.01 | 3.09 | 0.74 | 697 ± 94 | 436 ± 38 | 169 ± 8 | 3.7 |
| Shfd01031 | 1.01 | 3.57 | 0.77 | 714 ± 93 | 458 ± 38 | 181 ± 9 | 5.2 |
| Shfd01032 | 1.54 | 6.93 | 0.98 | 904 ± 100 | 672 ± 44 | 166 ± 8 | 11.6 |
| Shfd01033 | 0.89 | 2.69 | 0.63 | 593 ± 86 | 374 ± 35 | 173 ± 9 | 4.4 |
| Shfd01034 | 0.94 | 3.26 | 0.74 | 690 ± 94 | 435 ± 37 | 130 ± 6 | 4.0 |
| Shfd01035 | 0.94 | 3.60 | 0.80 | 715 ± 91 | 452 ± 37 | 140 ± 7 | 6.6 |
| Shfd01036 | 0.96 | 3.49 | 0.77 | 709 ± 93 | 450 ± 38 | 165 ± 8 | 5.0 |
| Shfd01037 | 1.02 | 2.93 | 0.75 | 682 ± 92 | 420 ± 37 | 174 ± 9 | 5.8 |
| Shfd01038 | 0.89 | 2.17 | 0.66 | 621 ± 88 | 364 ± 35 | 140 ± 7 | 3.0 |
| Shfd01039 | 0.94 | 1.83 | 0.68 | 623 ± 87 | 352 ± 34 | 157 ± 8 | 3.5 |
| Shfd01040 | 0.92 | 1.81 | 0.67 | 596 ± 88 | 312 ± 33 | 173 ± 9 | 2.4 |
| Shfd01041 | 1.13 | 4.09 | 0.77 | 734 ± 93 | 494 ± 39 | 147 ± 7 | 5.6 |
| Shfd01042 | 0.90 | 4.68 | 0.83 | 763 ± 99 | 513 ± 40 | 147 ± 7 | 5.4 |

**Table A-4.** Summary of OSL Results: Paleodose and Age Data.

| **Depth** (cm) | **Lab Code** | **Field Ref.** | **Dose Rate** ($\mu$Gy/a$^{-1}$) | **Sample Type** | **Palaeodose** (Gy) | **Age** (ka) |
|---|---|---|---|---|---|---|
| 220 | Shfd01013 | MS6, S32 W116.1 | 1171 ± 110 | II | 58.42 ± 2.97 | 49.9 ± 5.3 |
| 195 | Shfd01014 | " | 1018 ± 108 | III | 50.50 ± 3.27 | 49.59 ± 6.16 |
| 170 | Shfd01015 | " | 1141 ± 117 | III | 6.85 ± .020 | 6.01 ± 0.64 |
| 150 | Shfd01016 | MS4, S29.26 W114 | 1232 ± 158 | I | 5.60 ± 0.10 | 4.55 ± 0.59 |
| 130 | Shfd01017 | " | 1276 ± 129 | II | 33.79 ± 1.55 | 26.5 ± 2.90 |
| 120 | Shfd01018 | " | 1265 ± 130 | III | 4.57 ± 1.55 | 3.61 ± 0.38 |
| 100 | Shfd01019 | " | 1244 ± 130 | I | 4.59 ± 0.12 | 3.69 ± 0.40 |
| 70 | Shfd01020 | " | 1278 ± 132 | I | 3.07 ± 0.07 | 2.40 ± 0.25 |
| 125 | Shfd01021 | MS7, S30 W118 | 1228 ± 123 | I | 5.57 ± 0.12 | 4.54 ± 0.46 |
| 95 | Shfd01022 | " | 1243 ± 122 | I | 4.48 ± 0.08 | 3.62 ± 0.36 |
| 55 | Shfd01023 | " | 1251 ± 123 | I | 3.47 ± 0.08 | 2.77 ± 0.28 |
| 155 | Shfd01024 | MS1, knoll top | 1208 ± 121 | III | 9.15 ± 0.28 | 7.57 ± 0.79 |
| 120 | Shfd01025 | " | 1256 ± 130 | I | 5.01 ± 0.20 | 3.99 ± 0.44 |
| 90 | Shfd01026 | " | 1263 ± 123 | I | 2.16 ± 0.08 | 1.71 ± 0.18 |
| 70 | Shfd01027 | " | 1312 ± 131 | III | 1.59 ± 0.06 | 1.21 ± 0.13 |
| 50 | Shfd01028 | " | 1332 ± 132 | III | 2.74 ± 0.17 | 2.05 ± 0.24 |
| 165 | Shfd01029 | MS2, S12 W88 | 1377 ± 130 | I | 8.32 ± 0.28 | 6.05 ± 0.61 |
| 105 | Shfd01030 | " | 1301 ± 130 | III | 4.91 ± 0.24 | 3.78 ± 0.42 |
| 55 | Shfd01031 | " | 1353 ± 129 | I | 2.48 ± 0.13 | 1.83 ± 0.20 |
| 90 | Shfd01032 | MS9, BHT-G1 | 1743 ± 141 | I | 43.94 ± 0.84 | 25.2 ± 2.1 |
| 120 | Shfd01033 | " | 1140 ± 119 | II | 58.01 ± 2.87 | 50.9 ± 5.9 |
| 305 | Shfd01034 | MS10, BHT-G2 | 1255 ± 129 | II | 64.44 ± 3.38 | 51.3 ± 5.9 |
| 245 | Shfd01035 | " | 1306 ± 126 | I | 7.48 ± 0.21 | 5.73 ± 0.57 |
| 125 | Shfd01036 | " | 1324 ± 129 | III | 2.77 ± 0.26 | 2.10 ± 0.28 |
| 85 | Shfd01037 | " | 1277 ± 127 | III | 2.64 ± 0.16 | 2.06 ± 0.24 |
| 250 | Shfd01038 | MS11, N52.3 E14.7 | 1124 ± 121 | I | 59.02 ± 2.61 | 52.5± 6.10 |
| 160 | Shfd01039 | " | 1132 ± 120 | III | 8.26 ± 0.19 | 7.29 ± 0.79 |
| 90 | Shfd01040 | " | 1081 ± 117 | III | 4.49 ± 0.13 | 5.89 ± 0.12 |
| 210 | Shfd01041 | S4 W83 | 1375 ± 129 | III | 6.37 ± 0.22 | 4.63 ± 0.46 |
| 210 | Shfd01042 | " | 1242 ± 137 | III | 21.21 ± 0.67 | 14.9 ± 1.5 |

test dose applied throughout the SAR protocol. Only aliquots in which the corrected OSL signal for the first and last regeneration dose points was ±10 percent of unity (recycling value) were used in the final age calculations. A preheat of 200° C for 10 seconds prior to OSL measurement was used to remove unstable signal generated by laboratory irradiations. This preheat was derived experimentally from a range of preheat temperatures as it showed the most consistency and best recycling ratios. Between 11 and 36 replicate measurements were made per sample to give an indication of the reproducibility of the palaeodose measurements and to attempt to assess sample bleaching behaviour (see below)

### *Effects of Poor OSL Resetting and Pedoturbation*

OSL dating assumes that the palaeodose absorbed by a sample reflects the time elapsed since it was last exposed to sunlight and the OSL signal was reset. This process of resetting in sunlight (bleaching) is very rapid for the OSL component in quartz (in the order of seconds). However, some depositional contexts (e.g., during mass movement or alleviation) may preclude even this modest sunlight exposure to all the grains in a sediment. The effects of this incomplete bleaching of the sediment can be profound. Typically, poorly bleached sediments retain a significant level of residual signal from previous phases of sedimentary cycling, leading to inherent inaccuracies in the calculation of a palaeodose value. It has been suggested that histogram plots of palaeodose for partially bleached samples should show a considerable high-dose tail reflecting this partially bleached signal (Olley et al. 1999).

Likewise, post-depositional mixing due to bioturbation can also cause difficulties for accurately ascertaining an OSL age. Exhumation of material from ancient sediment may cause resetting of the OSL signal leading to an apparently young age for the sediment. Alternatively, the burrowing action of some animals can cause subsurface mixing of sediment. This post-depositional mixing may lead to the incorporation of sediment from both younger and older horizons into a given horizon. Thus, the danger is that the calculated OSL age will reflect not just the burial age but also the degree of bioturbation and what has been bioturbated. If sedimentation is rapid and OSL sampling detailed, then the effects of bioturbation (which predominantly affects the uppermost meter of sediment) may be reflected in OSL age reversals down profile. However, situations in which sedimentation has been slower than post-depositional mixing (assuming a constant amount of bioturbation through time) may lead to OSL ages that increase with depth but reflect both burial age and degree of sediment mixing. In principle, mixing should cause a decrease in the reproducibility of the palaeodose measured from replicates. However, recent work by Bateman et al. (2002) has shown that much of the OSL heterogeneity of bioturbated samples is masked by the analysis of multiple grains (typically there are 4,000 grains on an aliquot). Only when measuring at the single-grain level can the full range of mixing be established. Results from this work also showed that, as bioturbation can move sediment down as well as up profile, when replicate palaeodoses are plotted as histograms it is possible to have both positively and negatively skewed distributions.

It is difficult to establish with any certainty from OSL data whether partial bleaching and/or bioturbation have affected a sample. For the samples analyzed for the purposes of this report, the reproducibility of the OSL data from each of the samples was examined and the samples' location within the site stratigraphy and the possible event being dated were taken into consideration. As part of this, the replicate data for each sample was plotted as a probability density plot.

The distribution of the palaeodoses from individual samples from this site can be categorized into three types—Type I is normally distributed with high reproducibility, Type II is normally distributed but with a lower reproducibility, and Type III has skewed distributions (both positive and negative) or is polymodal. The probability plots for examples of each of these categories can be seen in Figure A-2. Table A-4 shows the category into which each sample is thought to fall.

Samples that fall into Type I category have De values that are highly reproducible and consequently have a highly peaked probability curve that is normally distributed around the mean. Such samples are assumed to have been well bleached upon burial and unaffected by post-depositional disturbance.

Samples in the Type II category primarily are from the Deweyville Formation (e.g., Shfd01013, Shfd01033, Shfd01034, and Shfd01038). Whilst the mean De's are reasonably consistent between samples and broadly normally distributed, the associated error is high, thus reflecting the low reproducibility between aliquots. These samples may have been partially bleached on deposition and/or undergone post-depositional mixing. However, the lack of a clear higher De tail, typical of partially bleached fluvial samples (Olley et al. 1999), prevents the identification and ex-

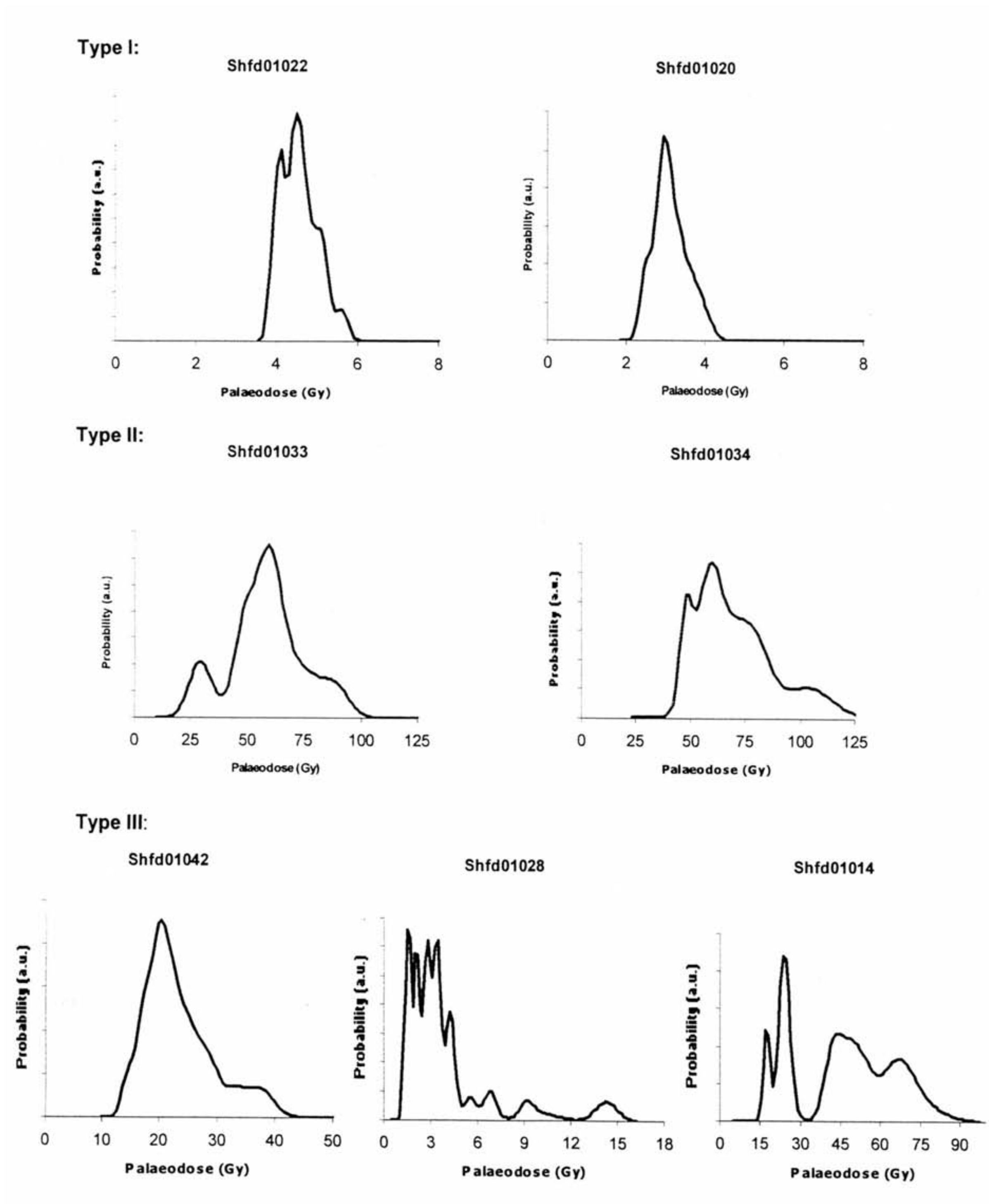



**Figure A-2.** Probability density plots of replicate De OSL data exemplifying the three categories of distribution identified.

clusion of particular aliquots to help reduce the effects of any partial bleaching contamination. Thus, the derived ages should be treated with some caution rather than accepted as definite, absolute burial ages.

Type III samples can be found particularly at sedimentary boundaries (e.g., Shfd01014) and in samples closest to the present-day surface (e.g., Shfd01028). Some samples are skewed with a considerable higher De tail, suggesting incorporation of older material or partially bleached material into the sample. Other samples in this category are bimodal, suggesting mixing of sediment with two different De's. The assumption is that, for a sample that was well reset prior to burial and not post-depositionally bioturbated, the palaeodoses should be normally distributed. All significant deviations away from this normal distribution were examined carefully. Where there was a clear tail of palaeodoses much higher or lower than the bulk of the replicates, these were excluded from the final age calculated on the basis that they may be partially bleached or contaminated with older/younger material. Thus, with Type III samples it is believed that the calculated ages, whilst possibly still containing a small component resulting from partial bleaching/contamination, should be accurate absolute ages reflecting the burial age of the sediments sampled.

Many of the problems raised in terms of poor bleaching, contamination, and/or bioturbation of OSL ages are dealt with on a unit-by-unit basis in the following sections, thereby allowing integration of stratigraphic, sedimentological, and other information. The exception to this are the two samples collected from within and adjacent to a prehistoric pit (Feature 13) excavated in the Knoll Top Area, Unit S04W83. Sediment adjacent to the pit feature OSL dated to 4.63 ± 0.46 ka (Shfd01041), which would correlate it with Holocene Unit 2 (see below). The sample from within the pit feature, counter to expectations, dated to 14.9 ± 1.5 ka (Shfd01042). It is a Type III sample with a broad spread of De values from the repeated aliquot measurements that range from 14.4 Gy to 38.3 Gy. These De values are in a skewed distribution suggesting that significant amounts of not-fully-reset material have been incorporated into this sample. The lack of any De values in the same range or less than those from the sample in the sediment adjacent to the pit (4.5 to 9.5 Gy) suggests that no aliquot from the pit sample was dominated by well-bleached sediment. The inference is that the activity of pit filling used material of significant antiquity (e.g., Deweyville sand), which was not reset; thus, the OSL age for Shfd01041 does not reflect the age when the pit was dug and filled. The best we can say about this feature is that it has a maximum age of 4.63 ka.

### *Age Calculation*

To calculate an age from the De values derived from the above-selected single aliquot measurements, a single weighted mean value was calculated from the probability density plot. In doing so, the weighting factors take into account both the variation between each palaeodose value and the associated S.D. values for each aliquot. Ages are quoted in absolute years from the present day (in this case 2001 when the samples were collected) with one-sigma confidence intervals. These errors incorporate systematic uncertainties with the dosimetry data, uncertainties with the palaeomoisture content, and errors associated with the De determination. Some of these errors are incorporated during the final stage of analysis (age calculation). For comparison, radiocarbon ages will need calibration using the expression published by Bard et al. (1990). A summary of the results was presented earlier in Table A-4.

## *Stratigraphic Field Observations*

The goal of this section is to interpret the site stratigraphy in light of the cultural remains, the luminescence dates, and the results of other analytical work pertinent to understanding the deposits. It starts out with a basic description of the units present, starting with the oldest units, and ends with a discussion of the Holocene sequence and its depositional origins.

### *Beaumont Formation*

#### *Stratigraphic Position*

In general, the Beaumont Formation was rarely exposed, as it formed the base of most excavations. It is overlain on valley-wall slopes (e.g., the West Slope) by the Deweyville Formation, as well as the Holocene deposits. The top of the Beaumont is presumed, on the basis of its irregular topography, to be an erosional surface, scoured by the Deweyville-age fluvial system.

#### *Sedimentological and Pedogenic Attributes*

The one place where this unit was exposed was in the backhoe trench (BHT G3) at N8.2W33.0 (our profile MS12). In this locality, 1.2 m of relatively clean sand rested unconformably upon Beaumont clay. The Beaumont appeared to have been truncated with little of the former A horizon preserved.

In fact, the only bits of the A horizon that were retained were wedged-shaped inclusions of very dark gray (10YR 3.5/2) clay that penetrated into a light olive gray clay. These wedges were clearly crack fills, presumably vestiges of the base of a former vertic A horizon that had been stripped by erosion prior to deposition of the overlying sand. Prominent vertisols formed within the Beaumont (known as the Houston black clay; cf. Ahmad and Mermut [1996]) and represent of the most common attributes of this unit. The top of the clay was very undulose (a sharp, irregular boundary), and had formed a 5- to 7-mm-thick iron pan at the interface. The 25 cm of this unit that were exposed in the trench exhibited no features associated with deposition, merely subsequent pedogenic alteration.

#### *Chronometric Evidence*

No dating samples were collected from the Beaumont, given its age and attendant lack of archaeological relevance. It is clear that the age of this unit is pre-Deweyville and widely considered to be in excess of about 100 ka (Blum et al. 1995). This is consistent with the dating evidence obtained from the Deweyville deposits (see below).

### *Deweyville Formation*

#### *Stratigraphic Position*

The Holocene deposits within which the cultural remains are situated lie inset adjacent to the eroded eastern edge of the Deweyville Terrace that overlooks the Holocene valley of the Guadalupe River. The Holocene deposits rest unconformably upon the Deweyville in some areas (i.e., the West Slope Excavation, in Geoarchaeological Trench 2 [BHT-G2], and on the north side of the knoll) and on the Beaumont Formation elsewhere. The Deweyville sands everywhere rest unconformably upon the Beaumont Formation clay, but at significantly different levels. This interface was lower in the West Slope Block and in BHT-G2 to the north of the knoll than it was in the Knoll Top Block.

In a single exposure in BHT-G2 (Profile MS10; see Figure A-3), a prominent truncated palaeosol (a palaeoargillic horizon) was observed formed at the top of the Deweyville Formation. Where the Deweyville soil had been eroded, the unconformity between the Deweyville sands and the Holocene deposits was impossible to denote on the basis of either field evidence or the granulometric data. Indeed, it was impossible to be certain that two different-age units were present, although this was suspected by the excavators and us. The similarity in the deposits is perhaps best illustrated in Profile MS4 in the West Slope Block where OSL dates clearly identify the Deweyville Formation at the base of the profile, but no clear granulometric break is evident (Figure A-4). In another section (see Figure A-3), there is a very subtle difference between the Deweyville and the Holocene deposits, where the Deweyville sands beneath the paleo-argillic horizon contain slightly less silt.

#### *Sedimentological and Pedogenic Attributes*

The Deweyville deposits could only be positively identified in the field in one exposure, Profile MS10 (in BHT-G2) where a prominent palaeosol separated the two units. In this section, the sands beneath the palaeosol were very pale brown (10YR 7/4) and did not preserve any sedimentary structures. These deposits exhibited a modal diameter between 200 and 300 microns, generally around 280 microns, and with a long tail into the silt range (Figure A-5). Following the results of the luminescence dating, it was possible to identify other probable Deweyville deposits, such as the base of Profile MS4 where the palaeosol had been stripped away and the Holocene deposits emplaced unconformably on top of the Deweyville sands. In this profile, the granulometric attributes of the Deweyville were nearly identical to the MS10 section, but slightly more silt was present, and in these samples the additional silt was present on the frequency histograms as a very low-amplitude, broad, secondary mode.

The palaeosol that demarcated the top of the Deweyville in BHT-G2 rose from a depth of 280 cm to near the surface. The top of the paleo-argillic horizon everywhere appeared to have been truncated by erosion, and no associated epipedon was observed. Rather it was overlain by almost 3 m of Holocene deposits (see Figure A-3). The Bt horizon exhibited 7.5YR hues, was about 40 cm thick, and the Cilas grain-size analysis indicates that it contained more than 5 to 7 percent clay. Given that laser particle-size instruments underestimate the clay content, these values should be considered minimums, and the actual values probably lie in the 20 to 40 percent clay range. We had intended to collect samples for traditional granulometry but, unfortunately, the trench collapsed soon after the OSL and cube samples were collected, even before a proper description could be made.

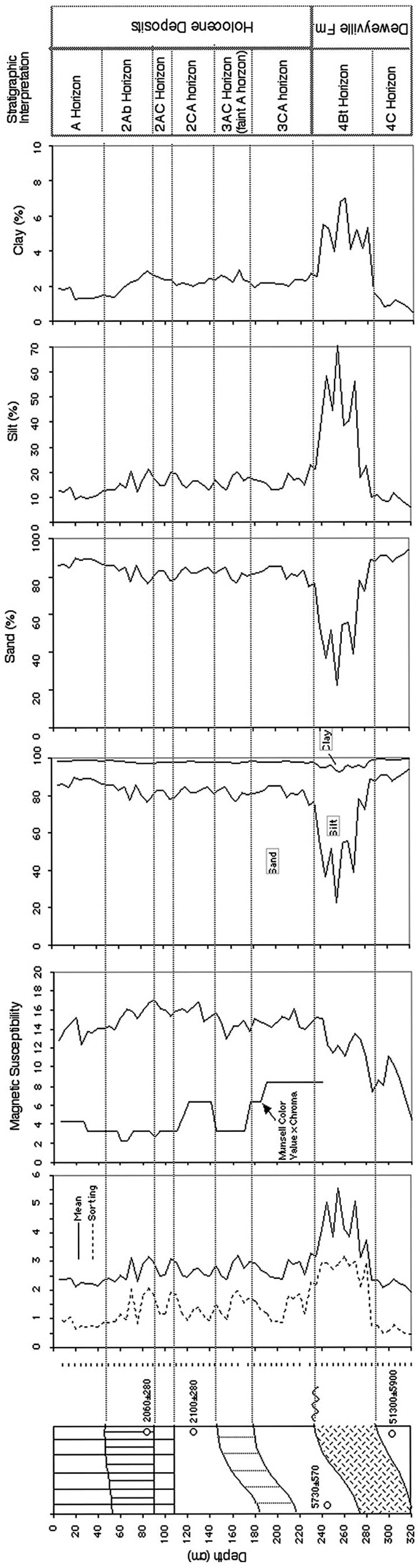



**Figure A-3.** Stratigraphy and granulometry of Profile MS10 at Buckeye Knoll.

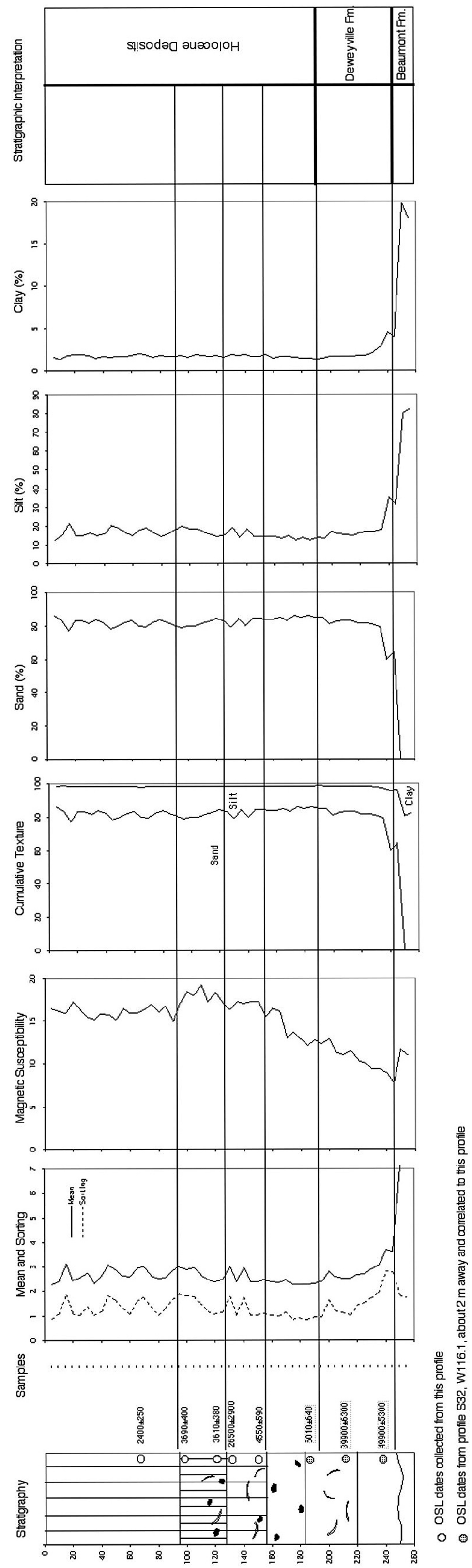



**Figure A-4.** Stratigraphy and granulometry of Profile MS 4 at Buckeye Knoll.

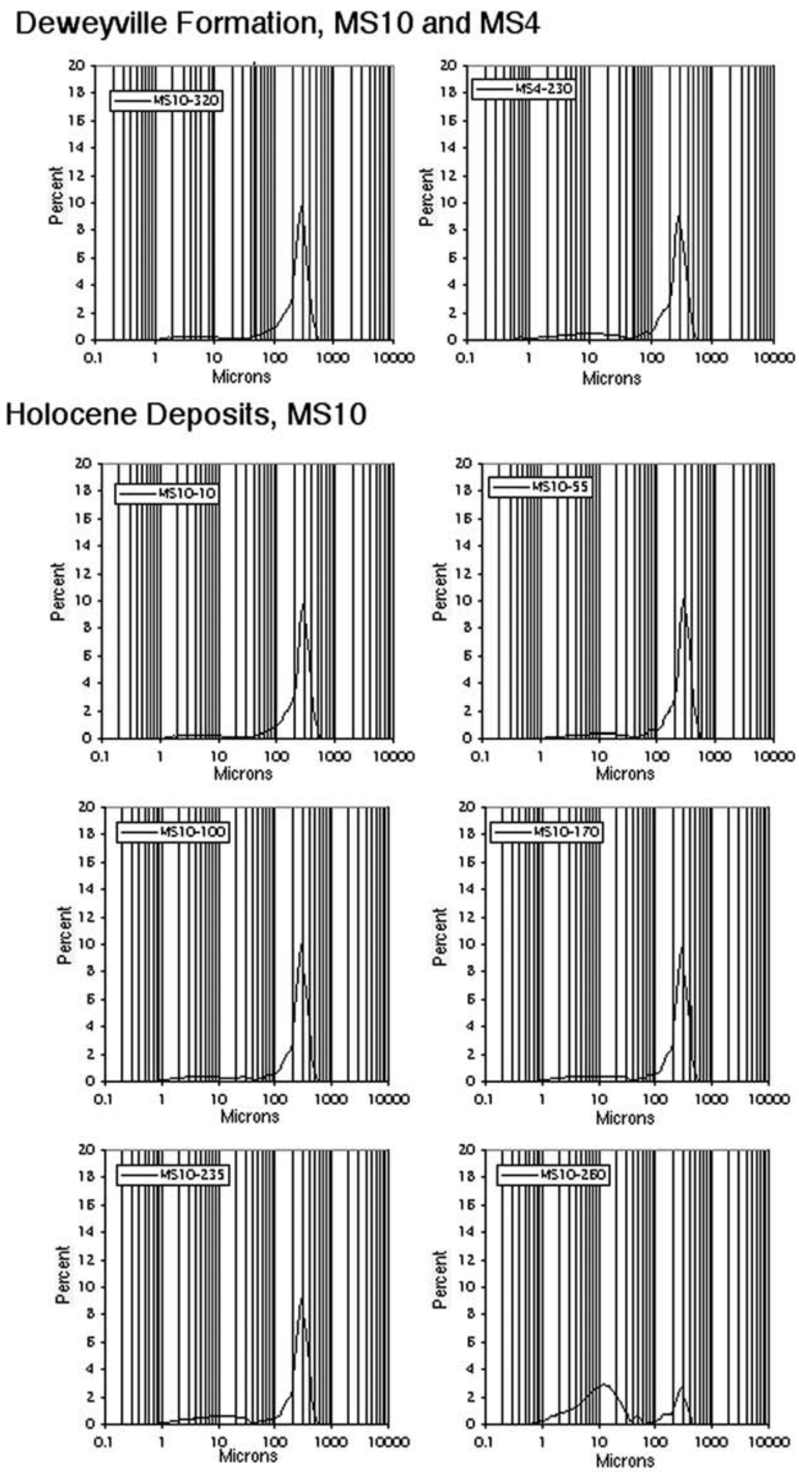



**Figure A-5.** Plot of sediment size frequency histogram comparing the Deweyville and Holocene deposits.

***Chronometric Evidence***

The luminescence dates from the Deweyville cluster around 49 to 53 ka, which possibly reflects the depositional age of the unit. However, OSL samples from near the upper boundary of this unit show evidence of pedoturbation, or Pleistocene colluviation of the Deweyville sands (e.g., Shfd01014 from MS6, Shfd01017 from MS4, and Shfd01032 from MS8).

The depositional age of the Deweyville appears to be around 49 to 53 ka based on a cluster of five dates around this time (49.9 ± 5.3 ka [Shfd01013]; 49.6 ± 6.2 [Shfd01014], both in Profile MS6; 50.9 ± 5.9 ka [Shfd01033] in Profile MS9; 52.5 ± 6.1 ka [Shfd01038] in Profile MS11; and 51.3 ± 5.9 ka [Shfd01034] in Profile MS10). Although outside the remit or interest of this project, these dates are potentially quite significant as there have been very few dates obtained from the Deweyville until now. It has been recognized that Deweyville terrace(s) were deposited after deposition of the Beaumont ceased but prior to the formation of the existing incised river valleys. The best general estimate for the Deweyville currently is between 100 ka and 20 to 14 ka (Blum et al. 1995), and most authors working upon this subject agree that the "Deweyville" is actually more than one stratigraphic unit, with Blum et al. (1995) and Sylvia (2002) identifying three distinct phases of deposition. More recently, Otvos (2001), working in Louisiana, has reported OSL ages between 50 and 30 ka for "Upper Terrace" Deweyville fluvial deposits that merge smoothly with the upper coastal plain terraces (i.e., the Beaumont Formation at this site).

At Buckeye Knoll, only one profile where such ancient dates were obtained exhibited a soil profile that is consistent with such an age. The rest of the exposures from which such ages were obtained were either gradational to Holocene deposits (as in MS4/MS6 in the West Slope Block Excavation), or consisted of clean, Deweyville-like sand with no stratigraphic or sedimentologic complexity (as at MS11). In the latter profile, a date of 52.5 ka was obtained at a depth of 2.5 m, and the next higher sample (at 1.6 m) yielded an age of 7.29 ka. The lack of an unconformity between these two samples, or any evidence of sedimentologic variability, suggests that either there was Holocene sedimentation that reworked the Deweyville (whose deposits were not altered by pedogenesis), or the younger dates nearer the surface were made young by pedoturbation. No evidence for the latter can be derived from the replicate OSL data. This contrasts to Sample Shfd01014 in Profile MS6 located near the base of the West Slope Block Excavation. There, a clear inclusion of young contamination (see probability density plot in Fig A-2) was present. When this is excluded, the sample yields an age of 49.6 ± 6.2 ka, which is directly comparable to the underlying Sample (Shfd01013) that dates to 49.9 ± 5.3 ka. It is probable that the younger palaeodoses in Sample Shfd01014 are the result of pedoturbation of the upper portion of the Deweyville sand.

Two Pleistocene dates significantly younger than the inferred depositional age of the Deweyville of ca. 50 ka were obtained from Profiles MS4 and MS9 situated in the West Slope Block Excavation and BHT G1, respectively. Sample Shfd01017 (26.5 ± 2.9 ka) was about 20 cm above an OSL date of 4.55 ± 0.59 ka (Shfd01016) and 10 cm below an age of 3.61 ± 0.4 ka (Shfd01018). Sample Shfd01017 is a Type II sample whose De replicate data show a wide range of values perhaps reflecting some post-depositional disturbance. However, the bulk of the replicates are of a value that is consistently lower than those measured for known in situ Deweyville but considerably higher than the Holocene-age samples from the site. Sample Shfd01032 (25.2 ± 2.1 ka) from MS9 was about 30 cm above an OSL date of 50.9 ka (Shfd01033), and the two were separated by a weak soil formed in loamy sediments. Shfd010232 is a Type I sample with good De reproducibility, thus ruling out bioturbation. Whilst the underlying sample is scattered in terms of its De reproducibility, it is consistent with the age of other Deweyville samples. It is inferred that these two ages probably represent a Pleistocene colluvial depositional event that, in the case of Shfd01017, has been subsequently locally reworked without significant resetting of the OSL signal into Holocene-age sediments.

In summary, the consistency of the OSL dates on the Deweyville appears to provide a very plausible depositional age for the unit. However, the existence of younger (but still Pleistocene) ages above the ca. 50-ka deposits and, in some cases, below clear Holocene deposits, suggests that one or more processes may be responsible. The first possibility is that pedoturbation may be causing an age error. The second is that there is some additional local reworking of the Deweyville prior to the Holocene.

***Holocene Deposits***

As intriguing as the Pleistocene deposits may be, the more significant, and clearly challenging deposits, are the Holocene sediments from which the cultural materials have been recovered. The discussion that follows attempts to unravel the depositional history of the Holocene deposits, and for this reason a slightly different stratigraphic nomenclature is employed. The principal reason for this is to emphasize stratigraphic situations that are significant in terms of depositional processes that get overlooked in the generic stratigraphic subdivisions employed in the excavation. This is most acute in the case of depression fills, where what would generally be described as Zone 3 is presumed to be younger than this unit elsewhere on the site.

In general, the Holocene deposits are dominantly sand (generally >80 percent) and exhibit a range of pedogenic alteration that extends from a complete lack of evidence of soil development, to the existence of multiple, variably developed A horizons interbedded with faint C or AC horizons. None of the Holocene deposits exhibited any significant evidence of B horizon development.

In the field it was apparent that the Holocene deposits aggraded in an episodic fashion, and this was most prominent where they filled former surface depressions. Two such depressions were examined, one in the middle of the main, Knoll Top Block, and a second that was exposed in BHT-G2 (see Profile MS10, Figure A-3). In both of these localities, the deposits exhibited three cycles of alternating A-AC profiles, which imply episodic phases of rapid sedimentation followed by periods when the rate of sedimentation declined dramatically or sedimentation ceased altogether, and during which the A horizons formed. The episodic nature of sedimentation was less apparent away from depressions, with only the latter two phases being clearly expressed. It was abundantly clear in the Knoll Top Block Excavation that Zone 2 actually was composed of two distinct depositional units that had both been modified by subsequent pedogenesis, and that away from the depression, these soils welded into one massive soil that exhibited no obvious internal stratigraphic complexity.

To deal with the apparent stratigraphic complexity exhibited by the Holocene deposits, the following discussion divides the Holocene deposits into four distinct units: Holocene Units 1, 2, 3, and 4. Holocene Unit 1 is equivalent to Zone 3 in the Knoll Top Block Excavation. Holocene Unit 2 is separated from Unit 1 by an erosional unconformity that was only observed in the Knoll Top Excavation and is everywhere else impossible to discern. This is one of two depositional units that contributes to Zone 2, although in some places a distinct soil is present at the top of this unit. The other unit, which contributed to Zone 2, is Holocene Unit 3. In depressions the soil formed at the top of this unit is clearly the midden, but in some exposures the soil at the top of Holocene Unit 2 was welded to it. The final unit is Holocene Unit 4, which is basically the same as Zone 1 as described in the section on the excavations.

The depositional origins of the Holocene deposits are a contentious and enigmatic issue. As will become apparent in the following discussion, the best evidence available suggests that these deposits are primarily eolian sand derived from very localized reworking of the Deweyville sands. However, none of the analytical procedures employed to identify the origin of these units clearly identified a single process (see discussion below).

***Holocene Unit 1***

The oldest unit in the Holocene sequence is the most important, yet it is also the most enigmatic. This deposit is widely described in the excavation records as Zone 3 in the Knoll Top Block Excavation. The diagnostic artifacts retrieved from Holocene Unit 1 consisted of Early Triangular and Bell points at the interface with Unit 2, plus a suite of Paleo-Indian materials in Zone 3A (top of the unit) that included Golondrina, St. Mary's Hall, and Wilson points, suggesting an age of about 9 to 10 ka.

***Stratigraphic Position:*** Holocene Unit 1 is the basal stratigraphic unit in the Knoll Top Excavation and is equivalent to Zone 3 as described by the excavation team in this area. It was divided by the excavation team into two parts (3A and 3B), which largely reflect the presence of an A horizon in the top of the unit and a less pedogenically modified basal unit. This deposit rests unconformably upon the Beaumont Formation clay and was clearly truncated by sediments that filled a depression centered around gird coordinates S12W88.

***Sedimentological and Pedogenic Attributes:*** The color of the basal portion of this unit was yellowish brown (10YR 5/4), and, like most units on the site, it was massive and exhibited numerous small krotovinas. The upper portion of the unit (Zone 3A) generally was transitional in color to the overlying soil and graded from a very dark gray to dark gray (10YR 3/1 to 10YR 3/1.5) near its upper boundary, to the yellowish brown (Zone 3B) at depth. Analysis of the total organic carbon content of this deposit clearly demonstrated a peak in organic carbon in the upper portion of the unit (Zone 3A) and a gradual decline with increasing depth. Significantly, this analysis also demonstrated a significantly lower organic carbon content in the immediately overlying deposits. This supports the assertion that a there was a topsoil formed in this stratigraphic position. Nowhere did the zone exhibit evidence of sedimentary structures related to deposition. Shell was present and ranged from trace amounts to quite abundant quantities. The primary taxa were land snails, but marine shells (primarily *Rangia* sp) were present in places. Trace amounts of secondary or pedogenic carbonate were also present in this unit, forming small concretions 1 to 2 mm in diameter and encrusting larger fragments of primary shell carbonate. Ganulometric analysis of these deposits indicate that they were primarily sand (83-86 percent) with lesser amounts of silt (12-14 percent) and a trace of clay.

***Chronometric Evidence:*** Two samples were collected from this unit for OSL dating in the Knoll Top Excavation. The age of the lowest of these, obtained 10 cm above the Beaumont interface, was generally consistent with the age of the Early Archaic burials, ca. 7.57 ± 0.79 ka (Shfd01024), but the stratigraphic position of this sample was below the Paleo-Indian occupational debris (MS1; Figure A-6). Hence the age of this sample appears to have been reset by the Early Archaic mortuary practices (AMS radiocarbon dated to between 6.3 to 7.4 Cal ka B.P.) and does not reflect the depositional age of the deposit. The second sample, situated at the interface with Zone 2 yielded an age of 3.99 ± 0.44 ka (Shfd01025), which is somewhat younger than the Early Triangular/Bell materials recovered there. The excavator (Ricklis) has suggested that this is an erosional surface, but there was no field evidence observed to supported this, other than the truncation of this unit by the deposits that filled the depression that was present in the Knoll Top Block. However, the organic carbon results from Holocene Unit 1 appear to support this argument.

***Interpretation:*** There are three possible interpretations of this portion of the Holocene depositional sequence: (1) this zone is an eroded remnant of Deweyville sand into which Paleo-Indian materials were incorporated by pedoturbation; (2) the zone is a late Pleistocene-Early Holocene depositional unit that has been severely altered by pedoturbation; (3) the sediment of Unit 1 was artificially put down in connection with the burials, thus reusing and resetting older sediment containing paleoindian material. From an OSL perspective, Sample Shfd01024 does have a bimodal De distribution with a couple of aliquots additionally yielding significantly higher doses (see Figure A-7). If the De distribution is split into two populations, ages of 7.12 ± 0.72 ka and 9.05 ± 0.92 ka are obtained, and these coincide, respectively, with the age of the mortuary deposits and the Paleo-Indian artifacts. Elsewhere in Profile MS11 (BHT-G3), an age of 7.29 ± 0.79 ka (Shfd01039) was obtained from a sample 160 cm below the present surface. If this is a sediment-burial age, it suggests further sedimentation in and around the time of the burials, although the lack of differentiation of the sand in this profile precludes correlation with anything other than the OSL age. Whilst very tentative, this would support the idea of a remnant and heavily pedoturbated early Holocene depositional unit into which the burials were dug, possibly coincident with further sedimentation.

It should be noted that if it had been apparent that Zone 3 on the Knoll Top was distinctly different than Zone 3 in the West Slope Block Excavation, then more dating samples would have been collected in the Knoll-Top unit. However, the significance of this unit only emerged in the analysis phase of the investigation. As such, only limited evidence that can be used to support a particular argument and the issue remains unresolved.

***Holocene Unit 2***

The fills within ancient depressions appear to be one of the best places to resolve the depositional dynamics at the site, and it is from the stratigraphic sequences in two such depressions that the following sequence of events is inferred. Depression fills were observed in two locations: one in the Knoll Top Block Excavation (Profile MS2; Figure A-8), and another revealed by BHT-G2 (our Profile MS10; see Figure A-3). In both of these locations, there appear to be three cycles of sedimentation, the oldest of which begins around 6 ka.

The origin of these depressions is uncertain. It is possible that they are linear features (gullies), but none of the existing exposures revealed enough of their geometry to make their origin clear. The fact that the OSL dates from the sediment filling these features are similar (5.7 to 6 ka) implies that they may be natural, erosional features, possibly tied to channel rejuvenation/incision on the Guadalupe River. There is not a detailed stratigraphic sequence for the Guadalupe, especially on the coastal plain, but many Texas rivers experienced a phase of channel incision and valley widening around that time. It is unclear to what extent channel incision may have occurred in this region at that time.

***Stratigraphic Position:*** In the Knoll Top Block this unit truncates Holocene Unit 1 (aka Zone 3) and fills the base of the depression in the northwestern part of the block. The base of the unit rested unconformably upon the Beaumont in this location and was about 60 cm thick. In BHT-G2 (Profile MS10) this unit was about 90 cm thick and rested unconformably upon the truncated paleo-argillic horizon of the Deweyville Formation. In the West Slope Block Excavation the unit identified in the field as Zone 3 is assigned to Holocene Unit 2 on the basis of the OSL date at the interface with the Deweyville sand. In the Knoll Top Excavation this unit laterally merged with Holocene Unit 3 to form the midden (Zone 2).

***Sedimentological and Pedogenic Attributes:*** In profile MS2 (S12W88) this unit exhibited a 45-cm-thick black (10YR 2/1) A horizon and a 15-to-20-cm-thick basal unit that ranged in color from very dark gray (10YR 3/1) to brown (10YR 5/3). In Profile MS10, it exhibited a 25-cm-thick very dark gray (10YR 3/1) A horizon and a 65-cm-thick dark grayish brown (10YR 4/2) AC horizon that rested unconformably upon the truncated paleo-argillic horizon of the Deweyville Formation. In the West Slope Block Excavation, this unit rested upon the Deweyville Formation. A clear, smooth boundary was observed in the field between the two units, but the significance of this boundary was not clear. There, the deposit consisted of a light yellowish brown (2.5Y 6/3) C horizon at its base and graded up into a weak, very dark gray (10YR 3/1) A horizon.

***Chronometric Evidence:*** Deposition of Holocene Unit 2 appears to have begun around 6 ka and ended around 4 ka. (i.e., AU 3 and including Middle Archaic points from erosional unconformity-related lag materials). Its base was dated to 5.73 ± 0.57 ka in BHT-G2 to 6.05 ± 0.61 ka of the depression in the Knoll Top Block Excavation and to 6.01 ± 0.64 ka in the West Slope Block Excavation in Profile MS6. The top of the unit is older than 2.10 ± 0.28 ka in BHT-G2 (where a date from the next younger unit dated 2.06 ± 0.24 ka), older than 3.78 ± 0.42 ka in Profile MS2 in the depression in the Knoll Top Block Excavation, and older than 3.61 ± 0.38 ka in the West Slope Excavation. A sample from the top of the unit in the latter profile yielded a date of 26.5 ka, which is interpreted as an incompletely reset sample (see Deweyville section above). Profile MS11 (BHT-G3) to the east of the Knoll Top also yielded an age of 5.89 ± 0.12 ka at 90 cm from the surface. This could indicate sedimentation of Holocene Unit 2 occurred farther afield, although this sample can only be correlated on the basis of its OSL age.

***Interpretation:*** The chronologic evidence from this unit is fairly consistent. The initial phase of deposition appears to follow a phase of erosion that predated roughly 6 ka and that created an unconformity in at least one part of the site (the Knoll Top). There is little stratigraphic evidence to support a more widespread distribution of this erosional interface, but the archaeological evidence would appear to support such an inference (Robert A. Ricklis, personal communication 2001).

***Holocene Unit 3***

***Stratigraphic Position:*** In general terms, this deposit rests unconformably upon the soil at the top of Holocene Unit 2. In the Knoll Top Block, this deposit and the soil formed within it merges with Holocene Unit 2 to form the midden (aka Zone 2). It was a maximum of 60 cm thick in this portion of the site. Away from the depression, it was impossible to discriminate these units, as their soils had welded together (and thus, both were subsumed under the archaeologically defined Zone 2). In BHT-G2, Holocene Unit 3 was again unconformably resting upon the palaeosol in Unit 1, and altogether this unit was up to 1 m thick. In the West Slope Excavation, Holocene Unit 2 again rested upon Holocene Unit 1, but there was no distinct underlying C horizon (just a dark A horizon), and the unit was about 30 cm thick.

***Sedimentological and Pedogenic Attributes:*** In BHT-G2, this unit exhibited a prominent A-AC profile, with the A horizon being a prominent black to very dark gray (10YR 2/1 to 10YR 3/1) color that is consistent with the midden elsewhere on the site. This graded gradually to a very dark grayish brown (10YR 3/2) AC horizon. In the Knoll Top Block Excavation, this unit in the depression consisted of a 25-cm-thick very dark gray A horizon that was separated from a 25-cm-thick dark gray (10YR 4/1) AC horizon by a gradual smooth boundary. In the West Slope, the unit was defined by the black (10YR 2/1) A horizon that elsewhere was called the midden (Zone 2). There was no underlying AC horizon that was clearly distinguishable from the top of Holocene Unit 2. In this area, the top and bottom boundaries were gradual and appeared to have been substantially altered by pedoturbation.

***Chronometric Evidence:*** The chronologic information from Zone 2 is highly variable, ranging from about 3.8 ka to 1.2 ka, but with somewhat different ages in different parts of the site. For instance, on the Knoll Top, the base of the unit in the depression dates

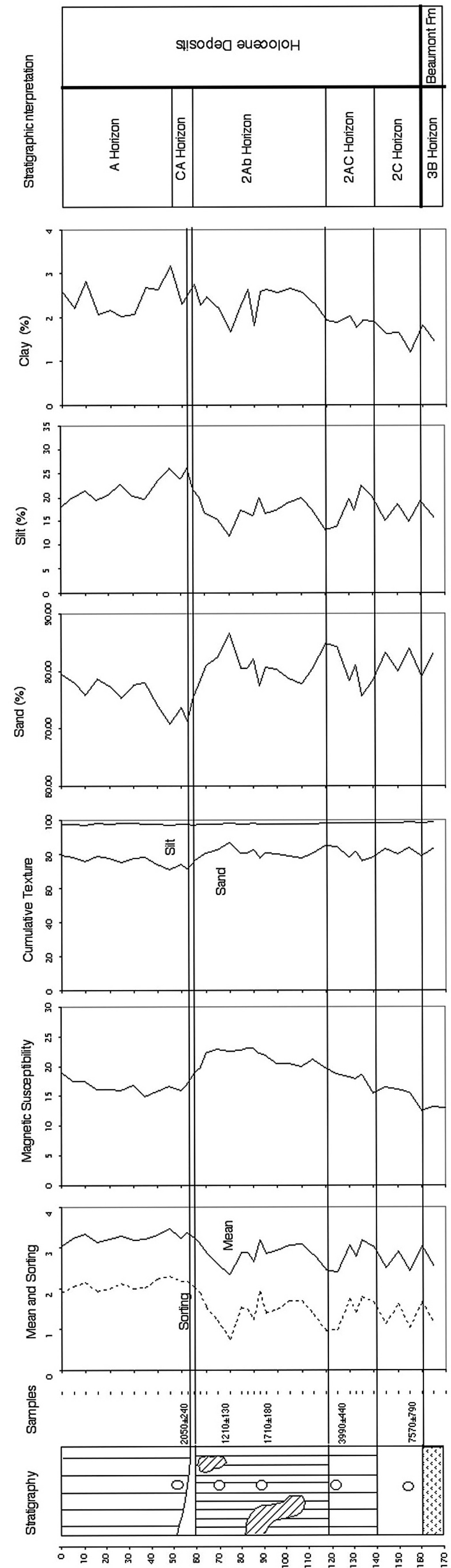



**Figure A-6**. Stratigraphy and granulometry from Profile MS 1.

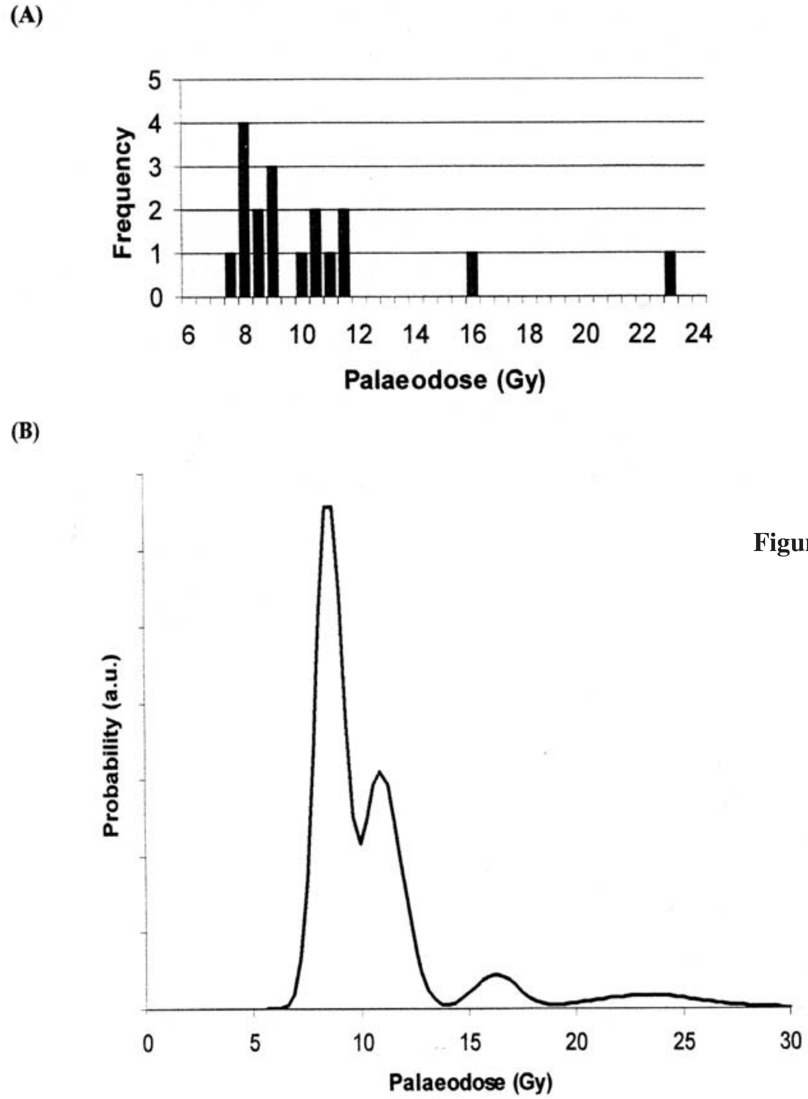



**Figure A-7.** Frequency histogram (A) and probability density plot (B) of De OSL data from Sample Shfd 1024 from Zone 3 in Profile MS 1 showing its bimodality.

to 3.78 ± 0.42 ka, and is less than 3.99 ± 0.44 ka. The middle and top of the unit, however dates to 1.71 ± 0.18 (AU 2) and 1.21 ± 0.13 ka (AU 1), respectively. These dates are in general agreement with the archaeology in this part of the site, which yielded Late Archaic and Late Prehistoric materials.

In BHT-G2, two dates were obtained. The lowest of these was situated about 15 cm above the base of the unit and yielded an age of 2.10 ± 0.28 ka. A second sample from the base of the midden-like A horizon, about 35 cm below the top of the unit, yielded an age of 2.06 ± 0.24 ka.

In the West Slope Excavation two dates were obtained from this deposit. A sample from near the base of the unit (i.e., base of Zone 2) yielded a date of 3.61 ± 0.38 ka; whereas, a sample from near the top (25 cm above the lower sample) yielded a date of 3.69 ± 0.40 ka. In this portion of the site, the excavation recovered Morhiss and Pedernales points, which are generally consistent with the OSL dates.

***Interpretation:*** This unit is one of the more conspicuous stratigraphic features at the site. It appears that deposition began about the same time on the lower and middle portions of the slope, but perhaps later in BHT-G2, although we do not have a date from the lower boundary in this locality. Cessation of deposition at BHT-G2 and the Knoll Top Block appears to be sometime post 2 ka, and probably around 1 ka. However, occupations of this age occur in Zone 1 in the West Slope Block (and these are supported by the OSL dates), but this is an enigmatic aspect of the sequence. In the field, this unit was identified as midden on the basis of its dark color and enhanced artifactual content.

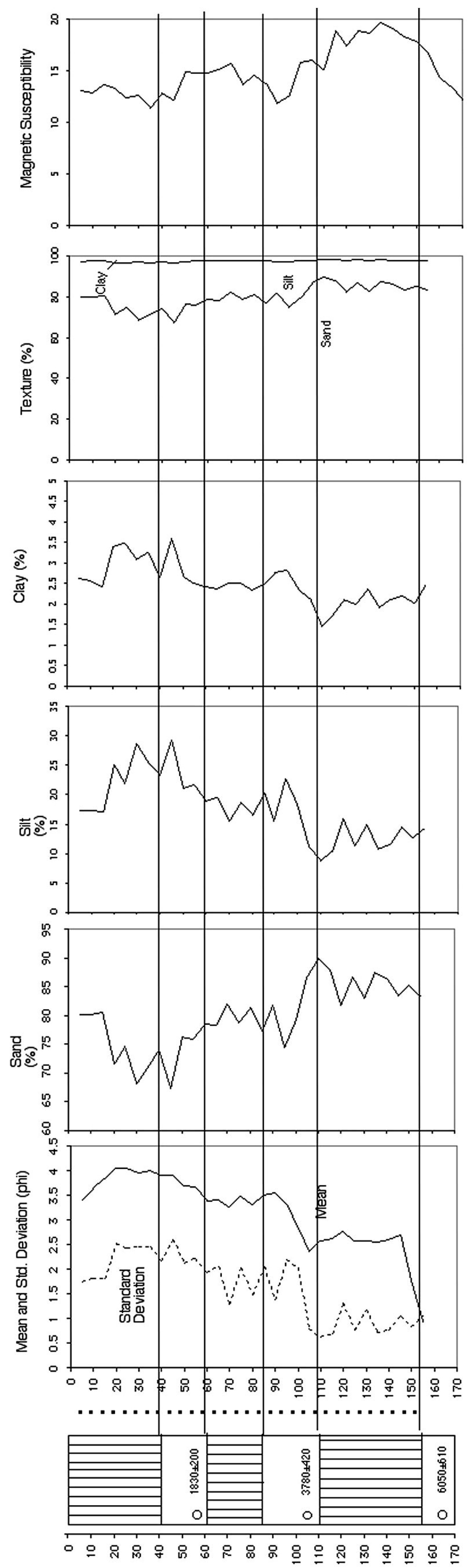



**Figure A-8.** Stratigraphy and granulometry form Profile MS 2.

***Holocene Unit 4***

***Stratigraphic Position:*** This deposit is the last in the sequence and is directly correlative to Zone 1 identified during the excavation. It rests on top of Holocene Unit 2, but that boundary ranged from abrupt to diffuse and appears to have been blurred by pedoturbation. The upper boundary of this deposit is the modern surface. The thickness of Unit 4 was quite variable across the site, but appeared to increase down slope. It was 45 cm thick in BHT-G2, 55 to 60 cm thick in the Knoll Top Block, and up to 95 cm thick in the West Slope Excavation.

***Sedimentological and Pedogenic Attributes:*** As with all of the site deposits, there were no sedimentary structures indicative of the depositional process, but rather numerous krotovina that indicated the existence of post-depositional disturbance. The color of this deposit was fairly uniformly dark gray to very dark gray (10YR 3/1 to 10YR 4/1) throughout and appeared to be a weakly developed A horizon. The thickness of this unit in places implies that this was a cumulic A horizon. In a few exposures this deposit exhibited a weak, very coarse prismatic structure, but this was one of the few places (besides the Deweyville paleoargillic horizon and the Beaumont surface) where soil structure was apparent.

Only in the Knoll Top Block Excavation was there evidence of a less pedogenically altered basal portion to the unit. This AC horizon was identified as Zone 1A in the excavation records. This basal component of Holocene Unit 4 was dark gray to dark grayish brown (10YR 4/1.5). It was thin, with its thickest measurement being 20 cm in the depression in the Knoll Top Block excavation. From there, it extended in a thin, interrupted sheet that it was best preserved in the basin-like depression on the top of Zone 2 (Holocene Unit 2). In these depressions it was generally less than 5 cm thick.

***Chronometric Evidence:*** The age of Holocene Unit 4 is a bit enigmatic, and the nature of the problem is best considered in light of the excavation results. The excavation results from the Knoll Top Block suggest that this deposit is post-Scallorn in age (i.e., after ca. 1.2 to 0.8 ka), but an OSL date from near the base of this deposit yielded an age of 2.05 ± 0.24 ka (Shfd01028), which is out of sequence when compared to the next lower date from the top of Holocene Unit 2 (the midden) where a date of 1.2 ± 0.13 ka (Shfd01027) was obtained. Given that the lower date is at the older end of (but within errors of) the expected age of a Scallorn occupation, the overlying 2.05 ka date for Zone 1 appears to be too old. Complicating matters is a date of 1.83 ± 0.20 ka (Shfd01031) from the basal portion of this unit in the depression (Profile MS2, S12W88), which also appears to be too old. If one assumes that significant contamination of older material has occurred either through bioturbation or deposition in a partially reset state, then the lowest De values measured in theory should provide ages closest to the true depositional age. If this is applied to Samples Shfd01027 and Shfd01031, the age estimates become 0.97 ± 0.11 ka for Sample Shfd01028 and 1.40 ± 0.14 ka for Sample Shfd01031. These are still too old when compared to the artifactual record and such manipulation of the OSL data is far from ideal. There is no readily apparent reason for this dating anomaly.

In the West Slope Excavation a date of 2.4 ± 0.25 ka (Shfd01020) was obtained from a depth of about 65 cm in Profile MS4 (S30.2W114). At first glance, this would appear to be too old. However, the excavation in this portion of the site recovered a Late Prehistoric component (potsherds and an arrow point fragment) overlying a Late Archaic, Ensor occupation and another Late Archaic component represented by Kent points near the base of the unit. Given that the OSL date was situated near the base of the unit, the 2.4 ka date appears to be reasonable.

***Interpretation:*** The archaeological and OSL dating evidence suggests that Holocene Unit 4 started to form on the lower slopes around 2,500 years ago, and only began to form on the Knoll Top around 1,000 years ago or less. Hence, the unit time appears to be time-transgressive, with the lower-slope portion starting to accumulate approximately 1,400 years, or more, earlier than the Koll Top component.

### ***Parent Material Determination***

One of the challenges presented by the site was to determine the sediment source of the Holocene deposits. Hypotheses concerning this issue were formulated in the field and samples were collected to permit testing their validity. In general terms, two competing hypotheses were recognized: (1) the site deposits originated with aeolian deflation of floodplain sand and the subsequent deposition of this material at the valley margin or (2) the site sediments were derived from local colluvial and/or aeolian reworking of the Deweyville sands.

***Hypotheses Testing***

To test these two hypotheses we collected (1) samples of modern floodplain sands and (2) samples of sands from the trench profiles that appeared to be part of the Deweyville Formation. If the site is developed from aeolian sediment deflated from the valley floor, we would expect its sediments (the Holocene deposits) to exhibit similarity to the overbank sands deposited on the floodplain. If the site originated from reworking of the Deweyville Formation, we would expect the deposits to bear a greater affinity to the deposits of that unit.

To test the competing hypotheses, we employed a number of distinct analyses that could potentially identify either the depositional process or affinities between the site matrix and either of these potential sources. The methods used were granulometric analysis, heavy mineral analysis, analysis of magnetic properties, quartz-grain surface micromorphology by scanning electron microscopy, and elemental analysis.

***Granulometry***

The grain size distribution is one physical attribute that can potentially indicate variations in parent materials in a profile (Birkeland 1999:161). In the course of the analysis, we performed more than 200 individual granulometric analyses on samples from profiles where OSL samples were collected and from samples of modern floodplain sands. Two ways of assessing the relationship between various materials are by (1) plotting the mean vs. the standard deviation and (2) examining the frequency histogram of the samples.

Figure A-9 depicts a cross plot of the graphic mean vs. the standard deviation for all of the samples in two profiles (MS1 and MS2) within the Knoll Top Block Excavation, with respect to sands from the Deweyville Formation (from Profile MS10, in BHT-G2, and below the paleoargillic horizon), modern floodplain sands, and a single sample collected from what appeared to be a possible dune, which was exposed in a road cut east of the canal. It is clear that the site matrix materials plot between the floodplain sands and the Deweyville Formation sands; whereas, the road-cut sample is completely different from everything else, although perhaps showing slightly more affinity with the Deweyville Formation sands. Hence, this method suggests that the site deposits may be derived from both, but that these deposits are considerably finer textured and more poorly sorted than either of the potential source sample suites.

The second granulometric method involves comparing the frequency histograms of the various samples. If the deposits are derived from different sources, then it is likely that there will be significant differences in the histograms. To examine similarities between the Deweyville Formation and the site matrix, histograms from two profiles (MS4 and MS10), both of which contain Deweyville deposits, were compared.

Several samples of the site matrix from the MS4 profile (from depths of 20, 65, 105, and 170 cm) were selected and compared with a sample from 230 cm that is presumed, on the basis of the OSL dates, to be the Deweyville Formation. A final sample from the very base of the profile, from the Beaumont clay, was also selected for comparison. Examination of the histograms reveals that there is no significant difference between the site matrix and the Deweyville sand. Both groups are bimodal and exhibit a dominant mode of 280 microns and a much smaller, very broadly distributed mode in the silt range between 3 and 30 microns. The Beaumont Formation is completely different from both of the overlying sand samples, being bimodal with peaks at 15 and 1.5 microns.

A similar analysis was performed using samples from the MS10 profile. Site matrix samples were selected from depths of 10, 55, 100, 170, and 235 cm (Figure A-10). Samples of the Deweyville were selected from the paleoargillic horizon (260 cm) and the clean, underlying sands at depths of 320 cm. All of these samples exhibited a dominant mode in the sand range around 280 microns (identical to that observed in MS4) and a secondary mode in the silt range between 3 and 30 microns. There is, however, significant variation in the amount of fine material present, with the Deweyville sands generally having less silt than the site matrix. The paleoargillic horizon exhibited a significantly different fine-grained mode than all the other samples, with a prominent peak at 10 to 12 microns, but a spread from <1 micron to 40 microns. When considered together, the histograms of the site matrix exhibit prominent similarities to the Deweyville sands.

If we compare the site deposits and/or the Deweyville sands with the floodplain sands, it becomes immediately apparent that there are significant differences (see Figure A-10). For instance, two of the samples (River Bar 6 and 3) had modal diameters of 212 microns; whereas, the third (River Bar 2) had a mode of 145 microns. This is significantly smaller than the Deweyville-Holocene deposit mode of 280 microns. A third possible source was a small hill of what was

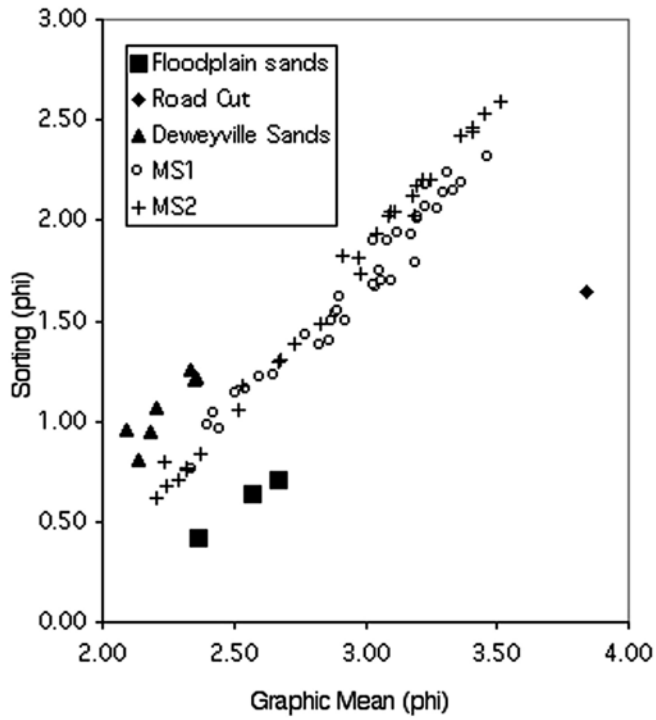



**Figure A-9.** Scattergram depicting the mean vs. standard deviation for site deposits and potential sources.

inferred to be potentially aeolian sand on top of the Deweyville that was exposed in the road cut immediately east of the canal. Granulometric analysis of this sample also yielded a modal diameter 212 microns.

Considered together, the granulometric evidence implies a strong and direct link between the Deweyville sands and the Holocene deposits. The latter contain consistently more silt than the Deweyville, but in at least one exposure (our Profile MS4) the two contained identical amounts of silt. There are significant differences between the Deweyville/Holocene deposits and the modern floodplain sands, with the latter being finer-textured and somewhat more variable in texture.

### *Heavy Mineral Analysis*

Heavy-mineral analysis is one method commonly used to establish provenance of sediments by comparison of the heavy mineral content of an unknown to that of potential sediment sources. The relative abundance of minerals whose proportions are not affected by chemical breakdown during weathering or physical fractionation during transport were used to compare samples from the site to potential sources of sediment, both contemporary (floodplain and from a road cut through a dune to the east of the site) and Pleistocene (Deweyville Formation). Three indices were used: rutile:zircon (RZi), garnet:zircon (GZi), and pink zircon (pZi). Archaeological provenance indices, based on the premise that anthrogenic activity should not change the relative ratios of any two component minerals, were also examined using zircon:tourmaline (ZTi), staurolite:tourmaline (STi), and euhedral zircon (eZi). The effects of chemical weathering were examined by looking at the apatite:tourmaline ratio (ATi). The heavy mineral analysis, as undertaken by Robert Knox (heavy minerals analysis consultant, formerly of the British Geological Survey), reveals that the geological provenance signatures show very little inter-sample variation, apart from the road-cut sample taken from the terrace top to the east of the site, as can be seen in crossplot in Figure A-11. There is a little variation between the floodplain and the Deweyville samples, but this could reflect the different antiquities as new rocks are constantly being exposed by fluvial erosion. Samples from the site itself (from MS1 and MS2 in the Knoll Top Block) plot closest to the Deweyville using the pZi index but closer to the floodplain samples using the Gzi values, therefore matching neither in terms of geological provenance. A similar story occurs for the archeological provenance indices where the site samples plot both closest to the Deweyville sands using eZi and to the floodplain samples using the Sti and Zti indices. The environmental index shows variable Ati/Rzi values, reflecting variable dissolution of the older samples by acidic groundwaters.

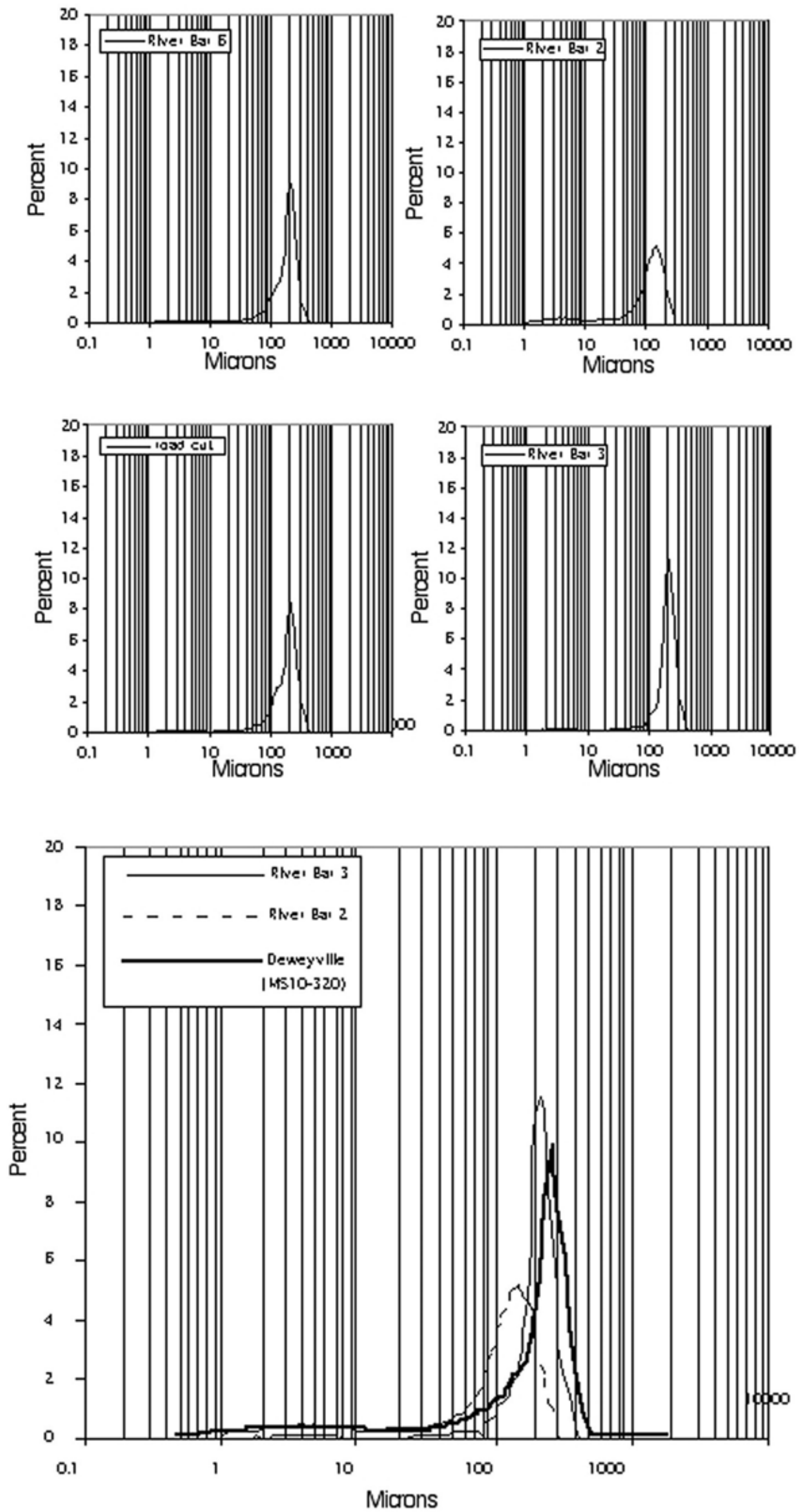
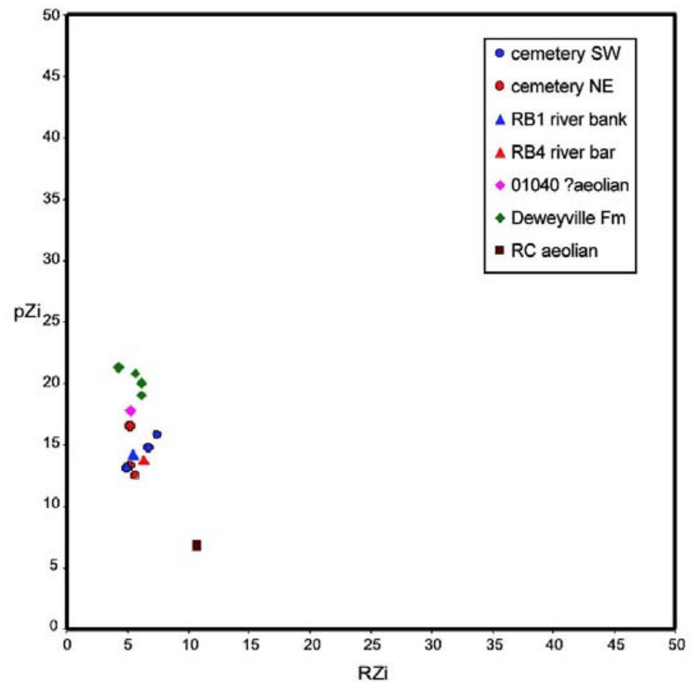
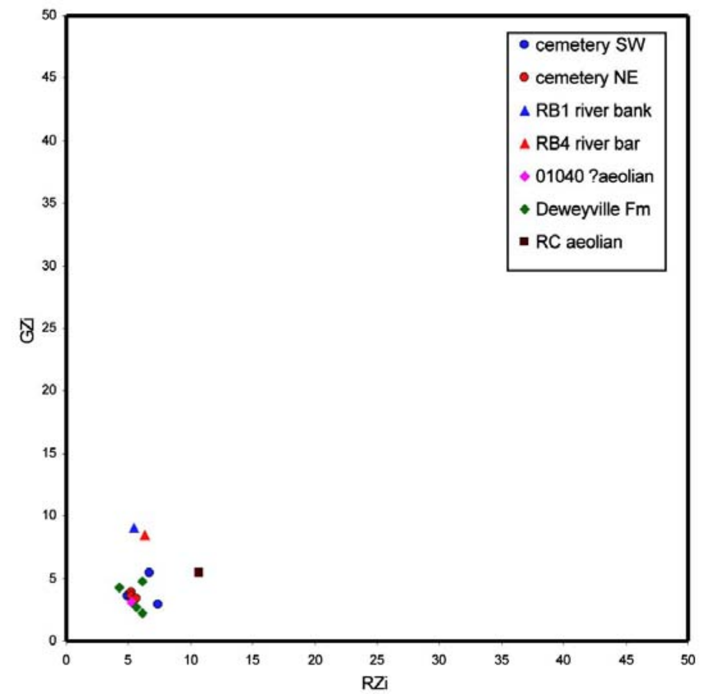


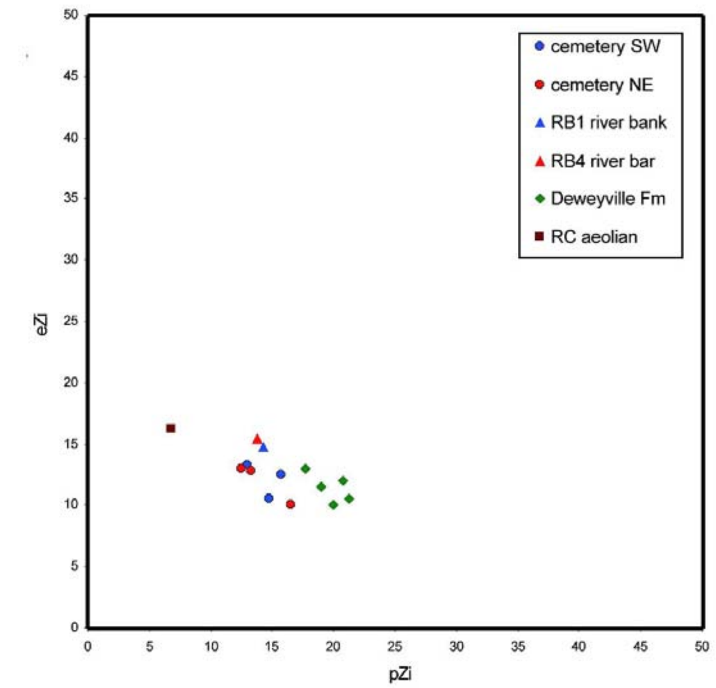

**Figure A-10.** Plot of sediment size frequency histograms for modern floodplain sands and road cut potential eolian deposits.



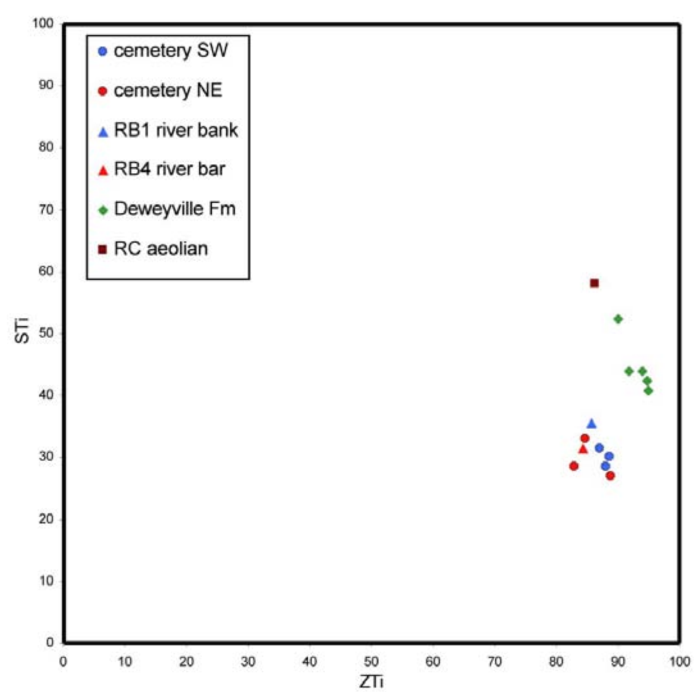

**(A)** pZi/RZi geological provenance crossplot, in which the site samples plot around the river samples.



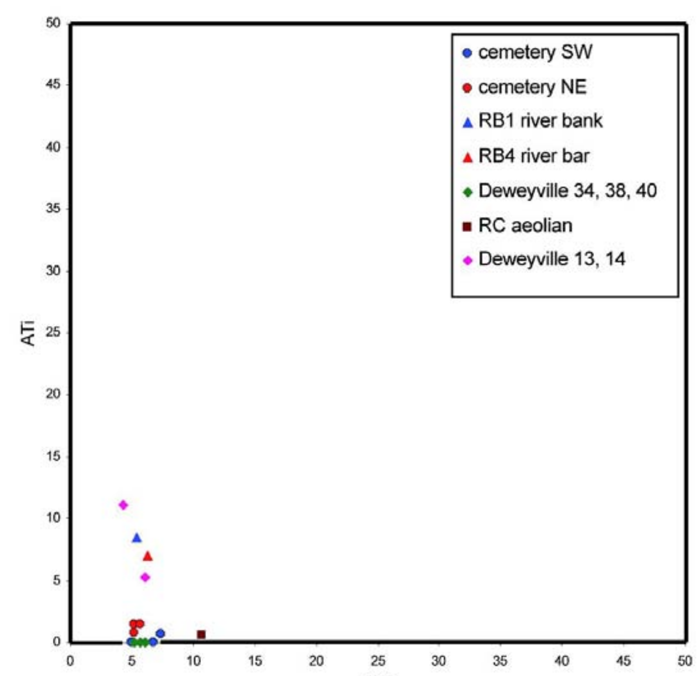

**(B)** GZi/RZi geological provenance crossplot, in which the site samples plot close to the field for the Deweyville Fm.




**(C)** eZi/pZi provenance crossplot, in which the site samples plot outside the fields for both the river and Deweyville samples.




**(D)** STi/ZTi provenance crossplot, in which the site samples plot close to the river samples and outside the field for the Deweyville samples.




**(E)** ATi/RZi crossplot, in which the very low ATi values for the site and most Deweyville samples probably reflect the in-situ leaching of apatite by acidic meteoric waters.

**Figure A-11.** Crossplots of the various geological, archaeological, and weathering indices used from the heavy-mineral analysis.

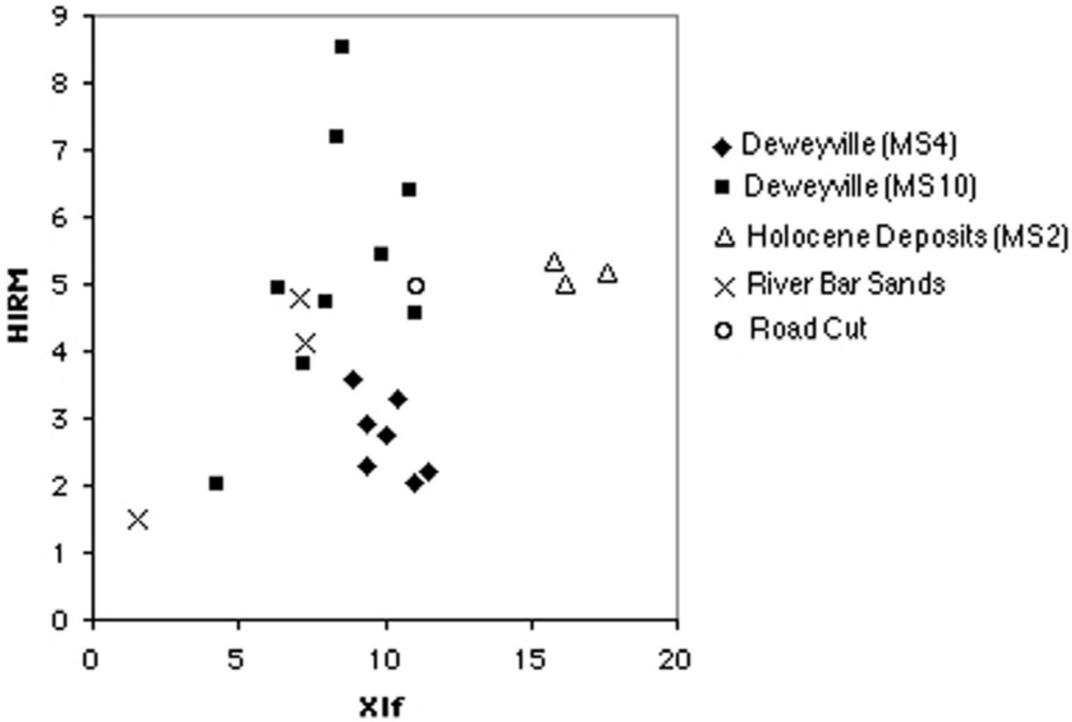



**Figure A-12.** Scattergram of the low frequency mass-corrected magnetic susceptibility vs. high-field IRM (or HIRM) comparing the potential sediment sources with the least pedogenically altered Holocene deposits.

The results of the heavy mineral analysis are somewhat inconclusive except hinting that the samples from Profiles MS1 and MS2 are probably not directly derived from Deweyville sediments that were exposed on the site. The Deweyville Formation is known to be variable (having formed over a considerable period of time), so the lack of a complete match between the site samples and the Deweyville may be an artifact of sampling. The site samples may reflect reworked Deweyville material from outside the site with a slightly different mineral composition than that present on the site. Further sampling of stratigraphically older Deweyville material from within the site and the surrounding area would test this hypothesis.

***Mineral Magnetics***

One method that has been used to discriminate sediment sources is the variation in the magnetic properties of potential source materials and sediment samples of an unknown source. One of the more widely used procedures involves examining bivariate scattergrams of various magnetic properties, and, in particular, the relationship between the high-field acquisition of Isothermal Remanent Magnetization (HIRM) and the mass corrected low-field magnetic susceptibility (Xlf; see Lees 1999).

The magnetic properties of samples from four profiles of the Holocene deposits (MS1 and MS2 in the Knoll Top Block, MS4 in the West Slope Block, and MS10 in BHT-G2 on the shoulder of the north slope of the knoll), two of which include segments of the Deweyville formation, as well as samples from potential alluvial sources, were analyzed to evaluate the potential source material of the Holocene deposits. Figure A-12 illustrates the results of the XLF vs. HIRM for many of the site samples. It is clear from the figure that the Holocene deposits are significantly different from all of the potential sources, and the primary reason for this is probably their pedogenic alteration. We attempted to avoid this problem by selecting the least pedogenically altered Holocene samples, namely those from the base of each depositional unit (Holocene Units 2, 3, and 4) in the depression in the Knoll Top Block Excavation (our Profile MS2). All of the other samples (the potential source materials) are from minimally altered C horizons or fresh (raw) sediment. Unfortunately, this appears to have been insufficient to filter out the secondary pedogenic alteration of these deposits, and it appears that the magnetic measures are unable to clearly distinguish a source for the Holocene deposits.

***Quartz-Grain Surface Micromorphology by SEM***

Grain-surface textures were examined to see if they could elucidate different transportational pathways of sediment to the site. Five samples were analyzed in this way: two contemporary riverine samples collected from the floodplain, one from the Deweyville Formation underneath the Bt horizon in Profile MS10 (BHT-G2), one from Zone 1 in Profile MS2, and one from the top of MS11 (BHT-G3). Twenty-five grains per sample were examined and their features recorded on a list derived from Tchakerian (1991), Goudie (1990), and Krinsley and Doornkamp (1973). These features sub-divide into morphometric, mechanical, and chemically derived categories and can be seen in Figure A-13.

Comparison of the morphometric features shows the site matrix from MS2-30 to be more rounded (>70 percent sub-rounded or rounded) with all other samples having >48 percent of grains sub-angular or angular. There is a clear distinction in terms of adhering particles between the few associated with the riverine samples and those of the Deweyville and site matrix, which have significant amounts. The degree of chemical weathering is also greater on the Deweyville (Sample MS10-305) and Samples MS11-90 and MS2-30. The MS2-30 sample appears to have slightly more concoidal fractures and grooves than the riverine and Deweyville samples.

The very nature of this type of analysis is qualitative, and the differences displayed by the two floodplain samples demonstrate that not too great an emphasis should be placed on individual surface textures. The differences identified also have to be interpreted in the light of the different antiquities of the deposits. So, while the floodplain samples appear less chemically altered, with few adhering particles, they are 40+ ka younger than the Deweyville, which is also thought to be of a fluvial origin. Many of the above differences could be attributed to post-depostional weathering of the Deweyville. Despite the above caveats, MS2-30 seems to have a stronger affinity to the Deweyville (MS10-305 and MS11-90) samples with the increased rounding and a slight increase in concoidal fractures and grooves, perhaps reflecting the reworking event in which it was finally deposited.

***Elemental Analysis***

Another method that may permit discriminating variations in parent material is the concentration of various elements. In soil studies, the ratio of titanium to zirconium is one such measure that is often employed as a test of parent material uniformity (Birkeland 1999:164). In uniform parent materials the ratio should remain relatively constant with depth.

This ratio has been plotted for the MS1 and MS4 profiles and is of little help in discriminating the Holocene sediments from the Deweyville deposits. In MS4, the OSL dates clearly indicate that below 220-cm depth the deposit is the Deweyville Formation, yet the Ti:Zr ratio indicates no significant difference. Likewise, there is little significant variation in the entire profile. However, many of the elements illustrated on Figure A-14 (e.g., Sr, Zn, Al, Mn, Mg, Pb, Zr and Ti) clearly denote the break between the sands (presumably Deweyville Formation on the basis of the OSL dates) and the underlying Beaumont Formation clay.

In the MS1 profile (Figure A-15), there is a substantial deflection of this ratio, especially in Holocene Unit 4 (Zone 1). Unfortunately, confidence in this trend is undermined by its absence in the MS4 profile, which should exhibit the same trend if these are directly correlative units deposited by the same process.

Hence, the elemental data suggest that the site matrix is derived from the Deweyville sands, while Holocene Unit 4 may derive from a slightly different source than the rest of the site.

***Summary***

Examined together, the results of the parent material studies suggest that the source of the site deposits is the Pleistocene-age Deweyville Formation, but it is worth noting that two of the four methods that yielded useful data also yielded equivocal results. The most convincing evidence for a Deweyville source is the granulometric data, with the SEM quartz-grain micromorphology providing reasonably convincing supportive evidence. However, both the heavy mineral and elemental analyses yielded conflicting results that may be viewed as contradicting this interpretation.

***Depositional Origin of the Holocene Deposits***

One of the more challenging parts of working on the Buckeye Knoll site has been determining the depositional origin of the Holocene deposits. From the

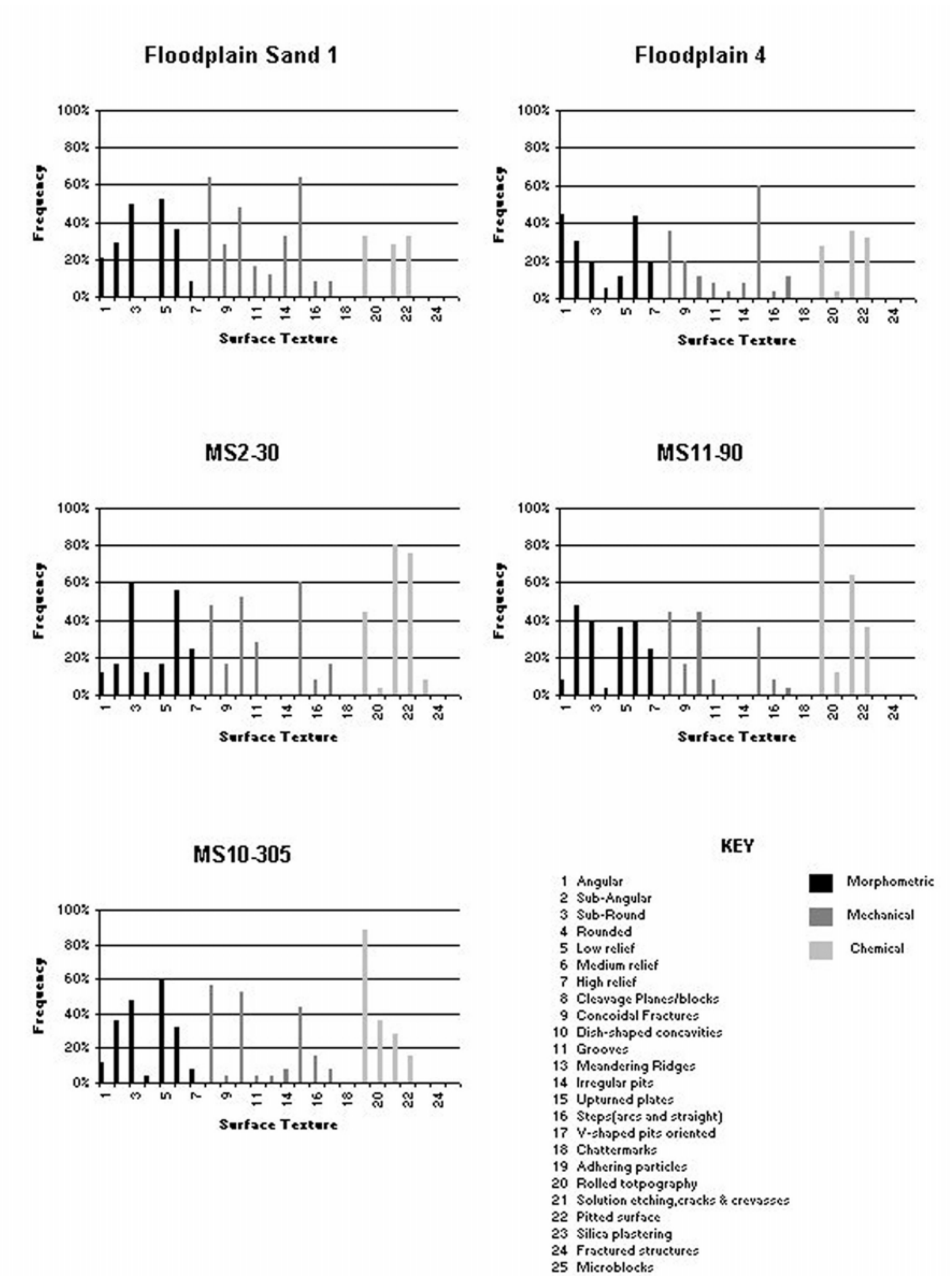



**Figure A-13.** Frequency histograms for the SFM grain surface texture analysis.

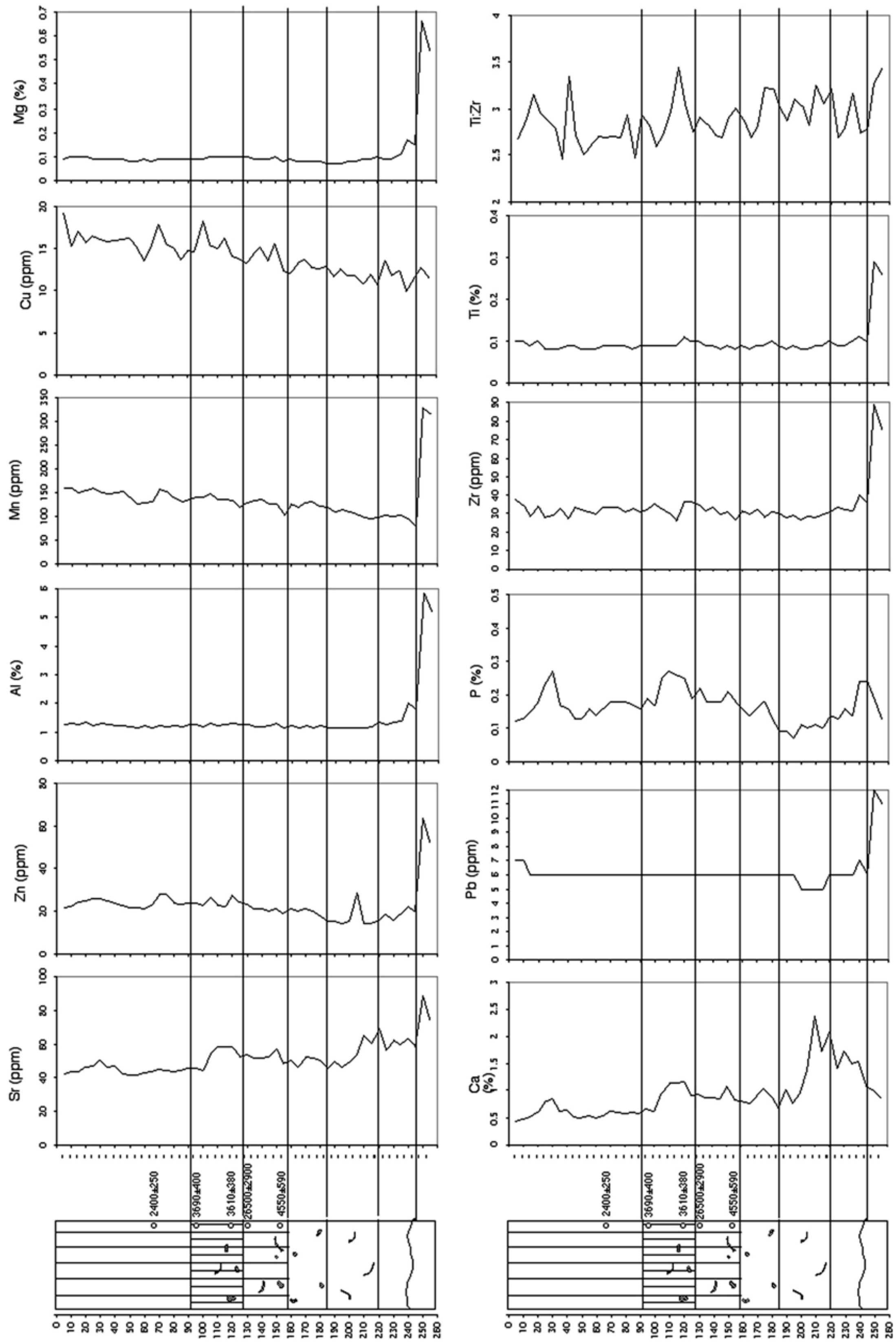



**Figure A-14.** Series of line charts depicting the stratigraphic variation in elemental abundance for various potentially anthrogenically concentrated elements in Profile MS 4, West Slope Excavation.

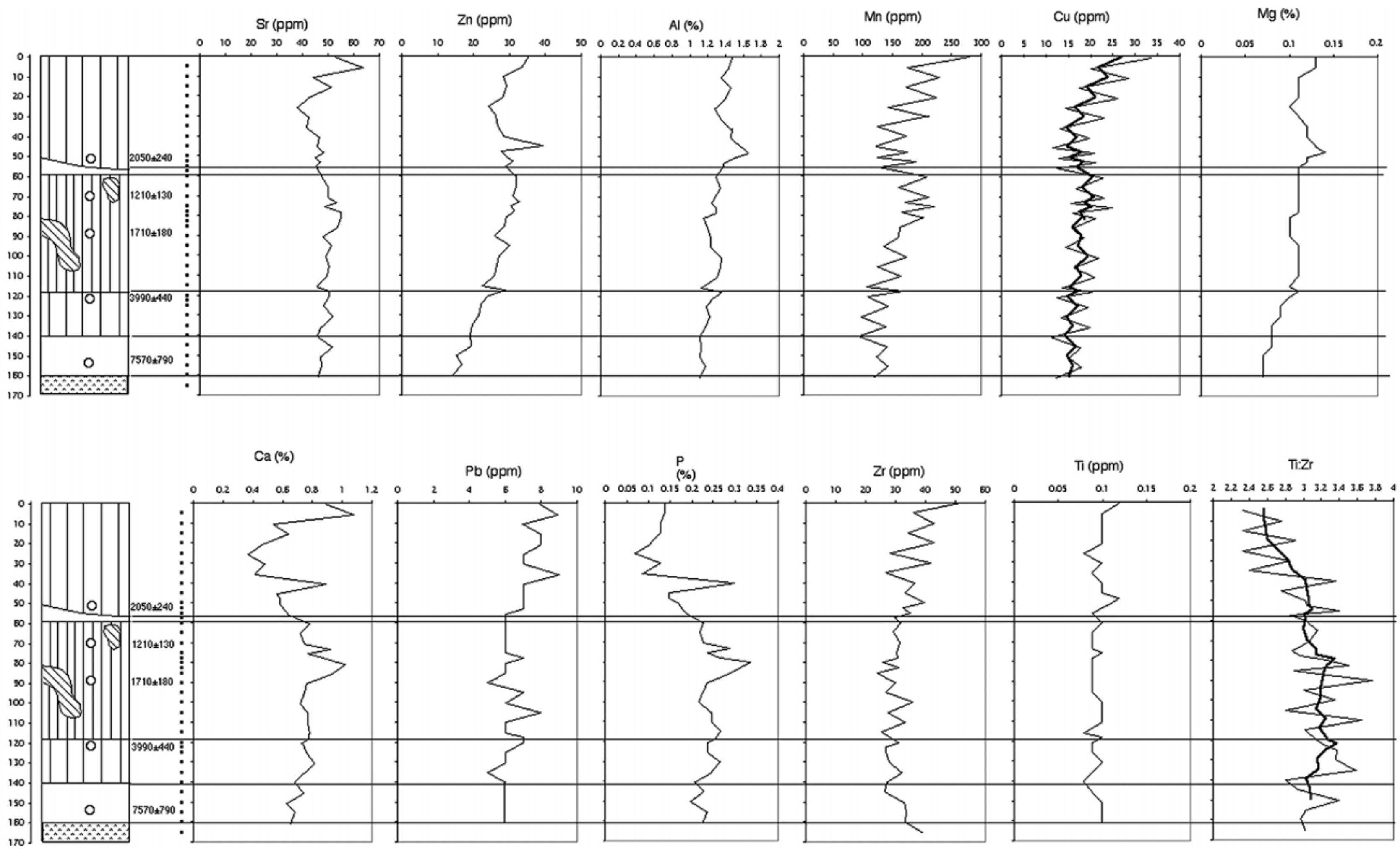



**Figure A-15.** Series of line charts depicting the stratigraphic variation in elemental abundance for various potentially anthrogenically concentrated elements in Profile MS 1, Knoll Top Excavation.

work discussed above, it seems likely that the site deposits are largely derived from the Deweyville Formation sands, although certain analyses such as the heavy mineral studies, may indicate that the Deweyville was not the sole source. When it comes to identifying the depositional process or processes responsible for the site, the most direct and simple explanation is that the deposits are attributable to local eolian reworking of the Deweyville Formation. Unfortunately, there is no direct evidence to support this hypothesis.

The granulometric attributes of the deposits are, if anything, inconsistent with this origin, because the site deposits are, in some instances, siltier than the apparent source. This discrepancy may be due to Holocene weathering of the deposits, but this would seem unlikely given the minimal pedogenic alteration exhibited by the Holocene deposits. The quartz-grain SEM micromorphology data may be used to address this issue, as some features such as upturned plates are considered to be diagnostic features of eolian transportation. However, the modern floodplain deposits show a higher frequency of upturned plates than either the Deweyville or the Holocene deposits. None of the deposits exhibited primary sedimentary structures that could be of use in settling this issue. The existence of very poorly reset Pleistocene OSL dates, bracketed by well-reset Holocene dates, could be attributable to mass movement. However, given the extensive amount of human activity at the site, much of which demonstrably included earth movement, it is impossible to rule out an anthrogenic source.

Perhaps the two most convincing pieces of evidence indicative of depositional process are the blanket-like geometry of the Holocene deposits, which accumulated more rapidly in depressions, and the age and elevation of the Holocene deposits with respect to the apparent source material. Excavation exposures and trial trenching both suggest that the Holocene deposits drape the Knoll Top. This, and the aggradational nature of the Knoll Top, would appear to best conform to an eolian depositional model. Likewise, the difference in elevation between the base of the Holocene deposits on the Knoll Top and the nearest Deweyville deposit that could have provided a colluvial source (approximately 2 meters) precludes a colluvial origin in the Holocene.

Hence, the best evidence suggests, albeit weakly, that the site deposits are attributable to local eolian reworking of the Deweyville sands. If this hypothesis is correct, the morphology of the Holocene deposits at Buckeye Knoll suggests that this was a sand-sheet depositional environment. Presumably, similar sites are present in similar stratigraphic positions throughout the Texas Gulf Coastal Plain. However, it is possible that local Holocene-age dune systems may be present on, and adjacent to, the Deweyville elsewhere in the region if eolian reworking was a significant process that was not just restricted to the edges of the formation.

### *Midden Formation Processes*

Testing of the site revealed that one particular stratigraphic unit (Zone 2; previously identified in this report as Holocene Units 2 and 3) is a probable prehistoric midden. The basis for this identification is its dark color, abundant artifactual content, and silty texture. The term "midden" is frequently used in Texas (and generally in North American) archaeology but there has been little work done to examine how different such deposits are from the parent materials or less significantly altered deposits in proximity to them. However, outside of Texas there is growing interest in how anthrogenic processes may affect sediments and soils, and, likewise, how the presence of various features (either artifacts or elements) may be used to identify deposits that might have been altered by cultural activity. Because of the significance of the Buckeye Knoll site, and the extensive, detailed, excavation data, we thought it would be worthwhile investigating various aspects of the Holocene deposits to better understand the processes that contributed to their formation, especially the anthrogenic processes. As a result, we established three lines of investigation that were designed to permit us to comment on these processes: (1) granulometry, (2) the stratigraphic variation in elements concentrated by human activity, and (3) stratigraphic variation in stable carbon isotopes.

#### *Granulometric Attributes*

In the field, the midden was noted to have an elevated silt content, as well as increased amounts of artifacts and organic matter. Following the detailed granulometric analysis of more than 200 samples from the site, it is clear that the silt content varies only slightly throughout the deposits and is not significantly greater in the midden. For instance, in Profile MS1 in the Knoll Top Block, the silt is slightly more common in the upper depositional unit (Holocene Unit 4, aka. Zone 1) than it is in the midden (Holocene Unit 3, aka. Zone 2). A similar trend is also present in Profile MS2 (located a few meters to the west of MS1) and centered on the depression in the northwest part of the Knoll Top Excavation.

In this section, the sections that combine to form the midden (Holocene Unit 2 and 3) have significantly and systematically less silt than Holocene Unit 4 (Zone 1). In particular, Holocene Unit 2 contains between 8 percent and 14 percent silt, Holocene Unit 3 contains between 15 percent to 22 percent silt, and the last depositional unit (4) contains between 17 percent and 30 percent silt. In the West Slope Block Excavation, granulometric analysis revealed little significant stratigraphic variation in the silt content. In BHT-G2 (Profile MS10) the midden does exhibit slightly more silt than the overlying strata but an amount of silt similar to the underlying Holocene unit.

Hence, the results of the granulometric work indicate that the midden does not contain more silt than the bounding units. Rather, in most cases, it is of similar silt content or slightly less than the overlying deposits. It is likely that the apparent elevated silt content indicated by field texture analysis is due to the presence of organic matter, which was removed as a standard pretreatment prior to performing the particle-size analysis. Given that the organic matter is significantly greater in this stratigraphic unit, this is a likely source of this field observation.

### *Anthrogenically Concentrated Elements*

One means of examining the potential anthrogenic nature of the midden is to examine the stratigraphic variation in elements that have been noted by previous researchers to be concentrated by human activity. The most common such element is phosphorous, which is directly concentrated through human activity, principally by human additions of organic material to the soil either in the form of organic refuse or fecal material. But, in addition to phosphorous, a number of other elements have been noted recently to be potentially concentrated by human activity (e.g., Entwistle et al. 2000; Linderholm and Lundberg 1994; Middleton and Price 1996; Parnell et al. 2002; Schlezinger and Howes 2000). Elements in this category include strontium, zinc, aluminium, manganese, copper, magnesium, calcium, lead, zirconium, and titanium. The specific vectors of anthrogenic concentration for many of these elements are poorly defined at this time, but some are fairly direct. For instance, calcium is one of the most abundant elements in hearth ash, and disposal of ash from prolonged occupation can significantly increase the concentration of this element.

To evaluate the potential anthrogenic nature of the midden and also see how it compares to other strata, we submitted samples for elemental analysis from two profiles (MS1 and MS4) to XRAL Laboratories in Fairbanks, Alaska. The samples were totally dissolved in a multi-acid digestion, and then the elemental abundance was determined by Inductively Coupled Plasma spectrometry (ICP). The results of these analyses were presented previously in Table A-2 and in graphic form on Figures A-14 and A-15.

#### *Profile MS 1*

Four (and possibly five) elements appear to exhibit a stratigraphic correlation with the midden in the MS1 profile (Knoll Top Block Excavation): phosphorous, calcium, strontium, zinc, manganese, and, possibly, copper. All of these elements exhibit a positive anomaly between 60 and 110 cm depth, but the position and magnitude of the anomaly varies considerably between them. Phosphorous, calcium, and strontium all reach a maximum around 80 cm depth, and then decline towards the top of the unit. Zinc, manganese, and copper exhibit a stratigraphically broad positive anomaly that peaks at the top of the unit and then declines into the base of the overlying stratum. Two of these, manganese and copper, also exhibit significant sample-to-sample variability, which is somewhat clarified by examining a 3-point running average (the heavier line on the plot).

Several elements (P, Ca, Pb, Al, Zn, Mg, and Ti) exhibit a prominent and discrete anomaly around 40 cm depth. In this case, strontium does not follow, suggesting that the cause of this anomaly is of a different nature than in the midden.

Nearly all of the elements exhibit a dramatic increase near the modern surface (upper 10-20 cm). However, the magnitude of this trend is variable, with it being most pronounced in Sr and Ca and the least well developed in phosphorous, the latter of which exhibits significantly lower concentrations near the modern surface than in the midden at depth.

#### *Profile MS 4*

Cursory examination of Figure A-14 clearly illustrates that some elements exhibit almost no variation throughout the profile except at the transition to the Beaumont Formation at the bottom (e.g., Al, Mg, Pb, and Ti). Other elements exhibit some stratigraphic variation but without distinct relation to the various stratigraphic units (e.g., Zn, Mn, Cu, and Zr). Several elements, however, show distinct stratigraphic anomalies that are coincident with the midden situated between 90 and 125 cm depth. The clearest elemental association is phosphorous, followed closely by calcium, and strontium. All three of these latter elements exhibit prominent anomalies in the midden, but they also denote an anomalous zone at a depth of about 30 cm, near the top of the profile. In the field, there was a noted concentration of terrestrial snail shells at this depth, but no significant soil features were observed. This should be considered a possible occupation surface. The calcium and strontium diverge from phosphorous near the base of the profile, but above the Beaumont (between 200 and 240 cm), where they exhibit a prominent anomaly that is completely out of phase with the phosphorous distribution. This portion of the profile coincides with the occurrence of minor amounts of secondary carbonate, and it is probable that the co-occurrence of the two elements is due to their geochemical affinity with calcite.

***Summary***

It is clear that there is an enrichment of phosphorous in the midden plus increases in at least two other elements (calcium and strontium). The phosphorous concentration in the midden is generally the greatest in the profile, but discrete, similar concentrations are present in overlying Unit 4 (Zone 1). The stratigraphic distributions of P do not directly correlate with the appearance of the midden but, rather, are at their greatest 10 to 20 cm below its upper boundary. Concomitant stratigraphic anomalies of calcium may indicate that the phosphorous is bound as a calcium phosphate mineral, such as apatite or dicalcium phosphate. The distribution of calcium diverges from phosphorous in some places, but is still highly correlated with strontium; this implies that strontium is geochemically tied with calcium.

***Stable Isotopic Study of Bulk Soil Organic Matter***

One of the principal attributes used in identifying Zone 2 as a midden was its dark color, which is imparted by the elevated organic-matter content. It was assumed, in light of the artifactual content of this zone, that human activity contributed more organic material to this deposit than would have occurred naturally, thereby enriching the deposit in organic carbon. It stands to reason that anthrogenic additions of organic matter may have consisted of different materials than would have been contributed to the deposits naturally, given that people would have gathered a wide range of materials and brought them back to the site for use, consumption, and eventual discard. Furthermore, given that the site appears to occupy an aggrading landform, it was thought that a detailed study of the bulk-soil organic matter might provide evidence of long term vegetation change at the site.

To evaluate these processes at a basic level, we submitted 60 samples for stable carbon isotope and total organic carbon analysis from two profiles: MS1 in the Knoll Top Excavation and MS4 from the West Slope Block Excavation. The results of these analyses are presented, together with the vertical trends in total organic carbon shown on Figure A-16 and in Table A-5 and discussed in detail below. The estimates of percentage $C_4$ biomass presented on Figure A-16 are derived from the theoretical isotopic-mixing line presented in Nordt (2001:424). In general terms, the results of the stable carbon isotopic analysis indicates that the vegetation growing on the site that contributed to the soil organic carbon has varied little throughout the Holocene, with the most pronounced changes occurring recently (the last several hundred years) and around the time Zone 1 began to accumulate (ca. 700-1,000 years ago). The isotopic composition of the bulk-soil organic matter in the midden (Zone 2) is stratigraphically variable, but consistently so, and is not significantly different from the overlying and undelying deposits. This suggests that if human activity was responsible for this accumulation, it varied consistently across the site throughout the period of formation and was not radically different from the extant vegetation.

The most significant vegetation change documented by the stable carbon isotopic analysis is an increase in $C_3$ biomass in the uppermost deposits (ca. top 15 to 20 cm). On the Knoll Top, this shift represents about a 22 percent shift from roughly 70 percent $C_3$ biomass to about 90 percent. On the west side, however, this shift is less than half this magnitude. Presumably, this is related to the establishment of the modern live-oak motte on the Knoll Top. The second most prominent vegetation shift occurred during the latter phases of midden formation and the initial depositional phases of Zone 1. During that period, the vegetation on the west side of the site shifted slightly in favor of $C_4$ plants, from approximately 30 percent $C_4$ biomass to about 37 percent $C_4$ biomass. A similar shift is observed on the Knoll Top, but the magnitude of the shift is much smaller. This anomaly may indicate a subtle but distinct period of more arid climate around that time.

A number of distinct stratigraphic variations in the carbon isotopic composition are present in the two curves, but most are of such a small magnitude that they are largely insignificant. It is perhaps worth dissecting

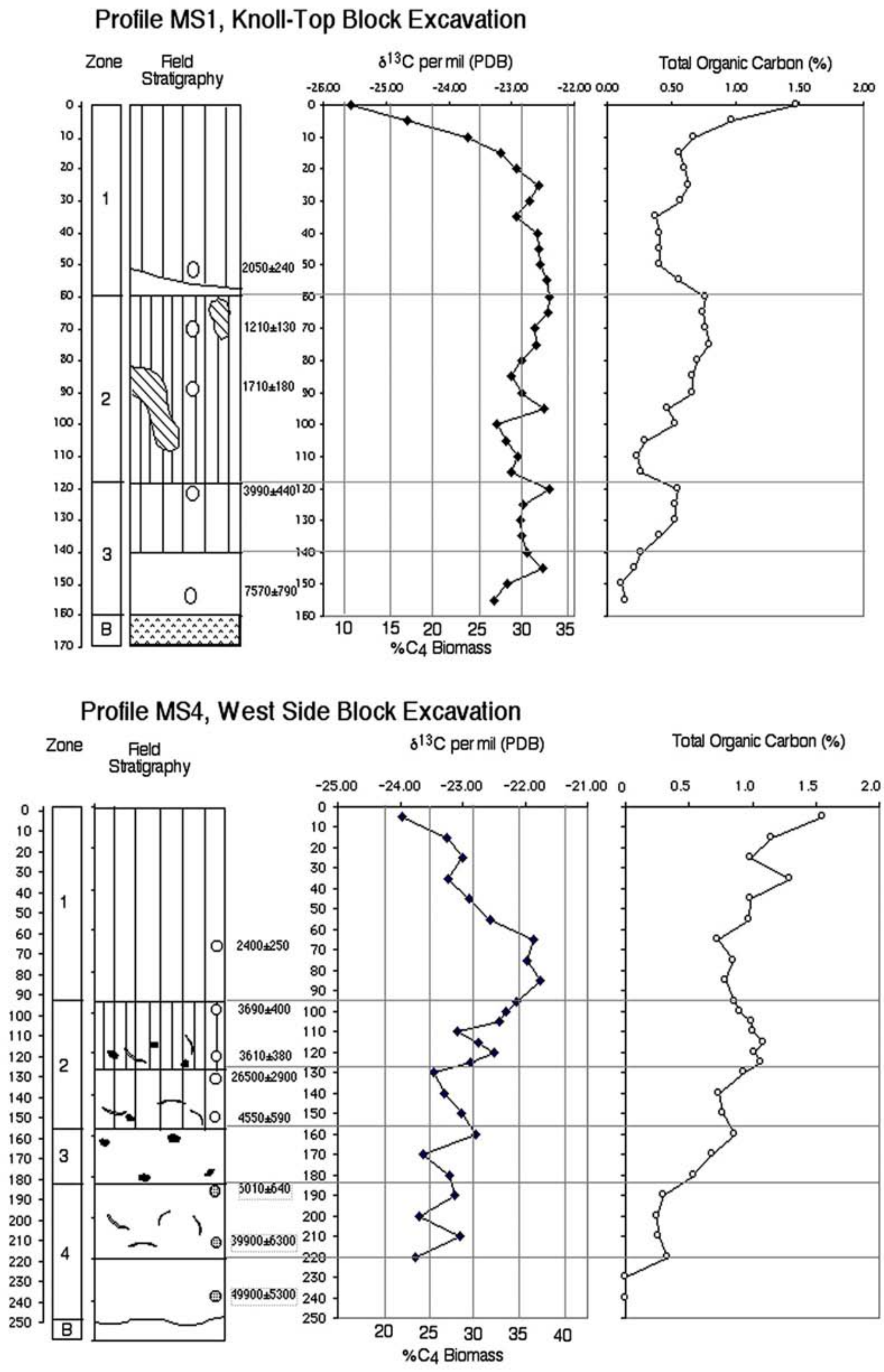



**Figure A-16.** Results of the stable carbon and total carbon content plotted with respect to the site stratigraphy profiles for MS 1 and MS 4, Knoll Top and West Slope excavations, respectively.

**Table A-5.** Stable Carbon Isotope Results from Buckeye Knoll.

| MS1 | | | MS4 | | |
|---|---|---|---|---|---|
| **Depth** | **OC (%)** | **δ13C** | **Depth** | **OC (%)** | **δ 13C** |
| 0 | 1.48 | -25.56 | 5 | 1.558 | -24 |
| 5 | 0.98 | -24.66 | 15 | 1.154 | -23.3 |
| 10 | 0.68 | -23.70 | 25 | 0.981 | -23 |
| 15 | 0.57 | -23.17 | 35 | 1.3 | -23.2 |
| 20 | 0.60 | -22.93 | 45 | 0.988 | -22.9 |
| 25 | 0.64 | -22.56 | 55 | 0.974 | -22.6 |
| 30 | 0.58 | -22.71 | 65 | 0.728 | -21.9 |
| 35 | 0.38 | -22.93 | 75 | 0.848 | -22 |
| 40 | 0.41 | -22.58 | 85 | 0.791 | -21.8 |
| 45 | 0.41 | -22.56 | 95 | 0.856 | -22.1 |
| 50 | 0.41 | -22.55 | 100 | 0.9 | -22.3 |
| 55 | 0.56 | -22.44 | 105 | 0.99 | -22.4 |
| 60 | 0.77 | -22.40 | 110 | 1.009 | -23.1 |
| 65 | 0.74 | -22.41 | 115 | 1.083 | -22.7 |
| 70 | 0.77 | -22.63 | 120 | 1.017 | -22.5 |
| 75 | 0.80 | -22.61 | 125 | 1.063 | -22.9 |
| 80 | 0.70 | -22.84 | 130 | 0.93 | -23.5 |
| 85 | 0.67 | -23.01 | 140 | 0.737 | -23.3 |
| 90 | 0.67 | -22.84 | 150 | 0.766 | -23 |
| 95 | 0.47 | -22.49 | 160 | 0.86 | -22.8 |
| 100 | 0.54 | -23.23 | 170 | 0.686 | -23.6 |
| 105 | 0.30 | -23.09 | 180 | 0.537 | -23.2 |
| 110 | 0.23 | -22.91 | 190 | 0.297 | -23.1 |
| 115 | 0.27 | -23.00 | 200 | 0.247 | -23.7 |
| 120 | 0.55 | -22.39 | 210 | 0.258 | -23.1 |
| 125 | 0.53 | -22.82 | 220 | 0.33 | -23.8 |
| 130 | 0.54 | -22.86 | 230 | 0 | na |
| 135 | 0.41 | -22.83 | 240 | 0 | na |
| 140 | 0.26 | -22.76 | | | |
| 145 | 0.22 | -22.50 | | | |
| 150 | 0.11 | -23.06 | | | |

the midden (Zone 2), because one of the principal motives for pursuing this line of inquiry was to examine whether the contribution of organic carbon to the midden differed from the deposits bounding it. The short answer to that question is "not significantly." There is, however, merit in discussing the internal variations in the carbon isotopic composition of Zone 2.

The general trend in stable carbon isotopic composition of the Zone 2 deposits is a small gradual increase in values, from its base to its top (representing a gradual shift in favor of $C_4$ plants). However, there is a significant (yet small-magnitude) anomaly within the zone that appears in both profiles. This "anomaly" consists of a discrete peak in $\Delta^{13}C$ values that represent a small shift in favor of $C_4$ plants (about 4 to 7 percent) in the middle of the midden. This anomaly is at 95 cm depth in the Knoll Top profile and at 120 cm on the West Slope profile. As with the larger $C_4$ anomaly at the base of Zone 1, the magnitude of this anomaly is greater on the West Slope than on the Knoll Top. That this anomaly appears on both profiles, and the overall stratigraphic trend in $\Delta^{13}C$ is similar in the two profiles, suggests that these are natural trends. It is also worth noting that the change in the carbon isotopic values across the Zone 1/Zone 2 interface is gradual, which suggests that the source of the vegetation was not significantly altered by this depositional event.

Overall, the stable carbon isotope analysis indicates that the major vegetation shifts on the site are recent, and that there have been subtle differences in vegetation composition on different parts of the knoll. The latter suggests that these shifts are related to either aspect or drainage, rather than significant cultural activity, although it is impossible to substantiate that inference with the data in hand.

***Organic Carbon Content***

Although there are minor differences between the two examined profiles, there are a number of distinct trends that they share. In general terms, the organic carbon content values are consistent with the visual appearance of the deposits, whereby the darker-colored deposits yield higher organic content values and the lighter-colored deposits yield less. However, there are two subtle peaks in organic carbon that were not expected given the appearance of the deposits. These include (1) a distinct enriched zone at the top of Zone 3, and (2) a broad peak in Zone 1 around 20 to 30 cm depth. Both of these features are best expressed in the Knoll Top Block profile and are discussed below.

***Buried Soil: Top of Zone 3:*** The peak at the top of Zone 3 (i.e., Zone 3A) is followed by a pronounced decline in the organic carbon content in the base of Zone 2. This suggests that there was a discrete soil formed in this position at one time. In the field, it was difficult to determine if the apparent organic enrichment was due to deepening of the A horizon associated with the midden or to a discrete and distinct soil. On the basis of the organic carbon content, it clearly appears to be a discrete palaeosol. This feature is at 120 to 130 cm depth in the Knoll Top profile and around 160 cm depth in the West Slope Excavation profile. The presence of this feature clearly supports the archaeological interpretation of a temporal gap at this point in the profile, and the small amount of organic carbon present (ca. 0.6 percent) could be used to infer the loss of topsoil, as both the midden and the modern soil have greater amounts of organic carbon. That said, some loss of organic carbon is to be expected following the burial of the soil.

***Buried Soil: Zone 1:*** The second anomaly is a distinct bulge in organic carbon between 15 and 30 cm depth in the Knoll Top profile and at 30 cm depth on the West Slope profile. Although there is a gradual increase in organic carbon throughout Zone 1, this feature is a clear and distinct anomaly within this trend and appears to represent a subtle pause in the accumulation of Zone 1. One interpretation of the anomaly is that it is the A horizon that formed on the Knoll Top prior to the establishment of the modern oak motte.

***Other Trends:*** In addition to these features, the other trend that merits brief discussion is the existence of three distinct cycles in organic carbon concentration: one within each of the major zones recognized in the field (Zones 1, 2, and 3). Each cycle consists of a basal section with low organic carbon content and a gradual increase in organic carbon to top of the zone. The most obvious interpretation of this cyclicity is that the three zones represent depositional units and the variation in organic carbon is simply associated with soils that have formed in the top of each depositional unit as the rate of sedimentation declined.

### *Burnt Clay Nodules*

Throughout the site, predominantly in Zone 2 on the Knoll Top and Zones 2 and 3 on the West Slope, burnt clay lumps or nodules were found. As part of this investigation, we undertook a study to determine the age of the clay nodules, because the act of burning them should have provided sufficient heat to thermally remove any stored luminescence signal. Upon burial, the ionizing radiation from the nodule itself, and from the surrounding sedimentary matrix, will have built up a signal that should relate to the time elapsed since the firing event. Two clay nodules were collected from within 30 cm of each other and from 112 and 122 cm below the present surface in profile MS7 in the West Slope Excavation Block. The samples were analyzed using fine-grain (1 to 8 micron) thermoluminescence (TL) at the University of Washington. Both samples showed considerable anomalous fading attributable to the feldspar content within the fine grains. The TL ages for the clay nodules are 3.595 ± 0.543 ka (UW762) and 6.759 ±1.689 ka (UW763) respectively. Correction for this fading problem, using the Huntley and Lamothe (2001) method made the calculated ages approximately 40 and 100 percent older respectively. The sedimentary OSL dates from just underneath the clay nodules gave a date of 4.54 ± 0.46 ka (Shfd01021) whilst the sample directly above the clay nodules (at 95 cm) gave an age of 3.62 ± 0.36 ka. The corrected age for UW763 is older and, when the error terms are considered, it is just barely significantly different from Shfd01021. It is impossible to completely disregard the potential that such differences may be due to some over-estimation on the part of the TL due to incomplete zeroing of the TL signal when the clay nodule was burnt, or to problems with correction for anomalous fading. However, the TL and OSL results from UW762 and Shfd01022 are similar, suggesting that both sedimentary deposition and burning of clay nodules may have occurred at a similar time.

### *Overview: Geoarchaeological Investigations*

It would be nice to conclude that the geoarchaeological investigations have provided solid observations that inform on the history and formation of the site. However, many of the studies we established in order to clarify specific aspects of the site's history have resulted in ambiguous results, leaving a less-than-clear image of the past. In general, though, the geoarchaeological studies have contributed to three basic areas of knowledge concerning the site: (1) the depositional history, (2) the chronology of the deposits, and (3) nature of anthrogenic alteration of the site.

### *Depositional History*

Detailed analysis of the site deposits has led to the identification of a four-phase depositional sequence during the Holocene. This begins with either a stable remnant of the Deweyville sands and/or Late Pleistocene/Early Holocene sandy deposits, the surface of which is settled upon during the Late Paleo-Indian period. This deposit appears to have been subsequently disturbed by mortuary practices around 7.0 ka. Sometime between then and about 6 ka, the site surface appears to have been eroded and one or more depressions created, most obviously revealed in the northwest part of the Knoll Top Excavation. The true nature of these depressions is unknown, but possibly they are gullies. Around 6 ka, sediment begins to accumulate in the low-lying portions of the site, and this phase of sedimentation persists until around 4 ka. A second phase of sedimentation appears to begin soon thereafter and continues until around 1.2 ka, although dates for this phase of deposition are variable across the site. The last phase of sedimentation appears to be diachronic, starting during Late Archaic on the lower slopes of the site and later than 1 ka on the Knoll Top. Unfortunately, much of this sequence is difficult to see as it is based on the lithologic sequences in depressions that accumulated sediment in thicker packages during phases of deposition and were often less altered by pedogenesis. Away from the depressions, the two middle phases of sedimentation weld together and are physically undistinguishable. Likewise, the basal unit, Holocene Unit 1, is lithologically indistinguishable from Unit 2 in most sections.

The most logical process responsible for the deposition of the Holocene deposits is local eolian reworking of the Deweyville sands at the margin of the Guadalupe River valley. There is potential for some colluvial processes on site as well, especially around the margins of the knoll, but on the basis of existing topography and stratigraphic information, it is difficult to entertain any process other than eolian sedimentation.

### *Chronology*

The OSL dating results presented here provide a detailed and independent dating framework for the site that can be compared with the stratigraphic occurrence of the diagnostic artifacts and with the series of radiocarbon dates from the site. Although there are a few inconsistencies within the data set, the OSL dates in general appear to be plausible and consistent with the artifactual and radiocarbon evidence. Furthermore, the OSL dating program permitted discrimination of what appear to be undisturbed Deweyville deposits from Holocene deposits of similar texture and provided a depositional date for the formation that would have been impossible using the radiocarbon method.

## *References*


Aitken, M. J.
1998 *An Introduction to Optical Dating: The Dating of Quaternary Sediments by the Use of Photo Stimulated Luminescence*. Oxford University Press, New York.

Ahmad, N., and A. Mermut
1996 *Vertisols and Technologies for their Management*. Developments in Soil Science No. 24. Elsevier, Amsterdam.

Bard, E., B. Hamelin, R. G. Fairbanks, and A. Zindler
1990 Calibration of the 14C Timescale Over the Past 30,000 Years Using Mass Spectrometric U-Th Ages from Barbados Corals. *Nature* 345:405-410.

Bateman, M. D., and J. A. Catt
1996 An Absolute Chronology for the Raised Beach Deposits at Sewerby, E. Yorkshire, UK. *Journal of Quaternary Science* 11:389-395.

Bateman, M. D., C. D. Frederick, M. K. Jaiswal, and A. K. Singhvi
2002 Getting to Grips with Bioturbation Using Luminescence. Poster presented at the International Luminescence Dating Conference, Reno, Nevada.

Birkeland, P. W.
1999 *Soils and Geomorphology*. 3 ed. Oxford University Press, New York.

Blum, M. D., R. A. Morton, and J. M. Durbin
1995 'Deweyville' Terraces and Deposits of the Texas Gulf Coastal Plain. *Gulf Coast Association of Geological Societies Transactions* 45:53-60.

Entwistle, J. A., P. W. Abrahams, and R. A. Dodgshon
2000 The Geoarchaeological Significance and Spatial Variability of a Range of Physical and Chemical Soil Properties from a Former Habitation Site, Isle of Skye. *Journal of Archaeological Science* 27:287-303.

Goudie, A.
1990 *Geomorphological Techniques*. Routledge, London.

Huntley, D. J., and M. Lamothe
2001 Ubiquity of Anomalous Fading in K-Feldspars, and Correction for it in Optical Dating. *Canadian Journal of Earth Sciences* 38:1093-1106.

Krinsley, D. H., and J. C. Doornkamp
1973 *Atlas of Quartz Sand Surface Textures*. Cambridge University Press, Cambridge, United Kingdom.

Lees, J.
1999 Evaluating Magnetic Parameters for Use in Source Identification, Classification and Modelling of Natural and Environmental Materials. In *Environmental Magnetism: A Practical Guide*, edited by J. Walden, F. Oldfield, and J. Smith, pp. 113-138. Technical Guide No. 6. Quaternary Research Association, London.

Linderholm, J., and E. Lundberg
1994 Chemical Characterization of Various Archaeological Soil Samples Using Main and Trace Element Determined by Inductively Coupled Plasma Atomic Emission Spectrometry. *Journal of Archaeological Science* 21:303-314.

Middleton, W. D., and D. T. Price
1996 Identification of Activity Areas by Multi-Element Characterization of Sediments from Modern and Archaeological House Floors Using Inductively Coupled Plasma-Atomic Emission Spectroscopy. *Journal of Archaeological Science* 23:673-687.

Murray, A. S., and A. G. Wintle
2000 Luminescence Dating of Quartz Using an Improved Single-Aliquot Regenerative-Dose Protocol. *Radiation Measurements* 32:57-73.

Nordt, L. C.
2001 Stable Carbon and Oxygen Isotopes in Soils: Applications for Archaeological Research. In *Earth Sciences and Archaeology*, edited by P. Goldberg, V. T. Holliday, and C. R. Ferring, pp. 419-448. Kluwer Academic/Plenum Publishers, New York.

Olley, J. M., G. G. Caitcheon, and R. G. Roberts
1999 The Origin of Dose Distributions in Fluvial Sediments, and the Prospect of Dating Single Grains from Fluvial Deposits Using Optically Stimulated Luminescence. *Radiation Measurements* 30:207-217.

Otvos, E. G.
2001 Northern Gulf Pleistocene Valley Evolution and Luminescence Chronostratigraphy; Role of Sea-level, Sediment Supply and Tectonic Uplift. Paper presented at the 113th Annual Meeting of the Geological Society of America, Boston.

Prescott, J. R., and J. T. Hutton
1994 Cosmic Ray Contributions to Dose Rates for Luminescence and ESR Dating: Large Depths and Long-Term Time Variations. *Radiation Measurements* 2/3:497-500.

Parnell, J. J., R. E. Terry, and Z. Nelson
2002 Soil Chemical Analysis Applied as an Interpretive Tool for Ancient Human Activities in Piedras Negras, Guatemala. *Journal of Archaeological Science* 29:379-404.

Schlezinger, D. R., and B. L. Howes
2000 Organic Phosphorus and Elemental Ratios as Indicators of Prehistoric Human Occupation. *Journal of Archaeological Science* 27:479-492.

Sylvia, D. A.
2002 Response of the Brazos River Dispersal System to Latest Pleistocene Climatic Variation and Eustatic Change. Unpublished Ph.D. dissertation, Department of Geological Sciences, University of Texas at Austin.

Tchakerian, V. P.
1991 Late Quaternary Eolian Geomorphology of the Daleo Lake Sand Sheet, Southern Mojave Desert, California. *Physical Geography* 12:347-369.

XRAL, Ltd.
n.d. ICMS80 – Geochem Analysis by Multi Acid Digestion / ICP-ES and ICP-MS. Document in possession of the authors.

## Appendix B

# Palynological Analysis

**Bruce M. Albert**

### *Methodological Background*

Pollen analysis of alluvial sediments poses particular problems of technique and method. Alluvial sediments consisting mainly of mineragenic particles with relatively little organic matter may prove difficult to reduce using standard chemical techniques designed for the treatment of peat and lake sediments. Despite such difficulties, the attraction of alluvial sediments lies in the frequency in which anaerobic, if not subaqueous, conditions are present, thus providing conditions favorable for pollen preservation.

On the other hand, the limitation of alluvial sediments for pollen analysis is the relative difficulty with which such sediments are reduced in the laboratory. This is the case particularly where a high proportion of clay particles is encountered, as clay makes gravity separation of pollen from mineragenics difficult, and certain clays may also be resistant to chemical (HF, or hydroflouric acid) treatment. Also, clay matrices are more likely to have experienced periodic drying relative to deposits of silt and sand closer to the active stream or river channel.

Problems of low initial pollen deposition also occur where fall-out velocities of a given stream or river channel above a given sedimentary matrix exceed the lower threshold requisite for the sedimentation of most pollen grains. As a result, alluvial sediments containing a high proportion of sandy sediments will rarely contain a great concentration of pollen grains. Thus, reduced silty (and particularly fine silty) sediments present the best prospects for alluvial pollen analysis, due to their indication of more favorable conditions for pollen preservation and high initial concentration. Such alluvially recruited pollen grains, once extracted, are likely to represent a spectrum of flora lying within the (dendritical) watershed, and thus reflect a taphonomic regime dominated by water- rather than air-transport of pollen. The land area represented by this vegetation is thus "dendritic" (following from the alluvial network) rather than "radial" (as is often the model at geo-botanical sites where the airborne recruitment of pollen predominates).

It is thus inferable that river-valley flora will be represented in alluvial pollen spectra at the expense of that of the interfluves, although enhanced sedimentation rates of grassland *vis a vis* woodland areas within a given river valley may still favor the representation of non-tree pollen within the valley. As a result, the quantitative relationship between actual aforestation levels and the ratio of tree to non-tree pollen is complex.

Once these taphonomic factors are assessed, interpretations of primary pollen data can be made on the basis of reconstructed vegetation communities, as well as their direct pollen responses.

A rough reckoning of vegetation cover in the area of pollen catchment allows for a reconstruction of human subsistence where pollen taxa may be directly indicative of economically important plant species such as pecan. More generally, pollen taxa may be indicative of overall biomass availability within this area, in terms of both floral and (inferable) faunal resources therein. More complex relationships between pollen evidence and climate are also explorable, on the basis of both the local presence of presently exotic species and the relative pollen responses of a wide array of taxa. As analog pollen taxonomic responses to summer temperature and annual precipitation are usually calculated after airborne rather than waterborne taphonomic situations, hypothetical transforms or "r-values" are proposed with which the climatic indicative values of alluvial pollen spectra may be estimated.

### *Site Introduction and Overview*

Pollen analyses of two cores from the Guadalupe River floodplain adjacent to the Buckeye Knoll site permit a preliminary reconstruction of regional vegetation history on the Central Texas Gulf Coastal Plain from 9500/9000 cal. B.P. until present[1]. During this period, significant changes in floral environment, climate, and general conditions for subsistence are evidenced in twenty-one zonal changes in pollen assemblages. These pollen "chrono-zones" track changes in the response surfaces of pollen taxa, as well as the waxing and waning of alluvial woodland, tall grassland, and dry grassland (or forbic) floral communities.

The appearance of presently exotic species, as well as proportional changes in general floral communities, is inferred to relate primarily to periodic variations in effective precipitation and temperature. The two cores discussed herein are far enough from the coast to exclude a significant influence of sea-level change on the flora represented in these twenty-one pollen chrono-zones. Core 1 ("P1") was retrieved from the pre-2600 cal. B.P. slack-water margin and alluvial accretion surface of the eastern part of the Guadalupe River floodplain (Figure B-1). Core 2 ("P2") was retrieved from an oxbow deposit of post-1500 cal. B.P. date, which unconformably overlies Pleistocene clays. The depositional environment of P1 is almost entirely sub-aqueous and anaerobic, while that of P2 is rendered largely anaerobic through periodic ponding and capillary action. A generally acidic sedimentary matrix has also promoted pollen preservation at these locations.

Viable pollen samples are derived from Core P1, the longer of the two cores showing fine-to-coarse alluvial sediment to a depth of 480 cm, and the shorter Core P2 containing mixed colluvial and eolian sediment to a depth of 192 cm. From P1, a series of six AMS and radiometric assays (all sequential with respect to depth) date to between 7700 and 1720 cal. B.P., while from P2, a basal AMS assay produced a one-sigma range between 1420 and 1350 cal. B.P. Unfortunately, significant data gaps in the viable pollen sequences occur intermittently between 6500 and 5500 cal. B.P., and continuously between 2600 and 1800 cal. B.P. Judging by qualitative visual assessments of pollen preservation, as well as quantitative pollen concentration according to contextual stratigraphic data, these gaps are most likely a result of low initial pollen deposition rather than post-depositional degradation. Slow rates of sediment accumulation between 4000 and 3000 cal. B.P. also limit the chronological resolution of pollen data from this period.

The pollen flora from viable samples have been ordered into six regional biotic groupings. Progressing from the river's edge to the interfluves, these groups include: (1) Riparian vegetation, (2) Floodplain woodlands, (3) mesic grasslands, (4) sub-xeric scrub, (5) sandy wastes, and (6) Forbic vegetation. An increase in the species richness and composite pollen response of the floodplain woodland is thought to be reflective of more mesic conditions. Particularly wet environmental conditions are inferable after uniformitarian (or direct bio-geographic comparison) principles with the regional or local appearance of boreal riparian woodland taxa, such as *Alnus* and *Betula*, that presently are restricted in Texas to river valleys east of the Trinity River. The pollen response surfaces of these taxa are also useful towards the reconstruction of specific temperature and precipitation conditions.

Of extraregional significance is a long-distance transport component of *Pinus* and *Ephedra*, although a possibility of local pine growths is suggested in palynological findings in Zone 5 at Core P1, when very high *Pinus* values are registered in tandem with an absolute maximum of *Betula*. More xeric conditions are inferable after the waxing of forbic communities, which reflect the expansion of dry grasslands and natural clearances on the floodplain itself. A *Compositae* flora make up much of the forbic division, although particularly xeric conditions may be inferred after the *Chenopodiaceae* pollen response, as this pollen type includes many halophytic species. Key tropical environmental indicator taxa include *Palmae* pollen, which makes an acute appearance in the sub-xeric Zone P1:2.

Conditions for human subsistence change markedly in the regional history of the Holocene. Of the various arboreal taxa, *Carya* (pecan) is presumably the most important for human subsistence due to the

[1] Three cores actually were extracted during the current research. However, one of the cores (Core P3) was of relatively shallow depth and basically replicated the stratigraphic sequence revealed by Core P2, and was therefore not analyzed (see later discussion).

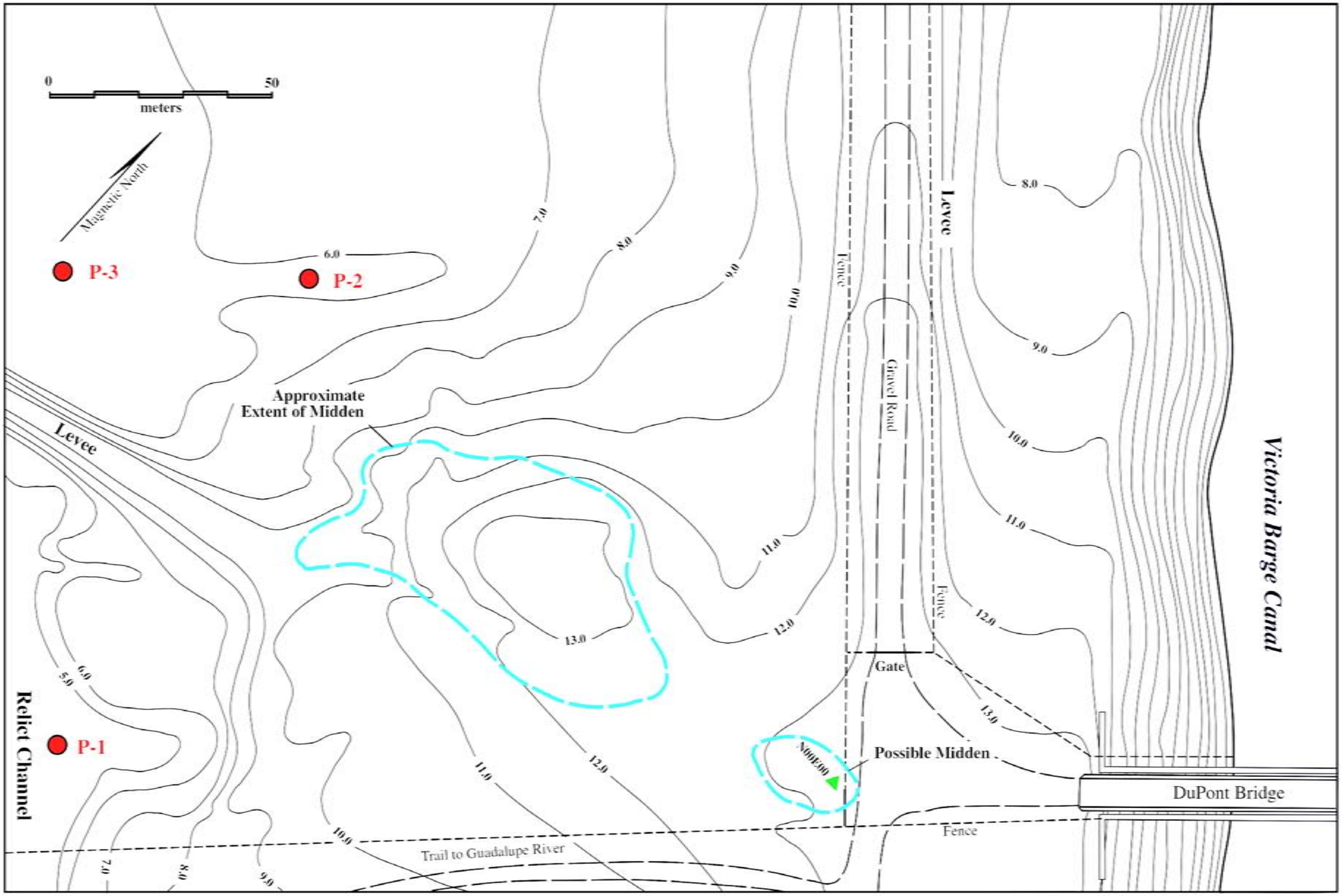



Figure B-1. A topographic map of the Buckeye Knoll Site showing the locations of three floodplain sediment cores extracted for pollen analysis. (Note that Core P3 was not analyzed due to its shallow depth and stratigraphic similarity to Core P2.)

high food value of the nut. From both cores, there is evidence for a high correlation between *Carya* pollen maxima and apparent peaks of settlement intensity at Buckeye Knoll.

### *Geo-Botanical Fieldwork at Buckeye Knoll*

The extraction of analyzed sediments at Buckeye Knoll was achieved with a mobile Geoprobe 54LT percussion-boring device provided and operated by Dr. Glen Doran of the Department of Anthropology, Florida State University. The Geoprobe was highly efficient in recovering pollen cores from the minerагenic sediments on the eastern margin of the Guadalupe floodplain immediately adjacent to the Buckeye Knoll site. Three pollen cores were extracted, and were designated as P1, P2, and P3. The locations of these cores are shown in Figure B-1. Of these three pollen cores, P1 yielded the longest post-Pleistocene sequence within an alluvial content. The base of this sequence is at the surface of the Beaumont clay at a depth of 490 cm. The entirety of the alluvium, from 145 to 490 cm, appears reduced, although a horizon of calcium carbonate precipitate is notable between ca. 460 and 450 cm. Much shallower post-Beaumont colluvial deposits are encountered in the medial core P3, with the basal contact with the Beaumont Formation at a depth of 202 cm. In Core P2, a sloping Beaumont surface was encountered between 222 and 192 cm. Above this sloping contact, a largely colluvial, reduced sedimentary matrix occurs; the reduced appearance is most likely a product of near-continuous ponding from and capillary action of the water table. Due to the reduced condition of the sediments, pollen samples were extracted from Cores P1 and P2. As Core P3 basically replicated most of the P2 sequence, the remainder of this study will revolve around Cores P1 and P2.

### *Stratigraphy, Dating, and Rates of Accumulation*

Cores P1 and P2 reflect a Holocene accumulation of reduced alluvium and colluvium above an unconformable Beaumont surface. Core P3 had little depth, probably due to its location near the base of the sloping valley wall of a minor drainage, and thus it was decided that palynological analysis here would probably not add to the data from Cores P1 and P2. The stratigraphic sequence in Core P1 is shown in Figure B-2, along with the calibrated age of dated sediments. The dates are summarized in Table B-1.

#### *Core P1*

Core P1 produced a basal deposit (490 to 460 cm) of very poorly sorted Holocene sediment that consists of clayey sand with colors ranging between 10YR 6/2 and 5/1 hue. This deposit rested directly on Beaumont Formation clay that had a color of 10YR 7/4 and inclusive caliche modules. The Holocene sediments are indicative of variable water flow conditions. Above this basal Holocene unit (at 460 to 450 cm) is a distinctive sedimentary change, represented by a deposit consisting of 10 cm of coarse-grained silty sand (10YR 4/1 in color), interspersed with calcium carbonate inclusions.

Following upon this silty-sand unit is a long sequence (450-145 cm) of reduced silt-sand alluvium. An intermittent colluvial influence is also discernible in sporadic finds of gastropods and *Rangia* in these layers. A tendency towards increased clay deposition in the upper part of the alluvium may reflect incipient fallout effects of lower water velocities locally experienced as the river channel began its late Holocene (post-3000 cal. B.P.) migration westward towards its modern position.

Color variations in the main alluvial unit (450-145 cm) in Core P1 are related to variable charcoal content, as revealed during light microscopic (LM) work. From this observation, it might be inferred that fire frequency (or extent) was greater during the middle period of (darker, 10YR 2/1) sedimentary accumulation than during the earlier or later periods when lighter-colored (10YR 3/1 and 10YR 3/2) sediments were deposited. In general, this middle period of ca. 5100 to 4900 cal. B.P. produces pollen evidence for complex depositional events at Core P1, likely reflecting initial pulses of colluviation in more sandy strata (definable from a BHT exposure adjacent to Core P1), followed by a period (post-2000 cal. B.P.) of oxbow formation with reduced clays.

A series of six AMS and radiometric assays date the overall sequence at Core P1. The assays results are all sequential with respect to depth, although variation in rates of deposition are discernible.

Below the basal AMS date in P1, rates of accumulation for sediment between 490 and 430 cm cannot be established. However, a hypothetical accumulation rate whereby 1 cm equals 34 years, might be extrapolated from the earliest assays (Beta-164221 and Beta-164222) for the basal deposit on a provisional basis. This provision produces a ca. middle tenth millennium

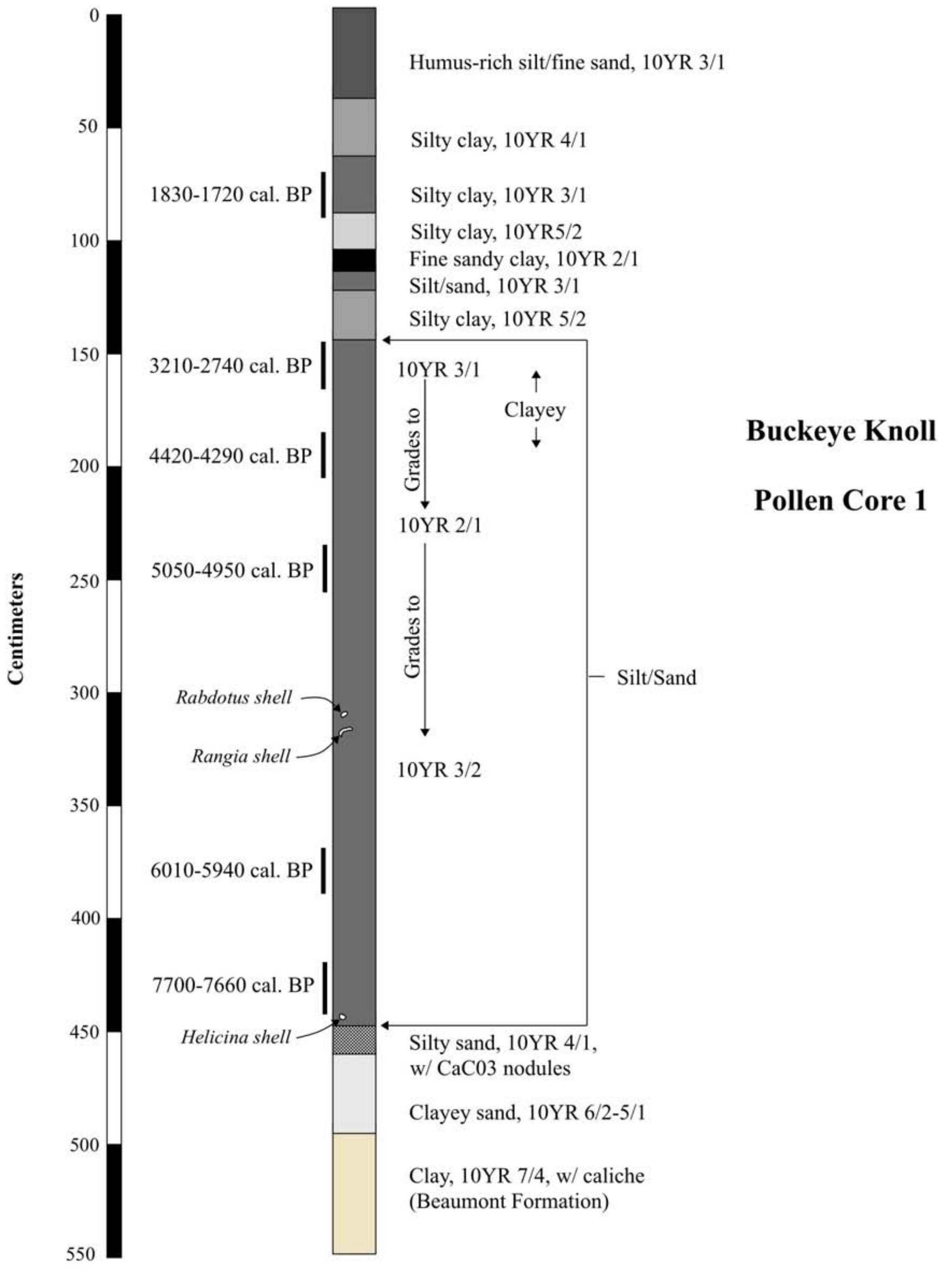



**Figure B-2.** Diagram of Pollen Core P1 showing stratified sediments, Munsell colors of those sediments, and depths and calibrated age ranges for the six radiocarbon dates from the core.

**Table B-1.** AMS and Radiometric Dating of Core P1.

| Depth (cm) | Sediment | Beta Analytic, Inc. Sample No. | Uncalibrated Age (B.P.) | Calibrated Age Range (B.P.) (1 Sigma) | Dating Method |
|---|---|---|---|---|---|
| 430 | Silt-Sand | 164222 | 6820 ± 40 | (7700-7660) | AMS-Humate |
| 380 | Silt-Sand | 164221 | 5260 ± 40 | (6010-5940) | AMS-Humate |
| 250 | Silt-Sand | 164220 | 4420 ± 40 | (5050-4950) | AMS-Humate |
| 200 | Silt-Sand | 164219 | 3920 ± 40 | (4420-4290) | AMS-Humate |
| 160 | Silt-Sand | 164218 | 2780 ± 110 | (3210-2740) | Radiometric |
| 80 | Silty Clay | 164217 | 1840 ± 40 | (1830-1720) | AMS-Humate |

(cal.) B.P. date range for the sandy clay contact above the Pleistocene Beaumont clay.

***Core P2***

In Core P2, a lensed colluvium, mostly of reduced aspect, was present down to the contact with the sloping Beaumont surface (Figure B-3). A sole basal AMS age (Beta-164223) of 1520 ± 40 B.P. calibrates (at 1 sigma) to 1420-1350 B.P.

Interspersed in the complex colluvial strata at Core P2 are lenses of pure (eolian?) sand. An emphatic bi-pulsatory expression of eolian conditions occurs at around 70 cm, where twin sandy layers were deposited that bound a thin clay layer containing the subxeric local pollen Zone P2:4. The sharply defined and complex stratigraphic divisions observable throughout Core P2 also suggest that its reduced deposit has been subjected to minimal post-depositional bioturbation.

Well-defined, vertically distinct, and phyto-taxonomically sensible pollen zonation established from the palynology of the Core P2 colluvium, along with highly discrete, level-to-level variations in pollen concentration in these strata (see below), are also unlikely to reflect conditions of significant vertical soil movement and mixing of pollen of a secondary character.

### *Laboratory Methodology and Pollen Sample Viability*

A total of 97 pollen samples (all with volumes of 10 $cm^3$) from 62 levels was extracted and reduced from Cores P1 and P2. Double samples were reduced for certain low-pollen-concentration layers in Core P1 in order to achieve statistically viable counts in cases where undegraded pollen was present, albeit in low quantities. For Zone P1:1 (A-D), of probable Paleo-Indian age, triple samples were reduced.

These 97 primary pollen samples were first immersed in a 5 percent solution of sodium hexa-metaphosphate in distilled water in order to deflocculate mineragenic particles and organics. Deflocculated samples were then filtered through a 171-micron brass screen in order to remove particles larger than pollen. The retained effluent was then filtrated by means of sieving with a "Gilson" SS-15, using turbation through an 8-micron "nytex" screen, retaining the larger fraction. Turbation deters the stretching of the nytex beyond its rating, reducing pollen loss to a very low order of magnitude. A use of nytex, provided through the Southern Illinois State Museum, is also advisable where clay volumes are greater than 1 $cm^3$ in sample material. This is because a mutual O-H attraction of clay particles reduces cation penetration (especially in kaolin), and hence their chemical reactivity with HF, while effective HF reactions with $SiO_2$ produce silico-flourides, which are reduced via hot HCL. Thus, a pre-chemical reduction in potential silico-flouride mass will reduce real dangers of pollen loss in the exine-sensitive, HF-subsequent hot HCL chemical treatment, while the cation exclusion of kaolins is minimized via phosphate-deflocculation and filtration.

The remaining sample between 8 and 171 microns in size was then reduced chemically through the addition of HCL, KOH, HF, hot HCL, and an acetolysis solution of 90 percent acetic anhydride and 10 percent

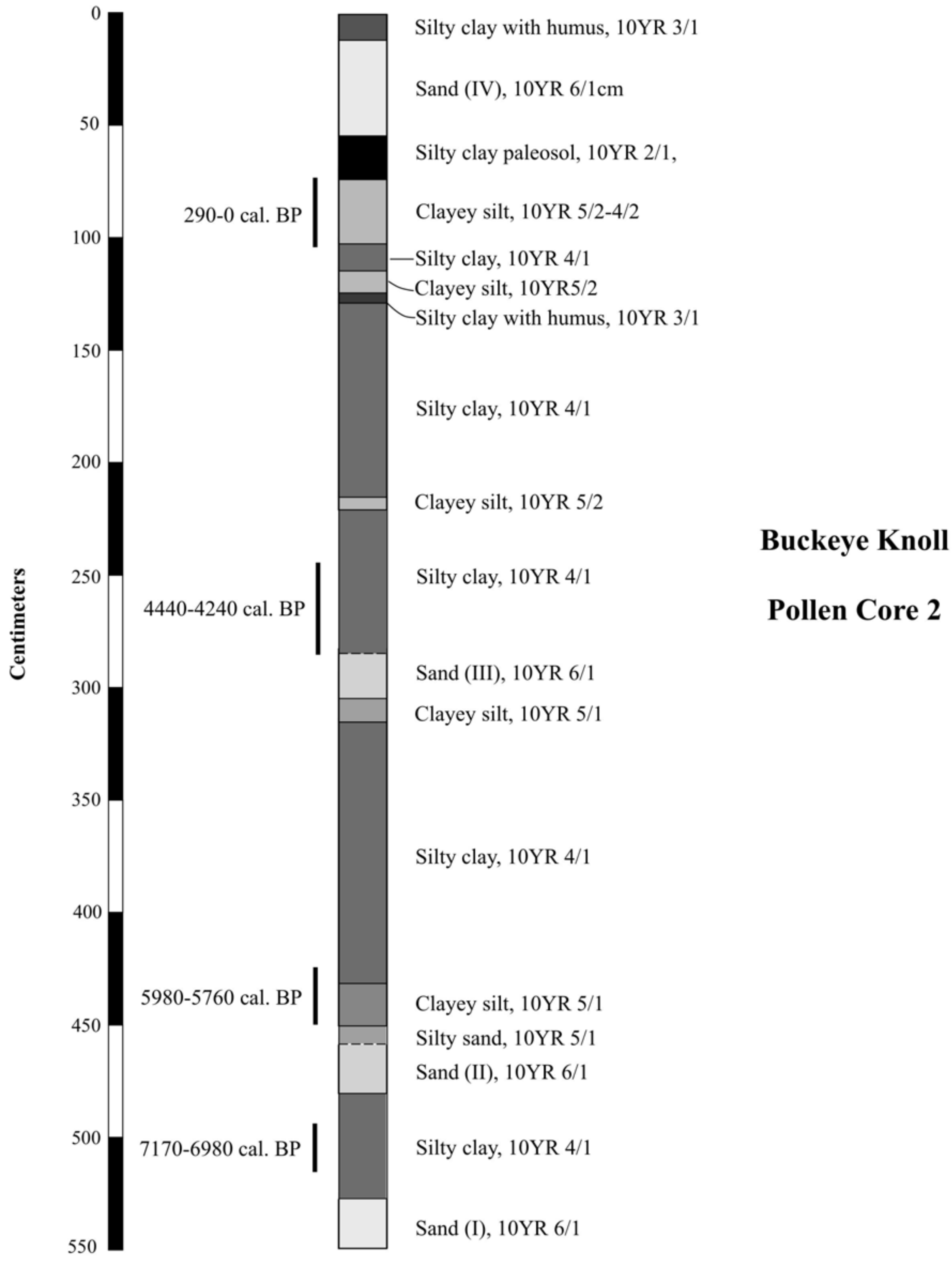



**Figure B-3.** Diagram of Pollen Core P2 showing stratified sediments, Munsell colors of those sediments, and depths and calibrated age ranges for the six radiocarbon dates from the core.

sulfuric acid. Subsequently, an identical chemical reduction was also made to check pollen loss in three samples of clay effluent from filtration processing. In order to ascertain pollen concentration in each of these 103 (primary and effluent) samples, tablets of 6000 *Lycopodium* club-moss spores, through the courtesy of Thomas Persson of the Department of Quaternary Geology, Lund University (Sweden), were introduced. Pollen concentration could then be calculated after the original volume of sample sediment and the number of spores encountered in LM work.

This grand total of 103 samples was then cleaned in distilled water, dehydrated in ethanol, and stained in a solution of safranine and ethanol. The pollen preparations were finally mounted in a matrix of 2000-viscosity silicone oil for purposes of LM analyses, with the aim of achieving counts of between 150 and 500 grains. The latter range is deemed statistically sufficient for purposes of general environmental reconstruction (Faegri et al. 1989). Notably, pollen loss in turbational nytex-filtration is calculated to be ca. 0.1 to 0.5 percent, after concentrations observed in the clay effluents *vis a vis* the retained sample matter, based on total counts of 800 *Lycopodium* spores.

Of the 62 levels analyzed from 97 primary pollen samples from Cores P1 and P2, statistically viable counts of non-degraded pollen were achieved in 39 levels. Of the non-viable sample-levels, conditions of pollen degradation or low initial concentration are suspected in eleven cases of colluvium (P1:6-10 and P2:8-9, 12, and 17-19), while problems of low initial concentration are suspected in alluvium from twelve sample levels from Core P1 (15, 20, 22-3, 29, 32-4, 36, 39, 42, and 45; see Table B-2).

### *Pollen Concentration in cores P1 and P2*

Pollen concentration in cores P1 and P2 varies largely due to factors of initial pollen recruitment into sediment, where such taphonomy is determined by (1) rate of colluvial accumulation (esp. in Core P2) as compared to rates of airborne pollen deposition (an inverse relation) and (2) fall-out velocities of waterborne pollen in alluvial sediment (especially in Core P1).

In the case of colluvial deposition, it can be assumed that cumulic sediments in the vicinity of the Buckeye Knoll site will contain little pollen unless such deposits derive from contemporaneous surfaces. This is because pollen exines will degrade within a matter of decades in circumstances of enhanced microbial activity under oxidation in basic soils or those of moderate acidity. Exceptions to this rule include certain sporo-pollenin-rich, degradation-resistant taxa such as *Pinus* and *Abies*. In a given colluvial deposit, pollen from the contemporaneous surface will be preserved if the colluvium is primarily deposited under anaerobic (and preferably acidic) conditions, conditions most commonly attributable to ground water action or ponding.

Rapid colluviation into a ponded (e.g., oxbow) situation will tend to reduce pollen concentration for two reasons. Firstly, direct airborne pollen deposition is time-dependent, and higher volumetric rates of accumulation will dilute this constant input in an inverse relation. Secondly, rapid accumulation will lead to the deposition of a higher proportion of sub-surface, older-source sediment containing low concentrations of degraded pollen, thus reducing the concentration of total pollen in the consequent accumulation. High relative *Pinus* values are often encountered in such consequent accumulations, due to the resistance of pollen of this taxa to degradation. Notably, one demonstrable case of secondary deposition occurs in the uppermost oxbow stratum of Core P1 (Sample 1, 37 cm), where an isolated, if highly degraded *Abies* grain must reflect the erosion and accumulation of local sandy sediments of Pleistocene date. In any event, little interpretive weight is given to the pollen of these conifers.

In the case of alluvium, waterborne pollen concentration is modulated by the specific gravity (0.3-1.0, depending on water-logging, cf. Firbas 1949) and size range (ca. 15-100 microns) of pollen grains that determine their fallout velocity in a fluvial system. Because turbulence on a stream-bed will prevent the fallout of particles with a smaller diameter (0.2 mm) and lower specific gravity (in silicates, this is 2.5) than sand grains, pollen will only fall out of suspension in slack-water deposits containing finer sediments, particularly the finest silt-fraction, whose fallout characteristics “mimic” those of most pollen grains. Lower concentrations of hydrologic pollen will thus be encountered in predominantly clayey, vertical-accretion deposits of the extreme slack-water margins of the lower Guadalupe River.

In the case of Core P1 alluvium, sediments in the main middle-to-upper unit vary in size largely between finer sands and coarser silts, while lower units above the Beaumont clays consist largely of sands and clays. Pollen concentration in the composite alluvium is generally low (see below), and ranges mostly between 50 and 400 grains per $cm^3$. This concentration range is

**Table B-2.** Pollen Concentration, Sample Viability, and Viable Sample Zonation in Cores P1 and P2.

| Sample | Depth (cm) | Pollen Concentration (grains/cm$^3$) | Viability (Zone) |
|---|---|---|---|
| **Core P-1** | | | |
| P1:45 | 490 | ~0.0 | NV |
| P1:44 | 480 | 74.0 | 1A |
| P1:43 | 470 | 104.3 | 1B |
| P1:42 | 460 | 46.9 | NV |
| P1:41 | 450 | 106.2 | 1C |
| P1:40 | 440 | 315.7 | 1D |
| P1:39 | 430 | 54.0 | NV |
| P1:38 | 420 | 221.1 | 2 |
| P1:37 | 410 | 121.2 | 2 |
| P1:36 | 400 | 12.0 | NV |
| P1:35 | 390 | 118.5 | 3 |
| P1:34 | 380 | ~0.0 | NV |
| P1:33 | 370 | ~0.0 | NV |
| P1:32 | 360 | 22.6 | NV |
| P1:31 | 350 | 181.5 | 3 |
| P1:30 | 327 | 706.3 | 4 |
| P1:29 | 317 | ~0.0 | NV |
| P1:28 | 307 | 370.9 | 5 |
| P1:27 | 297 | 313.0 | 5 |
| P1:26 | 287 | 197.5 | 5 |
| P1:25 | 277 | 344.7 | 5 |
| P1:24 | 267 | 264.0 | 6 |
| P1:23 | 257 | ~0.0 | NV |
| P1:22 | 247 | ~0.0 | NV |
| P1:21 | 237 | 280.0 | 6 |
| P1:20 | 227 | ~0.0 | NV |
| P1:19 | 217 | 1473.4 | 7 |
| P1:18 | 207 | 149.4 | 8 |
| P1:17 | 197 | 104.7 | 9 |
| P1:16 | 187 | 221.6 | 10 |
| P1:15 | 177 | 6.0 | NV |
| P1:14 | 167 | 295.6 | 11 |
| P1:13 | 157 | 118.6 | 11 |
| P1:12 | 147 | 125.9 | 12 |
| **Core P-1 (cont.)** | | | |
| P1:11 | 137 | 211.0 | 12 |
| P1:10 | 127 | ~0.0 | NV |
| P1:9 | 117 | 43.6 | NV |
| P1:8 | 110 | ~0.0 | NV |
| P1:7 | 100 | 36.0 | NV |
| P1:6 | 90 | ~0.0 | NV |
| P1:5 | 80 | 704.7 | 13 |
| P1:3 | 60 | 1356.8 | 14 |
| P1:1 | 37 | 1200.0* | 15 |
| **Core P-2** | | | |
| P2:19 | 222 | ~0.0 | NV |
| P2:18 | 212 | 8.0 | NV |
| P2:17 | 202 | 1.7 | NV |
| P2:16 | 192 | 708.8 | 1 |
| P2:15 | 182 | 268.6 | 1 |
| P2:14 | 172 | 130.2 | 1 |
| P2:13 | 162 | 73.8 | 2 |
| P2:12 | 152 | ~0.0 | NV |
| P2:11 | 142 | 3685.7 | 2 |
| P2:10 | 132 | 598.0 | 3 |
| P2:9 | 122 | 1836.0 | 3 |
| P2:8 | 112 | ~0.0 | NV |
| P2:7 | 102 | ~0.0 | NV |
| P2:6 | 92 | 2323.4 | 3 |
| P2:5 | 82 | 303.0 | 3 |
| P2:4 | 72 | 2017.2 | 4 |
| P2:3 | 62 | 1000.0 | 5 |
| P2:2 | 52 | 444.4 | 5 |
| P2:1 | 42 | 4762.5* | 6 |

NV — Pollen count not statistically viable.
* — Compression due to the fact that the Geoprobe has increased time-depth and physical density of these near-surface samples.

only around 0.5 to 4.0 percent of that encountered by the author in pure fine silts (of Bronze Age date) at the alluvial pollen site of Vransky Potok, in northwest Bohemia (Albert 2005). This comparison gives rise to suspicions that pollen concentration in Core P1 may be a function of its relative fine-silt content (which is generally less than 5 percent of the matrix volume). Where concentration is lower than 50 pollen grains per $cm^3$, statistically viable counts proved to be practically unobtainable, while viable counts for samples of ca. 100 grains per $cm^3$ could be achieved via multiple lab sample reductions. In such low-concentration alluvial pollen samples, no pollen degradation was visible, nor were enhanced pine values observed, facts suggesting that pollen concentration in reduced alluvium is not affected by degradational factors.

A limited effect of degradational factors on pollen concentration can be seen in Core P2. For example, Zone P2:1 pollen concentration varies from 130.2 to 708.8 grains per $cm^3$, while Zones P2:2 and 3 contain ranges between 73.8 to 3,685.7 and 303.0 to 2,323.4 grains per $cm^{3,}$ respectively. These pollen concentrations are influenced by colluvial sedimentary processes rather than in-situ degradation.

General concentration variation is lower in viable samples from Core P1 alluvium (Zones P1:1-12), although very low concentrations of pollen in this matrix may be related to flow conditions marginal to the fallout velocity of pollen grains. Such flow characteristics may be a function of various hydrological factors, such as base sea-level (vertical) position, local channel (horizontal) position, variable velocity of water flow and its level variability through time, as well as particularistic changes in floodplain geometry resulting from progressive alluvial sedimentation. Altogether, this complex array of possibilities may produce a quasi-random diachronic pattern of low pollen concentration in alluvial accumulations. High pine values of up to 21.0 percent are encountered in Zone P1:5, which also contains higher pollen concentrations of more than 300 grains per $cm^3$. It is of interest that high *Pinus* percentages are concurrent with higher pollen concentrations, phenomena which contradict the high-*Pinus*-to-low-general-pollen-concentration expectations of the degradation hypothesis relevant to Core P1.

### *Interpretive Pollen Taphonomy*

Arboreal (AP) to non-arboreal (NAP) pollen ratios in alluvial sediments are modulated by variations in sedimentary sources, as well as actual changes in regional vegetation. After studies of pollen influx in stream-fed lake sediments (Bonny 1976, 1978; Pennington 1979), it is demonstrated that the majority (80-97 percent) of pollen is recruited into such sediments by water transport through surface runoff within the site-specific drainage basin. Self-evidently, pollen recruitment into alluvial sediments will also be achieved principally by means of water transport, with a surface runoff over-representation by flora of the proximate riparian and floodplain biomes. Because these proximate biomes are more aforested than the interfluvial landscape, there is a potential for AP over-representation, unless deforestation in the river valley enhances the surface-runoff non-arboreal-pollen (NAP) contribution by grassland, forbic, and sandy wasteland communities.

Importantly, the relationship between deforestation, increased surface runoff, and potential alluviation is not linear, but rather logarithmic. This is because, per unit time and area, open grasslands contribute ten times the sediment load from erosion (85.0 tons/year per $km^2$) as do woodlands (8.5 tons/year per $km^2$), all of which is potentially deposited as alluvium (Shelby 1985). Thus, there may be a preferential representation of NAP in such alluvium (depending on the "patchiness factor," see below) which might override an arboreal pollen (AP) over-representation once a critical deforestation threshold is attained. As will be apparent from Table B-3, this threshold is crossed after a relatively low order of woodland denudation.

With respect to AP:NAP ratios in alluvial sediments, a final factor to be considered is the potential patchiness of clearings within the floodplain and valley margins. The extent of non-arboreal areas within this context will also determine the proportion of (initially air-deposited) AP to NAP in eroded sediments that are ultimately deposited by water as alluvium.

Airborne pollen taphonomy in small clearings is modulated by low wind velocities induced by trunk-space interference. Such low-wind velocities, which are also experienced over small bogs with wooded margins (e.g. at Hershop or Boriack bogs, cf. Bryant and Holloway 1985; Larson et al. 1972), as well as oxbow situations under higher levels of aforestation (e.g. at Buckeye Knoll, Core P2; cf. Anderson 1974; Jacobson and Bradshaw 1981; Tauber 1965, 1967), limit airborne pollen recruitment largely to the immediate canopy area and forest verges, as well as herbaceous vegetation of the clearing (or the bog/oxbow surface) itself.

As clearances widen (or bog/oxbow surfaces increase), the constitution of pollen influx to terrestrial surfaces becomes more regional in character as the ra-

**Table B-3.** Quantitative Relationships (%) Between Woodland Cover and Arboreal Pollen (AP) Percentages in Alluvium.

| A. Actual Woodland Extent (Ex. Riparian) | B. Woodland Sediment Input (1[A.]/t, r=1.0) | C. Grassland Sediment Input (10[100-A.]/t) | D. Inferred r-Values of AP in C. | E. Relative AP/NAP influx/t | AP (%) of E. |
|---|---|---|---|---|---|
| 100 | 100 | S | 1.0* | 100/0 | 100 |
| 95 | 95 | 50 | 0.8 | 135/10 | 93 |
| 90 | 90 | 100 | 0.7 | 160/30 | 84 |
| 80 | 80 | 200 | 0.6 | 200/80 | 71 |
| 70 | 70 | 300 | 0.5 | 220/150 | 59 |
| 60 | 60 | 400 | 0.4 | 220/240 | 48 |
| 50 | 50 | 500 | 0.3 | 200/350 | 36 |
| 40 | 40 | 600 | 0.2 | 160/480 | 25 |
| 30 | 30 | 700 | 0.15 | 135/595 | 18 |
| 20 | 20 | 800 | 0.10 | 100/720 | 12 |
| 10 | 10 | 900 | 0.05 | 55/855 | 6 |
| 0 | S | 1000 | 0.0 | 0/1000 | 0 |

S—Spordic
* — As per B.

dius of clearance extends beyond 200 to 300 m; larger clearings enhance both local wind velocities and the recruitment of pollen from regional air flow over forest canopies.[2]

Up to this 200-to-300-m radial limit, NAP will increase in proportion with the increase in clearance area, while AP will increase as a function of clearance circumference. Empirically, in terms of relative pollen percentages, clearings of ca. 0.003 hectare may register ca. 80 percent AP ($r$=0.8), while those of ca. 0.5 hectares may register ca. 50 percent AP ($r$=0.8). Declines in AP then level off after a 200 to 300 m clearance radius is reached (cf., Lange 1971), wherein clearings in the order of 10 to 15 hectares may register AP values of ca. 20 percent ($r$=0.2). This "patchiness" factor (or "r value") becomes less significant as still-larger clearings recruit a higher proportion of regional airborne pollen from a largely interfluvial landscape as optimal wind velocities for regional pollen catchment are attained ($r$™ 2.0).

It may be deduced, then, that actual reductions in woodland cover will not only increase the volume of erosional sediment available for alluviation, but also the proportion of NAP within this erosional sediment.

[2] Incidentally, at the geo-hydrological Hershop Bog in Gonzales County, Texas, a cited maximum bog diameter of 155 m implies an effective "clearance" radius of 75-80 m (Larson et al. 1972), so that the continuously low proportion of Holocene AP encountered here (ca. 5 to 8 percent) may also be understood in terms of a low regional pollen representation due to aerodynamic factors considered above. This low regional pollen recruitment against a backdrop of a dominant bog flora (at equilibrium with geo-hydrology, not climate) will thus limit the responsiveness of the Hershop pollen spectra to extralocal environmental change. These latter changes in a minor pollen component will barely be discernible from "statistical noise" common to pollen diagrams.

The latter "r-value" of woodland pollen representation might then be placed at ca. 0.8 in sporadic clearings of a closed-floodplain woodland, falling to less than 0.2 once large clearings predominate (i.e., aforestation levels below 40 percent). Based on these assumptions, a rough quantitative relationship between AP percentages and actual woodland cover in the drainage basin providing the source of alluvium is shown in Table B-3. The comparative relationship between actual woodland extent and AP percentages, as shown in Table B-3, will be used to reconstruct levels of aforestation up to the valley margins of the lower Guadalupe valley based on the geo-botanical evidence from Core P1 alluvium. Notably, a "bell-shaped" effect can be seen in this quantitative relationship.

### *Phyto-Taxonomy of Pollen Groups at Cores P1 and P2*

Pollen assemblages from Cores P1 and P2 have been ordered into seven groups or divisions of regional (*n*=6), and extraregional (*n*=1), significance (Tables B-4 to B-11). These groupings of individual pollen taxa are employed as a synthetic aid in the interpretation of pollen spectra. As such, regional pollen groups represent specific biotic habitats, while a long-distance transport component is of extraregional significance. These seven floral divisions are described in the following paragraphs.

#### *Long-Distance Transport*

Superior aerodynamic characteristics of *Ephedra* and *Pinus* pollen allow for their distribution to more than 100 km from their original habitats. *Pinus* pollen presumably derives from the loblolly stands in the environs of present-day Bastrop County, but a pronounced *Pinus* maximum together with maximal *Betula* values in Zone P1:5 suggest a regional presence under boreal environmental conditions.

#### *Riparian Flora*

Riparian or river's edge flora is comprised of a variety of AP and NAP taxa. Of the NAP taxa encountered, only *Potamogeton* is truly aquatic. Semi-aquatic species requiring standing water include *Typha domingensis*, while the *Cyperaceae* are tolerant of periodic dryness. Likewise, of AP flora, *Salix* is tolerant of variable hydrologic conditions, although *Alnus* require a continuously saturated soil matrix. A further arboreal taxon, *Betula* (river birch) likes moist riparian conditions. Notably, *Alnus* and *Betula* are limited today to river valleys east of the Trinity River in east Texas areas enjoying more than 44 inches of rainfall per annum, although river birch thrives in regions having more than 48 inches of rainfall.

#### *Woodland*

Comprising woodlands of both the floodplain and the valley margins, this division represents generally mesic conditions, although live-oak complexes of the valley margins tend to have wider edaphic tolerances than other arboreal species. Most-important for human subsistence is *Carya*, which in this regional context most likely derives overwhelmingly from *Carya illinoensis*, or pecan. Its moderate production of pollen makes high values of *Carya* indicative of substantial groves within local (Core P2) or regional (Core P1 alluvium) pollen catchments. Other taxa representing the floodplain woodland include *Juglans* (black walnut), *Ulmus* (cedar elm), *Tilia* (basswood), *Ilex* (youpon or bog holly), *Myrica* (myrtle), and *Celtis* (sugar hackberry). The rare *Fraxinus* pollen type also derives from green ash, known from Victoria County today, and is found as isolates in more aforested (mesic) pollen zones. Finds of *Palmae* pollen in sub-xeric Zone P1:2 most likely derive from *Sabal mexicana*, the Texas palmetto which grows presently in small patches along Garcitas Creek, also in Victoria County. Significantly, its present near-tropical primary range lies along the lower Rio Grande. *Acacia* has been assigned to the woodland, rather than the sub-xeric scrub division, due to the presence of *A. farnesiana* or huisache on today's floodplain margins. Notably, an analogous presence of *Acacia* pollen also appears from modern surface analogs from woodlands surrounding Hershop Bog (Larson et al. 1972). *Quercus* pollen may be of more variable taxonomic origins, ranging from the deciduous *Q. nigra* of the floodplain to *Q. virginiana* or live-oak of the valley margins.

#### *Mesic Grassland*

Undifferentiated *Gramineae* pollen has been placed into the "mesic" tall-grassland group due to a pan-American tendency for dry grassland pollen spectra to exhibit high forbic rather than *Gramineae* values (cf. Bartlein et al. 1986). Further taxa associated more typically with wet pasture include the *Umbelliferae* and *Trifolium* types. Some mesic types placed in this division, such as *Mentha*, are also common to riverbank vegetation.

#### *Sub-xeric Scrub*

This minor group includes many woody species of the *Leguminosae*, including *Prosopis* (mesquite), as

**Table B-4.** Absolute Pollen Counts from Core P1 (Samples 38-44).

| Pollen Group/ Pollen Taxon | Sample 44 (480 cm) | Sample 43 (470 cm) | Sample 41 (450 cm) | Sample 40 (440 cm) | Sample 38 (420 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **9** | **8** | **0** | **7** | **6** |
| *Pinus* | 9 | 8 | - | 7 | 6 |
| *Ephedra* | - | - | - | - | - |
| **B. Riparian Flora** | **13** | **12** | **10** | **29** | **26** |
| *Alnus* | 2 | 1 | - | 4 | - |
| *Betula* | 8 | 8 | 5 | 9 | - |
| *Salix* | 3 | 1 | 4 | 12 | 16 |
| *Potamogeton* | - | - | - | - | - |
| *Typha domingensis* | - | - | - | - | - |
| Cyperaceae | - | 2 | 1 | 4 | 10 |
| **C. Woodland** | **45** | **40** | **24** | **56** | **21** |
| *Carya* | 13 | - | 4 | 3 | 1 |
| *Quercus* | 23 | 36 | 20 | 50 | 11 |
| *Ulmus* | - | - | - | - | - |
| *Celtis* | - | 2 | - | - | 438 |
| *Juglans* | - | - | - | - | 1 |
| *Tilia* | 4 | - | - | - | - |
| *Acacia* | - | - | - | 3 | 2 |
| *Myrica* | - | - | - | - | - |
| *Ilex* | 5 | 2 | - | - | - |
| *Fraxinus* | - | - | - | - | - |
| Palmae | - | - | - | - | 2 |
| **D. Mesic Grassland** | **34** | **31** | **63** | **51** | **38** |
| Gramineae | 34 | 30 | 63 | 51 | 38 |
| Umbelliferae | - | 1 | - | - | - |
| Polygonaceae | - | - | - | - | - |
| *Geranium* | - | - | - | - | - |
| *Trifolium* | - | - | - | - | - |
| *Gentianella* | - | - | - | - | - |
| **E. Sub-xeric Scrub** | **0** | **2** | **0** | **0** | **0** |
| *Vicia* | - | - | - | - | - |
| *Prosopis* | - | - | - | - | - |
| *Opuntia* | - | 2 | - | - | - |
| *Euphorbia* | - | - | - | - | - |

continued.

**Table B-4.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 44 (480 cm) | Sample 43 (470 cm) | Sample 41 (450 cm) | Sample 40 (440 cm) | Sample 38 (420 cm) |
|---|---|---|---|---|---|
| **F. Sandy Wastes** | **0** | **0** | **0** | **0** | **0** |
| *Urticalia* | - | - | - | - | - |
| *Agrostemma* | - | - | - | - | - |
| *Plantago* | - | - | - | - | - |
| *Aesculus* | - | - | - | - | - |
| *Juniperus* | - | - | - | - | - |
| **G. Prairie-Forbs** | **46** | **46** | **108** | **96** | **163** |
| Chenopodiaceae | 6 | 12 | 46 | 28 | 68 |
| Asteraceae | 21 | 29 | 54 | 53 | 80 |
| *Arctium* | 12 | 3 | - | 1 | 7 |
| Compositae (Liguliflorae) | 2 | 1 | 8 | 13 | 7 |
| *Artemisia* | 5 | 1 | - | 1 | 1 |
| *Ambrosia* | - | - | - | - | - |
| *Centaurea* | - | - | - | - | - |
| **H. Varia** | **0** | **1** | **0** | **2** | **0** |
| Degraded *Abies* | - | - | - | - | - |
| Indeterminate | - | 1 | - | 2 | - |
| Added *Lycopodium* | (1,192) | (800) | (1,153) | (458) | (692) |
| **Total Land Pollen** | **147** | **140** | **204** | **241** | **255** |

well as the *Euphorbia* (euphorb) and *Opuntia* (prickly-pear cactus) types. Largely insect-pollinated, this interfluvial floral community is barely represented in pollen spectra from Cores P1 and P2.

***Sandy Wastes***

This minor group includes valley-margin or interfluvial taxa inhabiting dry sandy soils and disturbed areas. Members of this division include *Aesculus pavia* (red buckeye) and *Juniperus* (sand cedar). *Plantago* and *Onagraceae* types are also placed in this scarcely represented pollen grouping, reflecting probably the red plantain and various species of the genus *Gaura*.

***Forbs***

This major division of sub-xeric and halophytic flora of largely interfluvial origin might also opportunistically colonize open areas on the floodplain after deforestation. Its halophytic aspects include members of the *Chenopodiaceae* (atriplex). Such halophytes are capable of exerting great hydrostatic pressures on soil matrices, and are favored by dry climates. The general *Compositae* pollen flora are also placed in this group due to a pan-American tendency for the palynological expression of high *Compositae* values in dry grasslands (Bartlein et al. 1986). A high level of co-variation between *Compositae*, *Chenopodiaceae*, and general deforestation levels (as well as low co-variation with *Gramineae*) also affirms this phyto-taxonomical treatment.

***Pollen Zonation in Core P1***

The zonation of pollen spectra from geo-botanical cores at Buckeye Knoll has been made on the basis of statistically significant changes in key proxy-climatic indicator species or groups, and phyto-taxonomic changes of importance for human subsistence.

**Table B-5.** Absolute Pollen Counts from Core P1 (Samples 28-37).

| Pollen Group/ Pollen Taxon | Sample 37 (410 cm) | Sample 35 (390 cm) | Sample 31 (350 cm) | Sample 30 (327 cm) | Sample 28 (307 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **4** | **2** | **9** | **5** | **66** |
| *Pinus* | 4 | 2 | 9 | 5 | 66 |
| *Ephedra* | - | - | - | - | - |
| **B. Riparian Flora** | **11** | **8** | **15** | **21** | **56** |
| *Alnus* | - | - | - | - | 1 |
| *Betula* | - | - | - | - | 28 |
| *Salix* | 11 | 7 | 6 | 1 | 3 |
| *Potamogeton* | - | - | - | - | - |
| *Typha domingensis* | - | - | - | - | 3 |
| Cyperaceae | - | 1 | 9 | 20 | 21 |
| **C. Woodland** | **44** | **80** | **47** | **13** | **77** |
| *Carya* | 14 | 10 | 10 | 2 | 6 |
| *Quercus* | 22 | 67 | 28 | 10 | 51 |
| *Ulmus* | 1 | 2 | 4 | - | - |
| *Celtis* | 4 | - | 3 | 1 | 3 |
| *Juglans* | - | - | - | - | - |
| *Tilia* | - | 1 | 1 | - | 16 |
| *Acacia* | 2 | - | - | - | - |
| *Myrica* | - | - | 1 | - | 1 |
| *Ilex* | - | - | - | - | - |
| *Fraxinus* | - | - | - | - | - |
| Palmae | - | - | - | - | - |
| **D. Mesic Grassland** | **64** | **36** | **26** | **22** | **80** |
| Gramineae | 64 | 36 | 25 | - | - |
| Umbelliferae | - | - | 1 | - | - |
| Polygonaceae | - | - | - | - | - |
| *Geranium* | - | - | - | - | - |
| *Trifolium* | - | - | - | - | - |
| *Gentianella* | - | - | - | - | - |
| **E. Sub-xeric Scrub** | **1** | **0** | **0** | **0** | **1** |
| *Vicia* | 1 | - | - | - | 1 |
| *Prosopis* | - | - | - | - | - |
| *Opuntia* | - | - | - | - | - |
| *Euphorbia* | - | - | - | - | - |

continued

**Table B-5.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 37 (410 cm) | Sample 35 (390 cm) | Sample 31 (350 cm) | Sample 30 (327 cm) | Sample 28 (307 cm) |
|---|---|---|---|---|---|
| **F. Sandy Wastes** | **0** | **0** | **0** | **0** | **0** |
| *Urticalia* | - | - | - | - | - |
| *Agrostemma* | - | - | - | - | - |
| *Plantago* | - | - | - | - | - |
| *Aesculus* | - | - | - | - | - |
| *Juniperus* | - | - | - | - | - |
| **G. Prairie-Forbs** | **229** | **45** | **72** | **208** | **24** |
| Chenopodiaceae | 46 | 9 | 13 | 131 | 5 |
| Asteraceae | 121 | 36 | 41 | 70 | 15 |
| *Arctium* | 59 | - | 3 | 1 | - |
| Compositae (Liquliflorae) | 3 | - | 7 | 6 | 3 |
| *Artemisia* | - | - | 8 | - | - |
| *Ambrosia* | - | - | - | - | - |
| *Centaurea* | - | - | - | - | - |
| **H. Varia** | **0** | **1** | **8** | **0** | **6** |
| Degraded Abies | - | - | - | - | - |
| Indeterminate | - | 1 | 8 | - | 6 |
| Added *Lycopodium* | (1725) | (871) | (585) | (220) | (508) |
| **Total Land Pollen** | **354** | **172** | **177** | **259** | **314** |

Pollen zones from the 480-cm sequence in Core P1 are described below, beginning with the ill-defined Paleo-Indian period of Zone P1:1 (A-D). Figure B-4 illustrates the proportional representations of species in the pollen zones, while Figure B-5 summarizes the relative proportions of taxa as subsumed under the broad headings of the aforementioned types of floral communities.

***Zone P1:1A***

*Quercus*, *Carya*, *Betula*, *Alnus*, *Gramineae* (ca. 9340 cal. B.P. [estimated], 480 cm). The oldest viable pollen spectrum from Core P1 contains a mixture of floodplain woodland and mesic grassland taxa. *Carya* values are quite high (8.8 percent) in this sub-zone, although *Quercus* representation (15.6 percent) is relatively modest, considering its higher relative pollen production and dispersal efficiencies. The mixed-oak woodland also contains a significant admixture of basswood (2.7 percent) and youpon or bog holly (3.4 percent). Substantial open tracts are represented in mesic grassland (23.1 percent) and forbic (33.6 percent) components, although the contemporary climate must have been relatively wet, given the *Betula* value of 5.3 percent, and the traces of *Alnus*.

***Zone P1:1B***

*Quercus*, *Betula*, *Alnus*, *Gramineae* (ca. 9000 cal. B.P. [estimated], 470 cm). *Carya* pollen is absent at this time, although *Quercus* values rise to 25.9 percent, while *Betula* values are maintained at 5.8 percent, along with traces of *Alnus*. *Gramineae* (21.6 percent) and forbic (33.1 percent) values are nearly identical to those of the prior sub-zone, although traces of *Opuntia* are notable in this sub-zone.

**Table B-6.** Absolute Pollen Counts from Core P1 (Samples 21-27).

| Pollen Group/ Pollen Taxon | Sample 27 (297 cm) | Sample 26 (287 cm) | Sample 25 (277 cm) | Sample 24 (267 cm) | Sample 21 (237 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **28** | **23** | **41** | **28** | **9** |
| *Pinus* | 28 | 23 | 41 | 28 | 9 |
| *Ephedra* | - | - | - | - | - |
| **B. Riparian flora** | **29** | **38** | **28** | **37** | **18** |
| *Alnus* | 3 | 3 | 1 | - | 3 |
| *Betula* | 21 | 21 | 23 | 14 | - |
| *Salix* | 4 | 12 | - | 17 | 10 |
| *Potamogeton* | - | - | - | - | 1 |
| *Typha domingensis* | - | 1 | - | - | 1 |
| Cyperaceae | 1 | 1 | 4 | 6 | 3 |
| **C. Woodland** | **75** | **72** | **122** | **90** | **98** |
| *Carya* | - | 14 | 11 | 26 | 37 |
| *Quercus* | 71 | 44 | 107 | 52 | 56 |
| *Ulmus* | 2 | - | 1 | 2 | - |
| *Celtis* | - | 2 | - | 2 | - |
| *Juglans* | - | 3 | - | - | - |
| *Tilia* | 2 | 8 | 3 | 6 | 5 |
| *Acacia* | - | - | - | - | - |
| *Myrica* | - | 1 | - | 2 | - |
| *Ilex* | - | - | - | - | - |
| *Fraxinus* | - | - | - | - | - |
| Palmae | - | - | - | - | - |
| **D. Mesic Grassland** | **36** | **14** | **38** | **40** | **13** |
| Gramineae | 34 | 13 | 38 | 39 | 13 |
| Umbelliferae | 2 | - | - | - | - |
| Polygonaceae | - | 1 | - | 1 | - |
| *Geranium* | - | - | - | - | - |
| *Trifolium* | 0 | - | - | - | - |
| *Gentianella* | 0 | - | - | - | - |
| **E. Sub-xeric Scrub** | **2** | **0** | **1** | **0** | **1** |
| *Vicia* | 2 | - | - | - | - |
| *Prosopis* | - | - | - | - | - |
| *Opuntia* | - | - | - | - | - |
| *Euphorbia* | - | - | 1 | - | 1 |

continued

**Table B-6.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 27 (297 cm) | Sample 26 (287 cm) | Sample 25 (277 cm) | Sample 24 (267 cm) | Sample 21 (237 cm) |
|---|---|---|---|---|---|
| **F. Sandy Wastes** | **2** | **1** | **3** | **1** | **0** |
| *Urticalia* | - | - | - | - | - |
| *Agrostemma* | - | - | - | - | - |
| *Plantago* | 2 | 1 | - | - | - |
| *Aesculus* | - | - | 3 | 1 | - |
| *Juniperus* | - | - | - | - | - |
| **G. Prairie-Forbs** | **8** | **35** | **21** | **24** | **49** |
| Chenopodiaceae | - | 19 | 2 | 1 | 12 |
| Asteraceae | 8 | 9 | 16 | 21 | 21 |
| *Arctium* | - | - | - | - | 8 |
| Compositae (Liguliflorae) | - | 2 | 3 | 2 | 1 |
| *Artemisia* | - | 4 | - | - | 1 |
| *Ambrosia* | - | - | - | - | 5 |
| *Centaurea* | - | 1 | - | - | - |
| **H. Varia** | **0** | **1** | **8** | **0** | **1** |
| Degraded *Abies* | - | - | - | - | - |
| Indeterminate | - | 1 | 8 | - | 1 |
| Added *Lycopodium* | (345) | (556) | (456) | (500) | (405) |
| **Total Land Pollen** | **180** | **183** | **262** | **220** | **189** |

***Zone P1:1C***

*Quercus*, *Asteraceae*, *Gramineae* (ca. 8360 cal. B.P. [estimated], 450 cm). A somewhat less mesic environment is indicated in this sub-zone above the calcium carbonate contact. Forb values rise to 50.1 percent while oak and birch decline to 9.8 and 2.5 percent, respectively. Notably, alder is also absent in this spectrum, although small quantities of *Carya* (2.0 percent) are present.

***Zone P1:1D***

*Quercus*, *Betula*, *Alnus*, *Gramineae* (ca. 8020 cal. B.P. [estimated], 440 cm). *Carya* values remain low (1.5 percent) in this spectrum, which also registers a recovery of oak (20.7 percent) and river birch (3.7 percent), alongside isolates of alder. Somewhat more mesic conditions are thus indicated in this sub-zone. Forb values are accordingly modest in this zone.

***Zone P1:2***

*Asteraceae*, *Chenopodiaceae*, *Gramineae* (7335-6995 cal. B.P., 420-410 cm). A profoundly sub-xeric oscillation is recorded in this zone, which registers *Quercus* values of only 4.3 to 6.2 percent alongside forbic values of 63.9 to 64.7 percent. Low *Carya* values appear alongside isolates of subtropical *Palmae* (0.8 percent). Given the dispersal characteristics of *Palmae* pollen, it is likely that the Texas palmetto was growing regionally, if not locally.

***Zone P1:3***

*Quercus*, *Carya*, *Asteraceae*, *Gramineae* (6315-5750 cal. B.P., 390-350 cm). A return to mesic conditions in this zone is reflected in an initial rise of *Quercus* to 39.0 percent, which declines subsequently to 15.8 percent. Modest *Carya* values of 5.8 to 5.6 percent are respectively registered, while *Gramineae*

**Table B-7.** Absolute Pollen Counts from Core P1 (Samples 14-19).

| Pollen Group/ Pollen Taxon | Sample 19 (217 cm) | Sample 18 (207 cm) | Sample 17 (197 cm) | Sample 16 (187 cm) | Sample 14 (167 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **10** | **5** | **13** | **1** | **3** |
| *Pinus* | 10 | 5 | 13 | 1 | 3 |
| *Ephedra* | - | - | - | - | - |
| **B. Riparian flora** | 7 | 3 | 7 | 8 | 24 |
| *Alnus* | - | - | - | - | 2 |
| *Betula* | 2 | - | - | - | - |
| *Salix* | 2 | 3 | 1 | 7 | 20 |
| *Potamogeton* | - | - | - | - | - |
| *Typha domingensis* | - | - | - | 1 | - |
| Cyperaceae | 3 | - | 6 | - | 2 |
| **C. Woodland** | **112** | **20** | **69** | **17** | **66** |
| *Carya* | 10 | 1 | 16 | 2 | 15 |
| *Quercus* | 86 | 14 | 47 | 10 | 44 |
| *Ulmus* | 5 | 1 | 1 | 3 | - |
| *Celtis* | - | 3 | 3 | - | 5 |
| *Juglans* | - | - | 2 | 2 | - |
| *Tilia* | 2 | - | - | - | - |
| *Acacia* | - | - | - | - | - |
| *Myrica* | 1 | - | - | - | 2 |
| *Ilex* | 7 | 1 | - | - | - |
| *Fraxinus* | 1 | - | - | - | - |
| Palmae | - | - | - | - | - |
| **D. Mesic Grassland** | **21** | **24** | **29** | **25** | **32** |
| Gramineae | 21 | 24 | 28 | 25 | 31 |
| Umbelliferae | - | - | 1 | - | 1 |
| Polygonaceae | - | - | - | - | - |
| *Geranium* | - | - | - | - | - |
| *Trifolium* | - | - | - | - | - |
| *Gentianella* | - | - | - | - | - |
| **E. Sub-xeric Scrub** | **0** | **0** | **0** | **0** | **2** |
| *Vicia* | - | - | - | - | **2** |
| *Prosopis* | - | - | - | - | - |
| *Opuntia* | - | - | - | - | - |
| *Euphorbia* | - | - | - | - | - |

continued

**Table B-7.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 19 (217 cm) | Sample 18 (207 cm) | Sample 17 (197 cm) | Sample 16 (187 cm) | Sample 14 (167 cm) |
|---|---|---|---|---|---|
| **F. Sandy Wastes** | **4** | **0** | **0** | **2** | **0** |
| *Urticalia* | - | - | - | - | - |
| *Agrostemma* | - | - | - | - | - |
| *Plantago* | - | - | - | - | - |
| *Aesculus* | 4 | - | - | 2 | - |
| *Juniperus* | - | - | - | - | - |
| **G. Prairie-Forbs** | **39** | **140** | **44** | **147** | **71** |
| Chenopodiaceae | 11 | 20 | 14 | 16 | 20 |
| Asteraceae | 13 | 93 | 15 | 106 | 24 |
| *Arctium* | 7 | 15 | 2 | 5 | 9 |
| Compositae (Liguliflorae) | 1 | 7 | 11 | 11 | 7 |
| *Artemisia* | - | 5 | - | 9 | - |
| *Ambrosia* | 7 | - | 2 | - | - |
| *Centaurea* | - | - | - | - | 2 |
| **H. Varia** | **1** | **1** | **0** | **2** | **2** |
| Degraded *Abies* | - | - | - | - | - |
| Indeterminate | 1 | 1 | - | 2 | 2 |
| Added *Lycopodium* | (79) | (771) | (928) | (547) | (406) |
| **Total Land Pollen** | **194** | **192** | **162** | **202** | **200** |

also declines from 20.9 to 14.1 percent as forbs rise from 26.2 to 40.7 percent, anticipating extreme subxeric developments of Zone P1:4. An environment of moderately mesic grasslands and woodlands with lower species richness might be reconstructed for this period. A more extensive live-oak complex might be contributing to higher *Quercus* values initially expressed.

***Zone P1:4***

*Chenopodiaceae*, *Asteraceae* (ca. 5575 cal. B.P., 327 cm). An absolute maximum of *Chenopodiaceae* (50.6 percent) is attained in this spectrum, of a forbic total 80.3 percent (also an absolute maximum). *Quercus* is scarcely represented at 3.9 percent, suggesting that the floodplain woodland is highly denuded during this period of maximum halophytic vegetation.

***Zone P1:5***

*Quercus*, *Betula*, *Alnus*, *Gramineae* (5425-5200 cal. B.P., 307-277 cm). The most emphatic environmental change detectable in the geo-botanical sequence at Buckeye Knoll occurs in this highly mesic pollen zone, coeval with the Northern Hemispheric Piora II or Rotmoos II Alpine neo-glaciation. Much cooler and wetter conditions are experienced in the region of the lower Guadalupe River on the Central Texas Gulf Coastal Plain, as indicated in regional pollen spectra comprised of very high *Betula* values of between 8.8 and 11.7 percent Total Land Pollen (TLP). Additional traces of *Alnus* and very high values of *Pinus* (12.6 to 21.0 percent) also occur. It seems possible that the latter taxon might be growing locally as small stands of loblolly on sandier soils under a much more "boreal" climate. Oak values

**Table B-8.** Absolute Pollen Counts from Core P1 (Samples 1-13).

| Pollen Group/ Pollen Taxon | Sample 13 (157 cm) | Sample 12 (147 cm) | Sample 11 (137 cm) | Sample 5 (80 cm) | Sample 3 (60 cm) | Sample 1 (37 cm) |
|---|---|---|---|---|---|---|
| **A. Long-Distance** | **16** | **14** | **17** | **17** | **6** | **24** |
| *Pinus* | 16 | 14 | 15 | 17 | 6 | 24 |
| *Ephedra* | - | - | 2 | - | - | - |
| **B. Riparian flora** | 5 | **12** | **24** | **11** | **20** | **18** |
| *Alnus* | - | - | - | - | - | - |
| *Betula* | - | - | - | - | - | - |
| *Salix* | 5 | 10 | 5 | 8 | 3 | 13 |
| *Potamogeton* | - | - | - | - | - | - |
| *Typha domingensis* | - | - | - | - | - | - |
| Cyperaceae | - | 2 | 19 | 3 | 17 | 5 |
| **C. Woodland** | **65** | **55** | **80** | **62** | **22** | **58** |
| *Carya* | 18 | 28 | 31 | 21 | 4 | 32 |
| *Quercus* | 46 | 25 | 29 | 36 | 18 | 17 |
| *Ulmus* | - | - | 16 | 1 | - | 5 |
| *Celtis* | - | - | 4 | 1 | - | 2 |
| *Juglans* | 1 | - | - | - | - | - |
| *Tilia* | - | - | - | - | - | - |
| *Acacia* | - | - | - | - | - | 1 |
| *Myrica* | - | - | - | 2 | - | - |
| *Ilex* | - | 2 | - | 1 | - | 1 |
| *Fraxinus* | - | - | - | 1 | - | - |
| Palmae | - | - | - | - | - | - |
| **D. Mesic Grassland** | **16** | **33** | **39** | **37** | **18** | **30** |
| Gramineae | 16 | 32 | 37 | 36 | 18 | 26 |
| Umbelliferae | - | - | 2 | 1 | - | 1 |
| Polygonaceae | - | - | - | - | - | - |
| *Geranium* | - | 1 | - | - | - | - |
| *Trifolium* | - | - | - | - | - | 3 |
| *Gentianella* | - | - | - | 4 | - | - |
| **E. Sub-xeric Scrub** | **0** | **0** | **0** | **3** | **0** | **8** |
| *Vicia* | - | - | - | - | - | 1 |
| *Prosopis* | - | - | - | 2 | - | - |
| *Opuntia* | - | - | - | - | - | - |
| *Euphorbia* | - | - | - | 1 | - | 7 |

continued

**Table B-8.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 13 (157 cm) | Sample 12 (147 cm) | Sample 11 (137 cm) | Sample 5 (80 cm) | Sample 3 (60 cm) | Sample 1 (37 cm) |
|---|---|---|---|---|---|---|
| **F. Sandy Wastes** | **1** | **0** | **1** | **1** | **0** | **1** |
| *Urticalia* | - | - | - | - | - | 1 |
| *Agrostemma* | - | - | - | - | - | - |
| *Plantago* | 1 | - | - | - | - | - |
| *Aesculus* | - | - | - | 1 | - | - |
| *Juniperus* | - | - | 1 | - | - | - |
| **G. Prairie-Forbs** | **59** | **41** | **24** | **67** | **185** | **50** |
| Chenopodiaceae | 26 | 10 | 8 | 11 | 147 | 27 |
| Asteraceae | 18 | 19 | 9 | 39 | 36 | 15 |
| *Arctium* | 15 | 8 | 3 | 6 | 1 | 5 |
| Compositae (Liguliflorae) | - | 4 | 4 | 8 | 1 | 2 |
| *Artemisia* | - | - | - | 1 | - | - |
| *Ambrosia* | - | - | - | 2 | - | 1 |
| *Centaurea* | - | - | - | - | - | - |
| **H. Varia** | **5** | **0** | **0** | **0** | **0** | **1** |
| Degraded *Abies* | - | - | - | - | - | 1 |
| Indeterminate | 5 | - | - | - | - | - |
| Added *Lycopodium* | (845) | (739) | (526) | (172) | (111) | (95) |
| **Total Land Pollen** | **167** | **155** | **185** | **202** | **251** | **190** |

are initially low (16.2 percent), although these rise to 40.5 percent by the terminus of P1:5. *Carya* values are also minimal at the beginning of this period, although these increase with time to 7.7 percent of TLP. Save for an acute peak of *Tilia* (at 4.4 percent) at 287 cm, a low species richness typifies the woodland flora in this zone. Dry forbs also attain an absolute minimum (at 4.4 percent), a phenomenon that is indicative of very wet environmental conditions within the grassland interfluves. An initially open woodland mosaic gradually closed during the course of this period.

***Zone P1:6***

*Carya*, *Quercus*, *Gramineae* (5125-4830 cal. B.P., 267-237 cm). The woodland mosaic continued to close during this period as the peak of its floodplain development was reached. A wide array of arboreal taxa are encountered with the expression of high values of *Tilia* and *Acacia*. Pine values decline to 4.8 percent, a level commensurate with long-distance transport effects. Importantly, *Carya* increased significantly during this period, attaining its absolute maximum of 19.6 percent by ca. 4900/4800 cal. B.P.. This response level equates perhaps with a regional presence extending over 2 to 20 km$^2$, within a ca. 10-to-100-km$^2$ hydrologic pollen catchment upstream of the Buckeye Knoll site. Grasslands were mesic during this period after modest forb values expressed.

***Zone P1:7***

*Quercus* (ca. 4575 cal. B.P., 217 cm). Less-mesic conditions are evidenced in this zone, although *Quercus* attains an absolute maximum of 44.3 percent. A more oak-dominated woodland is encountered with lower *Carya* values (5.2 percent), although *Ilex* achieves its absolute maximum (3.6 percent) alongside oak. High *Quercus* values may be indicative of a more expansive live-oak complex that extended up

**Table B-9.** Absolute Pollen Counts from Core P2 (Samples 11-16).

| Pollen Group/ Pollen Taxon | Sample 16 (192 cm) | Sample 15 (182 cm) | Sample 14 (172 cm) | Sample 13 (162 cm) | Sample 11 (142 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **4** | **23** | **21** | **12** | **22** |
| *Pinus* | 2 | 23 | 21 | 12 | 22 |
| *Ephedra* | 2 | - | - | - | - |
| **B. Riparian flora** | **14** | **31** | **26** | **32** | **45** |
| *Betula* | - | - | - | - | 1 |
| *Salix* | 6 | 18 | 11 | 28 | 23 |
| *Typha domingensis* | 6 | - | - | - | 2 |
| Cyperaceae | 2 | 13 | 15 | 4 | 19 |
| **C. Woodland** | **93** | **77** | **80** | **89** | **139** |
| *Carya* | 22 | 19 | 31 | 9 | 10 |
| *Quercus* | 71 | 35 | 30 | 77 | 128 |
| *Ulmus* | - | 10 | 10 | - | - |
| *Celtis* | - | 7 | 5 | 3 | - |
| *Juglans* | - | 4 | 1 | - | - |
| *Tilia* | - | - | - | - | - |
| *Acacia* | - | 2 | 3 | - | - |
| *Myrica* | - | - | - | - | 1 |
| *Ilex* | - | - | - | - | - |
| *Rhus* | - | - | - | - | - |
| **D. Mesic Grassland** | **41** | **82** | **34** | **26** | **30** |
| Gramineae | 41 | 81 | 30 | 26 | 26 |
| Umbelliferae | - | 1 | 4 | - | 3 |
| Polygonaceae | - | - | - | - | 1 |
| *Trifolium* | - | - | - | - | - |
| *Mentha* | - | - | - | - | - |
| **E. Sub-xeric Scrub** | **0** | **0** | **1** | **0** | **3** |
| *Vicia* | - | - | 1 | - | 2 |
| *Prosopis* | - | - | - | - | 1 |
| *Euphorbia* | - | - | - | - | - |
| **F. Sandy Wastes** | **0** | **0** | **2** | **0** | **1** |
| Onagraceae | - | - | - | - | - |
| *Agrostemma* | - | - | 1 | - | - |
| *Plantago* | - | - | 1 | - | - |
| *Aesculus* | - | - | - | - | 1 |

continued

**Table B-9.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 16 (192 cm) | Sample 15 (182 cm) | Sample 14 (172 cm) | Sample 13 (162 cm) | Sample 11 (142 cm) |
|---|---|---|---|---|---|
| **G. Prairie-Forbs** | **35** | **75** | **38** | **67** | **277** |
| Chenopodiaceae | 6 | 19 | 5 | 34 | 119 |
| Asteraceae | 25 | 36 | 26 | 23 | 81 |
| *Arctium* | 3 | 10 | 5 | 4 | 61 |
| Compositae (Liguliflorae) | 1 | 9 | 2 | 6 | 1 |
| *Artemisia* | - | - | - | - | - |
| *Ambrosia* | - | - | - | - | 15 |
| *Centaurea* | - | 1 | - | - | - |
| **H. Varia** | **2** | **1** | **0** | **0** | **0** |
| Indeterminate | 2 | 1 | - | - | - |
| Added *Lycopodium* | (160) | (449) | (926) | (1837) | (84) |
| **Total Land Pollen** | **189** | **287** | **201** | **226** | **517** |

to the margins of the river valley. Interfluvial grasslands were becoming less mesic as evidenced by a continued increase in forbic vegetation.

***Zone P1:8***

*Asteraceae*, *Chenopodiaceae*, *Gramineae* (ca. 4445 cal. B.P., 207 cm). A third sub-xeric oscillation occurs in this spectrum as forbs rise to 72.5 percent and oak declines to 7.3 percent of TLP. Total woodland pollen recruitment into sediment is limited to 10.4 percent (indicative of a denuded condition), with traces of pecan, elm, celtis and youpon. An ultimate high of *Artemisia* (2.6 percent) is notable in this zone (this taxon is largely absent in the later Holocene). *Gramineae* values are lower, indicative of drier interfluvial grasslands.

***Zone P1:9***

*Quercus*, *Carya*, *Gramineae* (ca. 4250 cal. B.P., 197 cm). Similar to Zone P1:7, Zone P1:9 registers a floral dominance of *Quercus* (29.0 percent) with moderate forb values (27.2 percent), although *Carya* values are higher (9.9 percent). The floodplain woodland also contained traces of walnut and elm at this time, which is altogether one of greater species richness than Zone P1:7.

***Zone P1:10***

*Asteraceae*, *Gramineae* (ca. 3900 cal. B.P., 187 cm). Similar to Zone P1:8, Zone P1:10 registers a forbic high of 72.8 percent, with only traces of oak (5.0 percent) and pecan (1.0 percent). Woodlands were thus inferably highly denuded. Lower *Gramineae* values are indicative, then, of a prevalence of short-grass vegetation in the dry interfluves.

***Zone P1:11***

*Quercus*, *Carya*, *Gramineae*, *Asteraceae* (3215-2930 cal. B.P., 167-157 cm). C*arya* rises steadily in this zone from 1.0 (Zone P1:10) to 7.5 percent, and then to 10.8 percent of TLP, while total woodland pollen recovers from 6.0 percent (Zone P1:10) to 33.0 to 38.9 percent. These mesic tendencies continue to into Zone P1:12, the longest composite period of rational *Carya* highs.

***Zone P1:12***

*Carya*, *Quercus*, *Gramineae* (2780-2630 cal. B.P., 147-137 cm). *Carya* achieves sustained highs of 18.0 and 16.8 percent in this zone, where total woodland pollen also rises to 43.2 percent of TLP. The total expanse of *Carya* is thus similar to that of Zone P1:6, or ca. 2

**Table B-10.** Absolute Pollen Counts from Core P2 (Samples 4-10).

| Pollen Group/ Pollen Taxon | Sample 10 (132 cm) | Sample 9 (122 cm) | Sample 6 (92 cm) | Sample 5 (82 cm) | Sample 4 (72 cm) |
|---|---|---|---|---|---|
| **A. Long-Distance** | **14** | **5** | **6** | **5** | **8** |
| *Pinus* | 14 | 5 | 5 | 3 | 7 |
| *Ephedra* | - | - | 1 | 2 | 1 |
| **B. Riparian flora** | 20 | 10 | 7 | 19 | 28 |
| *Betula* | - | - | - | - | - |
| *Salix* | 8 | 10 | 7 | 14 | 6 |
| *Typha domingensis* | 2 | - | - | - | - |
| Cyperaceae | 10 | - | - | 5 | 22 |
| **C. Woodland** | **148** | **88** | **100** | **36** | **17** |
| *Carya* | 42 | 16 | 22 | 7 | - |
| *Quercus* | 96 | 72 | 77 | 23 | 13 |
| *Ulmus* | 3 | - | - | 1 | - |
| *Celtis* | 1 | - | - | 1 | 3 |
| *Juglans* | - | - | 1 | - | - |
| *Tilia* | 1 | - | - | - | - |
| *Acacia* | 2 | - | - | 3 | - |
| *Myrica* | 2 | - | - | 1 | - |
| *Ilex* | 1 | - | - | - | - |
| *Rhus* | - | - | - | - | 1 |
| **D. Mesic Grassland** | **47** | **53** | **21** | **40** | **16** |
| Gramineae | 47 | 53 | 19 | 37 | 14 |
| Umbelliferae | - | - | 2 | 3 | 1 |
| Polygonaceae | - | - | - | - | - |
| *Trifolium* | - | - | - | - | - |
| *Mentha* | - | - | - | - | 1 |
| **E. Sub-xeric Scrub** | **0** | **1** | **0** | **5** | **1** |
| *Vicia* | - | 1 | - | 4 | - |
| *Prosopis* | - | - | - | 1 | - |
| *Euphorbia* | - | - | - | - | 1 |
| **F. Sandy Wastes** | **0** | **0** | **1** | **0** | **0** |
| Onagraceae | - | - | - | - | - |
| *Agrostemma* | - | - | - | - | - |
| *Plantago* | - | - | - | - | - |
| *Aesculus* | - | - | 1 | - | - |

continued

**Table B-10.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 10 (132 cm) | Sample 9 (122 cm) | Sample 6 (92 cm) | Sample 5 (82 cm) | Sample 4 (72 cm) |
|---|---|---|---|---|---|
| **G. Prairie-Forbs** | **70** | **42** | **47** | **95** | **125** |
| Chenopodiaceae | 27 | 15 | 8 | 35 | 64 |
| Asteraceae | 24 | 26 | 24 | 52 | 49 |
| *Arctium* | 3 | 1 | 8 | 6 | 2 |
| Compositae (Liguliflorae) | 13 | - | - | 2 | 1 |
| *Artemisia* | - | - | - | - | 4 |
| *Ambrosia* | 3 | - | 7 | - | 5 |
| *Centaurea* | - | - | - | - | - |
| **H. Varia** | **0** | **4** | **0** | **0** | 0 |
| Indeterminate | - | 4 | - | - | - |
| Added *Lycopodium* | (300) | (66) | (47) | (396) | (58) |
| **Total Land Pollen** | **299** | **202** | **182** | **200** | **195** |

to 20 km$^2$, within a ca. 10-to-100-km$^2$ catchment. Elm comprised a considerable admixture to pecan and oak in the woodland canopy. Grasslands were becoming more mesic, so that interfluvial conditions were similar to those from Zone P1:6 of the prior *Carya* maximum. *Carya* maxima thus coincide with *Gramineae*-to-forbic ratios of ca. 1.0:1 in the Core P1 alluvium.

***Zone P1:13***

*Quercus*, *Carya*, *Asteraceae*, *Gramineae* (ca. 1775 cal. B.P., 80 cm, cf. Zone P2:1). Following upon a major colluvial hiatus (2600-1800 cal. B.P.) of pollen degradation, a taphonomy of viable pollen spectra resumed with the formation of a post-2000 cal. B.P. oxbow. The floral picture is not dissimilar to that of the previous zone, although the area of pollen catchment is much more localized in Zone P1:13 as the area of surface runoff represented by Core P1 sediments contracts to a much smaller land surface (less than 1 km$^2$). Basin-surface characteristics of the oxbow also comprised a true pollen trap rather than an over-flow surface, so pollen concentration also increased significantly (cf. see Table B-2, Samples P1:1, 3, 5). Within this local taphonomic context, woodland pollen is prevalent (30.7 percent), consisting of oak (17.8 percent) and pecan (10.4 percent). Local values of herbaceous gentian (2.0 percent) are notable; in regional terms, this will be a rare type. In its floral composition, this zone compares well with coeval zone P2:1 from an adjacent oxbow accumulation of the same formation, indicating that vegetation on the west slope aspect of the Buckeye Knoll site is largely replicated on the north slope.

***Zone P1:14***

*Chenopodiaceae*, *Asteraceae* (ca. 1030 cal. B.P., 60 cm, cf. Zone P2:2). A fifth sub-xeric phase dates to ca. A.D. 1000 with an expansion of forbs to 73.7 percent and a decline of the woodland to 8.8 percent. *Carya* experiences a low of 1.6 percent. In its floral composition, this zone compares well with coeval zone P2:2 from the northern oxbow deposit.

***Zone P1:15***

*Carya*, *Quercus*, *Gramineae* (ca. 445 cal. B.P., 37 cm, cf. Zone P2:3). Late Prehistoric vegetation conditions express modest forb values (26.3 percent) and very high levels of *Carya* (16.8 percent). A similar *Carya* high occurs in the *beginning* of Zone P2:3 (see below), suggesting that abundant pecan groves occured on the northern and western aspects of the rise supporting the Buckeye Knoll site during the Rockport phase.

***Pollen Zonation of Core P2***

Developments of vegetation during the last 1500 years are now described from 13 viable spectra in Core P2, representing a century-level time-scale of resolution. Notably, the chronologic periodicity of zones is maintained despite an increasing data density in Core

**Table B-11.** Absolute Pollen Counts from Core P2 (Samples 1-3).

| Pollen Group/ Pollen Taxon | Sample 3 (62 cm) | Sample 2 (52 cm) | -Sample 1 (42 cm) |
|---|---|---|---|
| **A. Long-Distance** | **2** | **13** | **20** |
| *Pinus* | 2 | 13 | 19 |
| *Ephedra* | - | - | 1 |
| **B. Riparian flora** | **27** | **14** | **22** |
| *Betula* | - | 1 | - |
| *Salix* | 26 | 3 | 10 |
| *Typha domingensis* | - | 8 | - |
| Cyperaceae | 1 | 2 | 12 |
| **C. Woodland** | **91** | **65** | **67** |
| *Carya* | 16 | 12 | 9 |
| *Quercus* | 74 | 46 | 53 |
| *Ulmus* | - | 1 | - |
| *Celtis* | - | 6 | 4 |
| *Juglans* | 1 | - | - |
| *Tilia* | - | - | - |
| *Acacia* | - | - | 1 |
| *Myrica* | - | - | - |
| *Ilex* | - | - | - |
| *Rhus* | - | - | - |
| **D. Mesic Grassland** | **36** | **29** | **28** |
| Gramineae | 34 | 29 | 26 |
| Umbelliferae | 2 | - | 1 |
| Polygonaceae | - | - | - |
| *Trifolium* | - | - | 1 |
| *Mentha* | - | - | - |
| **E. Sub-xeric Scrub** | **0** | **0** | **1** |
| *Vicia* | - | - | 1 |
| *Prosopis* | - | - | - |
| *Euphorbia* | - | - | - |
| **F. Sandy Wastes** | **1** | **0** | **0** |
| Onagraceae | - | - | - |
| *Agrostemma* | - | - | - |
| *Plantago* | - | - | - |
| *Aesculus* | - | - | - |

continued

**Table B-11.** (concluded)

| Pollen Group/ Pollen Taxon | Sample 3 (62 cm) | Sample 2 (52 cm) | Sample 1 (42 cm) |
|---|---|---|---|
| **G. Prairie-Forbs** | **58** | **79** | **116** |
| Chenopodiaceae | 23 | 31 | 78 |
| Asteraceae | 31 | 38 | 26 |
| *Arctium* | 3 | 1 | 12 |
| Compositae (Liguliflorae) | 1 | 9 | - |
| *Artemisia* | - | - | - |
| *Ambrosia* | - | - | - |
| *Centaurea* | - | - | - |
| **H. Varia** | **0** | **0** | **0** |
| Indeterminate | - | - | - |
| Added *Lycopodium* | (129) | (270) | (32) |
| **Total Land Pollen** | **215** | **200** | **254** |

P2. From Core P2, then, confidence in general zonal definition in the Buckeye Knoll geo-botanical project is increased with the perception of progressive xeric and mesic floristic trends. Pollen zones from the viable 192-cm sequence at Core P2 are described below, beginning in the terminal Archaic and extending to earlier Late Prehistoric period of Zone P2:1. Figure B-6 provides a pollen diagram for the core.

***Zone P2:1***

*Quercus*, *Carya*, *Gramineae* (1400-1120 cal. B.P., 192-172 cm, cf. Zone P1:13): This zone begins with an absolute maximum of *Typha domingensis* (3.1 percent) and high values of woodland pollen at 192 cm. High values of *Carya* (11.1 percent average) are also maintained in this zone, alongside very low average *Chenopodiaceae* values (4.0 percent). Mesic conditions of this zone are of a largely local-indicative value, although the pecan values suggest that groves of greater-than-two-hectares extent are present within a 200-300-m radius. Elm values are also high in parts of this relatively mesic aspect.

***Zone P2:2***

*Quercus*, *Chenopodiaceae* (1050-960 cal. B.P., 162-142 cm, cf. Zone P1:14). A major *Carya* decline to 3.1 percent is notable in this zone, when, in contrast, oak woodlands are less denuded. Increases in forb vegetation are furthermore indicative of increasingly sub-xeric conditions after ca. A.D. 1000. An isolated appearance of *Prosopis* is notable in this pollen zone.

***Zone P2:3***

*Carya*, *Quercus*, *Gramineae* (895-425 cal. B.P., 132-82 cm, cf. Zone P1:15). A rapid expansion of *Carya* is achieved in this zone as values rise to 14.0 percent, declining to 3.5 percent towards its terminus alongside a reduction in woodland pollen from 49.5 to 18.0 percent. Forbs rise during this period from 23.4 to 47.5 percent, anticipating sub-xeric developments of Zone P1:4. *Prosopis* makes an isolated appearance towards the terminus of this pollen zone.

***Zone P2:4***

*Chenopodiaceae* (ca. 370 cal. B.P., 72 cm). A sub-xeric maximum in Core P2 occurs at this time, with the expression of very high forbic values (64.1 percent) and an absolute maximum of *Chenopodiaceae* (32.8 percent). A *Carya* pollen response of 0.0 percent is indicative of its local absence or extreme moisture-stress upon extant groves.

***Zone P2:5***

*Quercus*, *Carya*, *Gramineae* (275-180 cal. B.P., 62-52 cm). Woodland recovers during this period, a recovery largely effected by oak (23.0 to 34.4 percent) rather than pecan (6.0 to 7.4 percent). Forb values

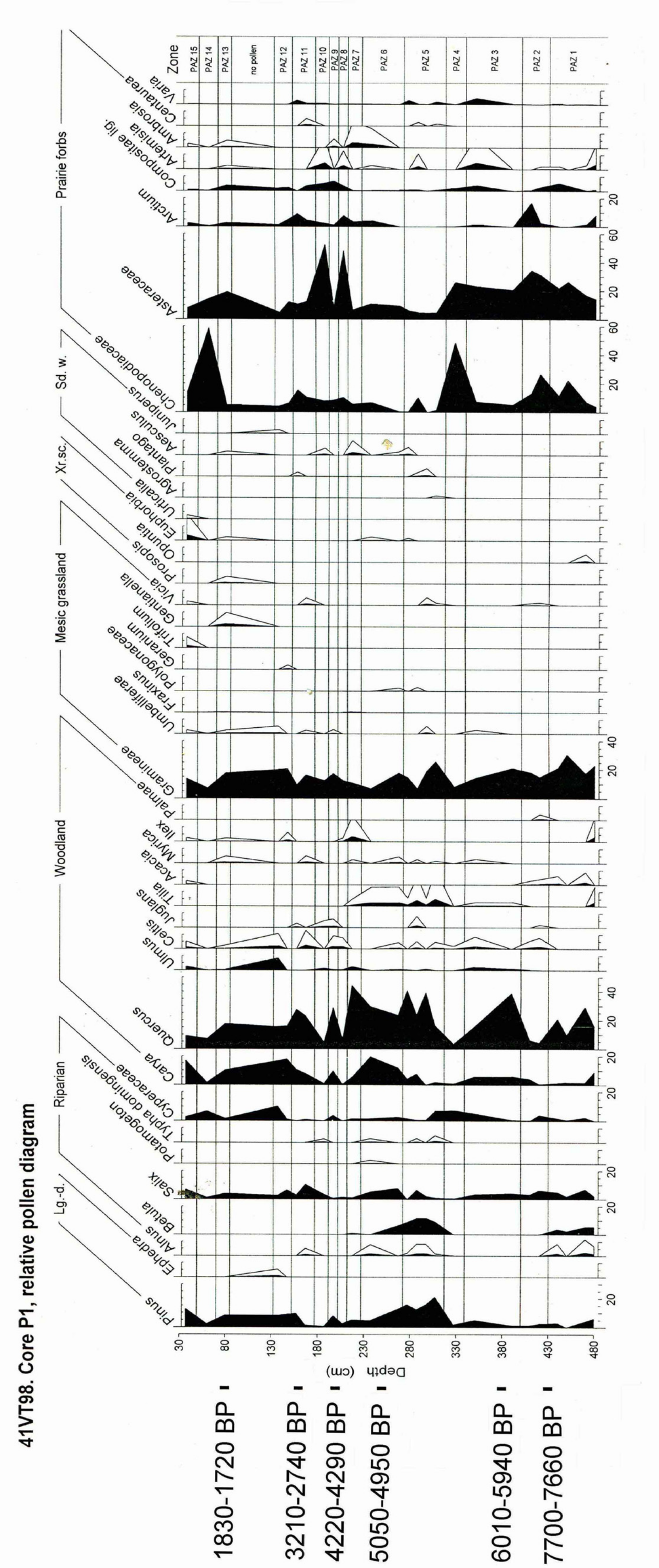



**Figure B-4.** Pollen diagram of Core P1 showing positions of calibrated radiocarbon age ranges.

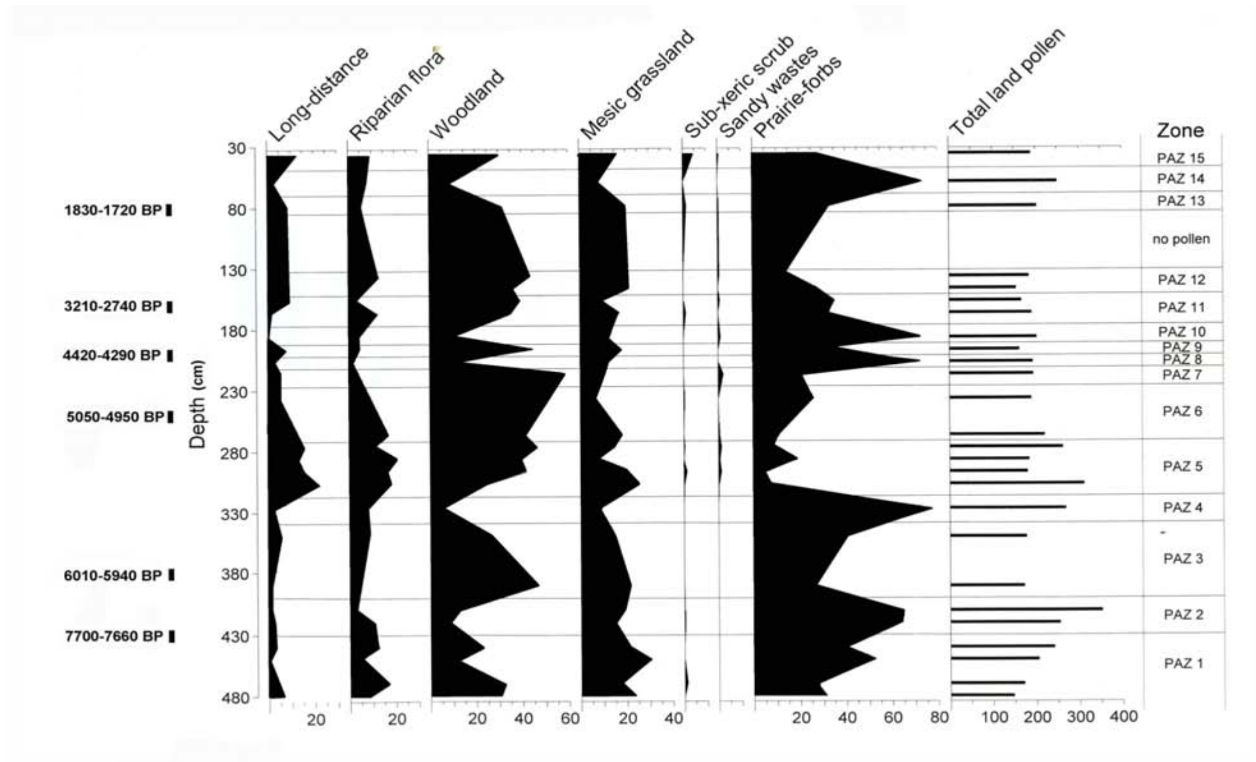



**Figure B-5.** Pollen Diagram for Core P1 showing various taxa subsumed under broad headings of plant communities associated with components of the environmental mosaic.

range between 27.0 and 39.5 percent, while an isolated appearance of *Betula* is notable.

***Zone P2:6***

*Quercus*, *Chenopodiaceae* (ca. 90 cal. B.P., 42 cm). Due to Geoprobe compression, this sample contains a highly diachronic spectrum averaging ca. 90 cal. B.P. (1950) in age. A high forbic pollen response (45.7 percent) most certainly reflects the effects of late Historic-era pastoral land use on the local flora. As a baseline for comparison, one can then infer that eleventh- and sixteenth-century "natural" clearings were still more extensive, although some interfluvial "cultural" impacts through aboriginal fire-setting cannot be excluded (cf. Albert 1999).

***Paleo-Climatic Inferences***

Three mesic and two sub-xeric phases can be traced in Core P2, which spans roughly the past 1,500 years. The perception of sub-xeric phases seems to be threshold-dependent, in that a considerable degree of moisture stress is required to denude the mixed-oak woodland so as to produce clearings that are colonized by forbs. Perhaps clinal declines in more moisture-sensitive taxa such as *Carya* may be indicative of progressive moisture stress, as may be seen in its reduced pollen response between Zones P2:1-2 and the terminus of Zones P2:3 and P2:4.

In terms of pollen response surface data from 830 North American surface sites (Bartlein et al. 1986), hypothetical but specific levels or ranges of mean precipitation per annum (MPA) can be reconstructed under different mean-July-temperature (MJT) conditions for sub-xeric periods or episodes represented in forbic maxima of Zones P2:2 and 3(terminus)/4 in dual spectra reflecting ca. 100-year averages. Pollen taphonomical limitations of Core P2 lie in its much more localized floral-areal indicative value *vis a vis* medial basins employed by Bartlein et al. (1986; cf. Jacobson and Bradshaw 1981) for the derivation of pollen response surfaces to climatic forcing. In the regional context of the Central Texas Gulf Coastal Plain, it seems intrinsically unlikely that temperatures below modern levels could produce forbic pollen responses seen in Zones P2:2 and 3(terminus)/4. In other words, these floral responses must be modulated by temperature to some extent. Because forbs respond positively, both to decreases in MPA and increases in MJT, paleo-precipitation reconstructions placed against near-mod-

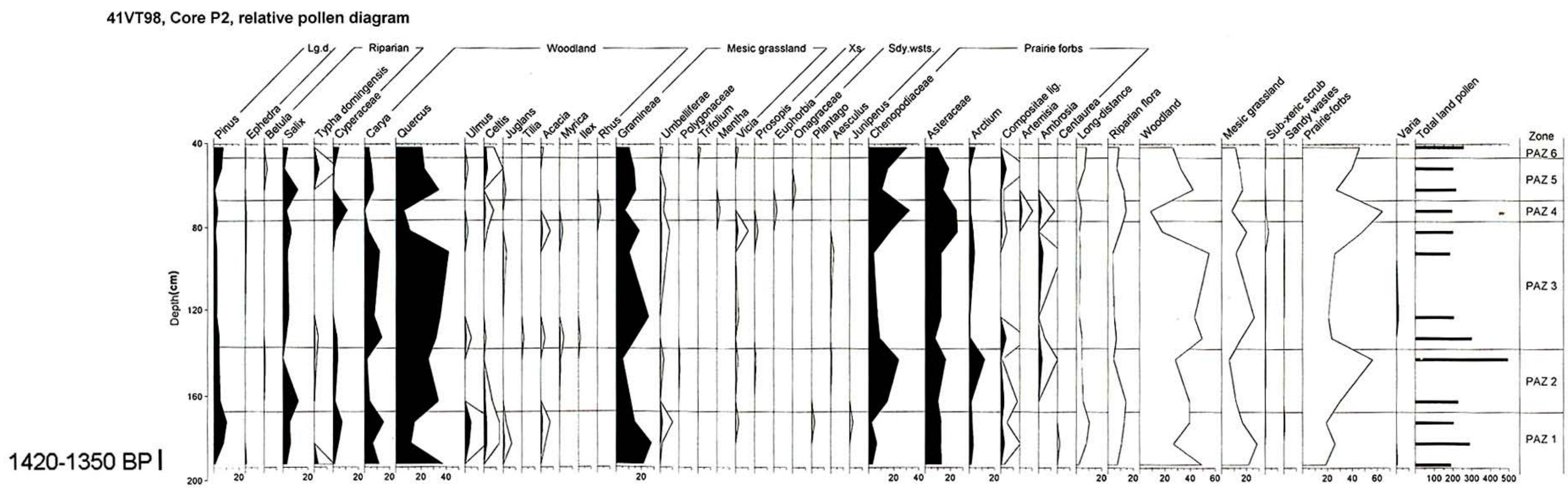



**Figure B-6.** Pollen diagram of Core P2 showing the lone calibrated age range obtained on bulk sediment from the base of the core.

**Table B-12.** Minimal Paleo-Precipitation Per Annum (MPA) Under Different Mean July Temperatures (MJT) During Sub-Xeric Phases of Core P2.

| Pollen zone (no. of spectra) | Forb pollen % (average) | MPA (inches) (29° C MJT) | MPA (inches) (30° C MJT) | MPA (inches) (31° C MJT) | MPA (inches) (32° C MJT) |
|---|---|---|---|---|---|
| P2:2 (2) | 41.7 | 32 | 34 | 36? | 38?* |
| P2:3/4 (2) | 56.6 | 30 | 32 | 34? | 36? |

* — (modern level)

ern MJTs (28 to 29° C) are probably too low, and may be viewed as minimal MPA estimates (Table B-12).

Pollen response surface data incompletely represent those surfaces exceeding the 30° C MJT threshold, largely due to the geographic limitation of analogs in east Texas. Well-defined linear trends of the forb response surfaces are provisionally projected above an MJT threshold of 30° C MJT, where higher MJTs produce higher MPA reconstructions. Intuitively, MJT-based MPA reconstructions seem most sensible under MJTs of ca. 31° C.

Maximal *Carya* pollen responses can now be used to reconstruct hypothetical precipitation ranges during mesic periods which largely exclude a forb pollen response (Table B-13). Due to perceived limits of the local evidence, an r-factor of 1/3 is roughly assessed, reflecting local over-representation (*Carya* maxima at P2 are ca. 300 percent realistic maxima in medium-sized basins).

Deductive uncertainties of paleo-climate reconstructions can be reduced through the principle of "overlapping" response surfaces, which narrows the potential range of reconstructable paleo-climate parameters through a process of elimination, once allied response surface data of a larger number of taxa are taken into account. For example, in Table B-13, Zone P2:5, potential MPA values below modern levels have been excluded from consideration due to the trace presence of *Betula* and greatly reduced prairie-forb values in the penultimate zone. These twin floral responses indicate cooler or wetter climatic conditions. Incidentally, this latter zone is also aligned with the Northern Hemispheric "Little Ice Age" of ca. A.D. 1600-1700 (Grove 1988), providing Zone P2:5 reconstructions of MPA vs. MJT a certain historic contextual affirmation.

Because the pollen represented in Core P2 most likely derived largely from flora growing within a 500-m radius, potential errors resulting from factors of "patchiness" in the vegetation mosaic preclude interpretation beyond a mere "mesic" vs. "xeric" ascription. Of course, anthropogenic impact on the recent environment (Zone P2:6) has rendered this environment more "xeric" than its true equilibrium state *vis a vis* climate. Prehistoric anthropogenic effects are more likely to be limited to the interfluves, where the practice of fire-setting is supported by palynological and ethnohistoric data (Albert 1999). Within empirical limits of local over-representation and localized "patchiness" in the floral mosaic, it seems likely that MPA and/or MJT have fluctuated by an amplitude of either 6 inches or 3° C, respectively (or a combination of both factors), after perceived changes in the local plant-climate interface at Core P2. In this latter hypothetical case, a change of one degree C of MJT "substitutes" for a change in one inch of MPA. These climate changes have furthermore been maintained over secular time spans on the order of 100 years during the last 1,500 years.

It remains to explain the amplitude and periodicity of climate change that has occurred in the more distant past, as indicated by data from Core P1 alluvium. Unlike Core P2 colluvium, Core P1 alluvium has recruited pollen from a much larger (drainage basin) area, probably on the order of 10 to 20 $km^2$. Importantly, the hydrologic transport of pollen involves an over-representation of floodplain flora and this lead to problems of surface runoff over-representation by floodplain flora which are somewhat analogous to those considered above with respect to the local over-representation of *Carya* in Core P2 colluvium.

This enhancement effect is demonstrated in *Carya* maxima of ca. 15-plus percent in hydrologic (alluvial) pollen spectra from Core P1, whereas air-transported *Carya* in medium-sized basins rarely exceeds 5 percent of TLP. A taphonomic exaggeration of *Carya* pollen response on the order of 300 percent is again suspected, so transformations of *Carya* pollen percentages using application an r-value of 1/3 are

**Table B-13.** Paleo-Precipitation Ranges (± 1 Inch) Under Different MJTs During Mesic Phases of Core P2.

| Pollen Zone | *Carya* | *Carya* | MPA | MPA | MPA |
|---|---|---|---|---|---|
| (No. of Spectra) | Pollen % (avg.) | r-value % (transformed) | (28º C MJT) | (29º C MJT) | (30º C MJT) |
| P2:1 (3) | 11.1 | 3.7 | 38 or 42 | 39 or 41 | 40 |
| P2:3 (3) | 11.1 | 3.7 | 38 or 42 | 39 or 41 | 40 |
| P2:5 (2) | 6.7 | 2.2 | 41 | 41 | 41 |

MPA measurements are in inches.

employed in order to model pollen response surface data. Basically, the peaks of *Carya* noted in Core P1 alluvium would become practically unobtainable once larger (though not extraregional) interfluvial areas contribute equally to site-specific pollen taphonomy, a taphonomy characteristic of airborne pollen recruitment into medium basins. Importantly, the latter data are derived from pollen catchment areas of the same order as those reflected in pollen spectra from Buckeye Knoll, Core P1 alluvium. Within this catchment, "mesic" maxima of *Carya* pollen occur within MPA ranges of 38 to 42 inches (modal maximum 40 inches MPA) under a MJT of 29° C. Present-day MPA averages are around 38 inches under MJTs of 28 to 29° C.

Due to the formation of sheltered alluvial microenvironments, high values of river birch in certain pollen zones from Core P1 are thought to reflect microclimatic conditions at the riparian verges rather than those of general climate. High *Betula* values are thus in metastable equilibrium with atmospheric climate, and reflect temperature conditions of about 5° C below those of general MJT levels.

Regarding the principle of direct comparison, the edaphic limit of river birch lies today near the 44 inches MPA contour in east Texas, with more prevalent growths limited by the 48" MPA contour in valleys proximal to Louisiana. *Betula* values of five percent or less might thus align with the former edaphic limit, while values of 10 percent might approximate environmental conditions within the latter contour. Empirically, the relative *Carya* pollen representation will actually *decline* under such higher precipitation conditions.

Values of *Carya* and *Betula* pollen are compared in Table B-14 for more mesic climate phases from Core P1 alluvium (pre-2600 cal. B.P.), alongside *Quercus* pollen response levels and the ratio of "wet-" *vs*. "dry-" grassland pollen taxa. Increasing values of *Carya* will signify paleo-climatic trajectories towards 29° C MJT and 40 inches MPA, while *Quercus* exhibits a cooler unimode at around 25°º C MJT under a much wider range of precipitation conditions. Notably, an r-value of 1/2 is applied to *Quercus* values due to its less-emphatic over-representation because of its habitation of wider ranges up to the limit of the valley margin. These margins are taken up by live-oak complexes whose moisture requirements are considerably less than oaks of the floodplain.

Importantly, arboreal and forbic pollen responses are never applied to pollen zones of major deforestation, due to distorting transforms of arboreal pollen to non-arboreal pollen (AP/NAP) ratios, quantified previously in Table B-3.

Augmenting the primary arboreal taxonomic response data, *Betula* response levels are positively correlated with higher precipitation values ranging from 44 to 48 inches MPA. Conversely, higher forbic (dry-) grassland values will signify drier or warmer conditions, depending on the relative climatic trajectories signified by AP responses. The incidence of certain "tropical" pollen indicators such as *Palmae* may also be of some interpretive value, as the regional presence of such taxa is suggestive of a lower penetration of polar airmasses in winter, given the susceptibility of the Texas palmetto to winter frosts.

**Table B-14.** Average Transformed *Carya* and *Quercus* Pollen Values, *Betula* Pollen Averages, and Ratios of Wet- to Dry-Grassland Pollen of Mesic Zones in Core P1 Alluvium.

| Pollen Zone | Cal. Yrs. B.P. (Range) | Av. *Carya* (Transformed) | Av. *Quercus* (Transformed) | *Betula* (Average) | Wet-/Dry-Grassland |
|---|---|---|---|---|---|
| 1A/B | ~9340-9000? | 1.4 | 10.4 | 5.6 | 0.7 |
| 1D | ~8020? | 0.4 | 10.4 | 3.7 | 0.6 |
| 3 | 6315-5750 | 2.9 | 13.2 | 0.0 | 0.6 |
| 5 | 5425-5200 | 1.2 | 20.1 | 9.9 | 2.5 |
| 6 | 5125-4830 | 5.2 | 13.3 | 3.2 | 1.0 |
| 7 | 4575 | 1.7 | 22.2 | 0.0 | 0.5 |
| 9 | 4250 | 3.3 | 14.5 | 0.0 | 0.7 |
| 11 | 3215-2930 | 3.1 | 12.4 | 0.0 | 0.4 |
| 12 | 2780-2630 | 5.8 | 7.9 | 0.0 | 1.2 |

The two-dimensional (MPA and MJT) overlap of primary AP and forbic response surfaces, as well as relative moisture availability inferred according to the principle of direct biogeographic comparison (here, in the case of river birch), will be used to define specific ranges of MPA and MJT for certain periods of the Holocene. Failing this, an ascription of generalized "mesic" and "xeric" conditions to certain periods will be made on the basis of pollen data from Core P2. Additional problems emerge in the interpretation of early Holocene spectra which seem to have limited modern analogs. In particular, *Carya* pollen response levels are poorly defined above the 30º-C-MJT threshold, although it seems likely that this taxon will experience a rapid fall-off in its pollen response to two percent or less (cf. *Carya* transformed values) of TLP as MJTs approach 31º C.

Generally speaking then, Zone P1:1 climate appears to have been warmer and wetter than that of today. Increased wetness in this context probably resulted from a stronger atmospheric circulation that delivered more moisture-bearing, marine (mT) or continental (cT) fully-tropical airmasses. A general trend towards increasing MJTs is noted within Zone P1:1, as *Carya* declines, forbs rise, and traces of *Opuntia* appear in sub-Zone 1B. Notably, declines in *Betula* are also experienced in sub-Zone P1:1C, coeval with the deposit of calcium carbonate. Given the strong relation between *Betula* presence and MPA, it seems likely that this sub-zonal dryness is modulated by a secular low in MPA. Given the *Carya* decline without a rise in *Quercus*, in tandem with forbic increases, it might be posited that MJTs are rising from around 30º C to around 32º between sub-Zones 1A and D, under MPA levels of 44 inches or more, with less rainfall in sub-Zone 1C.

The next definable mesic phase, based on Zone P1:3 pollen evidence, sees a return to higher *Carya* values, together with higher values of *Quercus*. Reduced temperature stress under lower precipitation may be inferable given an absence of *Betula* and the forb response, so that near-modern conditions of MJT (29º C) and MPA (38 inches) are inferable. Due to the combination of lower MPA levels *and* lower MJTs, the forbic response is relatively high in sub-Zone P1:1D.

Very much wetter conditions seem to typify Zone P1:5, with perhaps a slight decline in MJTs, judging by the *Betula* pollen response which is maintained at an emphatic high of around 10 percent TLP. Because these high values reflect its sheltered habitat, with micro-environmental MJTs of around 23º C, these may also reflect somewhat lower general MJTs of around 28º C, under very high MPA levels of around 48 inches. These same environmental conditions might also promote an in-migration of loblolly pine elements onto sandy soils of the floodplain (cf. Tharp 1926), explaining in turn very high levels of *Pinus* in a sediment of higher general pollen concentration. Emerging high *Quercus* values (initially at sub-climax, pre-equilibrium levels possibly due to sub-xeric conditions of Zone P1:3) validate these reconstructions, as do the absolute minimum values of forb or dry-grassland taxa expressed in Zone P1:5.

Zone P1:6 sees a continuation of "mesic" conditions, although MJTs are higher (29º C) under declining MPA levels of 42 to 40 inches in this zone, as *Betula* is gradually excluded and *Carya* reaches its absolute maximum during this period. Declines of *Quercus* are furthermore conformable with an MJT rise to 29º C. Somewhat drier conditions are also indicated by forbic ratios, although grasslands are still of relatively mesic aspect.

Still-drier conditions are evidenced in Zone P1:7, as effective precipitation declines to near-modern levels, and an increasing dryness is evidenced by rising forb ratios. Conditions for an optimal *Carya* pollen response are no longer extant, although near-modern levels of this taxon are expressed, in tandem with higher levels of *Quercus*. Climate is less mesic than that of Zone P1:6, with MPA levels of 38 inches or less, while MJTs are not significantly higher, and may, in fact, be somewhat lower, given the positive *Quercus* response, or around 28-29º degrees C.

Zone P1:9 reflects a resurgence of the floodplain woodland flora with higher *Carya* and a more modest *Quercus* values. Marginally more mesic grassland conditions indicate that climate was somewhat wetter than that of today, with MPA levels of 38 to 40 inches, under near-modern MJT levels of 29º C.

Zone P1:11 seems to reflect very near-modern precipitation conditions with MPA levels of around 38 inches, under MJT levels of 29º C, as suggested by moderately high *Carya* and *Quercus* values. Higher forb values relative to Zone P1:9 affirm a reconstruction of slightly lower relative MPA levels.

Zone P1:12 witnesses a trend towards a second *Carya* maximum, with transformed values averaging 5.8 percent. The expansion of *Carya* at the expense of *Quercus* suggests that an increasingly effective wetness, seen in low forb values, might be a product of slightly higher MPA levels rather than significantly lower MJTs. Thus MPA is reconstructed at 40 inches, while MJT is reconstructed at 29º C.

Reconstructions of sub-xeric phases from Core P1 alluvium depend almost entirely upon highly transformed forbic pollen values. Such transforms are due to logarithmic increases in sediment supply with deforestation (see Table B-2), although it seems intrinsically unlikely under conditions of Gulf coastal precipitation that regional deforestation will significantly progress unless MJTs exceed 31˚ C.

Independent evidence for higher MJTs for the sub-xeric Zones P1:2, 4, 8, and 10 comes from Zones P1:2 and 10 only. Locally, Zone P1:2 contains *Palmae* pollen whose presence is suggestive of higher MJTs, if not indicative of reduced polar air-mass penetration into the region. Regionally, Zone P1:10 is coeval with inferred warmer conditions of the post-4200 cal. B.P. marine transgression suggested for central Texas Gulf coast (cf. Ricklis and Blum 1997; Ricklis and Albert 1998). Of Zone P1:4 and 8, little can be said other than that these zones are demonstrably sub-xeric, with the former zone containing the highest pollen response levels of halophytic vegetation of any zone from cores P1 or P2 at Buckeye Knoll. Inclusive of sub-xeric phases, the pan-Holocene pattern of climate change in the lower Guadalupe River valley are thus surmised in Table B-15.

### *Inter-Regional Comparisons of Holocene Climate Change*

Cyclic climatic oscillations during the last millennium thus appear to have uniformitarian analogs in the pan-Holocene, judging by the geo-botanical evidence from the Guadalupe River floodplain adjacent to the Buckeye Knoll site. The amplitude of MJT variation in the subtropical south Texas region has probably been on the order of 4º C, or more moderate than mid-latitudinal variations of 5 to 6º attested during the course of the Holocene. Most likely, this temperature differential is reduced towards the tropics, reflecting the gross inefficiencies of the general atmospheric circulation (GAC) for the transference of thermal insolation to higher latitudes.

Pan-Holocene changes in MPA at Buckeye Knoll have been still more significant, and range over a differential of 11 inches per annum or more. Significant deforestation and dry grassland formation thus contrast with periods supporting significant stands of river birch, or a luxuriant oak-pecan-elm-basswood floodplain woodland in the lower Guadalupe River valley.

These changes in effective precipitation must be at least a partial product of enhanced tropical air-mass

**Table B-15**. Holocene Variation in Mean Annual Precipitation (MPA) Levels and Mean July Temperatures (MJT) in the Lower Guadalupe River Valley.

| Pollen Zone | Cal. Yrs. B.P. (Range) | MPA (Inches) | MJT (Cº) |
|---|---|---|---|
| P1:1A/B | ~9340-9000? | 44+ | 30 Increasing to 31 |
| P1:1C | ~8360? | Less Mesic | 31-32? |
| P1:1D | ~8020? | 44+ | 32 |
| P1:2 | 7335-6995 | Sub-xeric | 31+ |
| P1:3 | 6315-5750 | 38 | 29 |
| P1:4 | 5575 | Sub-xeric | 31+? |
| P1:5 | 5425-5200 | 48 | 28 |
| P1:6 | 5125-4830 | 42, Declining to 40 | 29 |
| P1:7 | 4575 | 38- | 29 |
| P1:8 | 4445 | Sub-xeric | 31+? |
| P1:9 | 4250 | 38-40 | 29 |
| P1:10 | 3900 | Sub-xeric | 31+ |
| P1:11 | 3215-2930 | 38 | 29 |
| P1:12 | 2780-2630 | 40 | 29 |
| P2:1 | 1400-1120 | Mesic | — |
| P2:2 | 1050-960 | Sub-xeric | — |
| P2:3 | 895-425 | Mesic | — |
| P2:4 | 370 | Sub-xeric | — |
| P2:5 | 275-180 | Mesic | — |
| P2:6 | Modern | 38 (Modern) | 29 (Modern) |

penetration into the region, given the poor correlation of "mesic" phases with periods of low MJTs. Of regional interest then is the presence of middle Holocene, tropical red mangrove micro-habitats at Nueces Bay (some 130 km south of Buckeye Knoll). The alluvial pollen sequence at Nueces Bay, investigated during the course of a National Science Foundation-funded project, relatively dated by grossly estimated sedimentation rates and bio-stratigraphic finds of *Rangia flexuosa*, attests to a reduced penetration of polar airmasses, as well as increased tropical air-mass penetration on the central Texas coast during the middle Holocene (Ricklis and Albert 1998). It is likely, then, that warmer *and* wetter periods such as those represented at Buckeye Knoll (in Zones P1:1 and 6 in particular) reflect a heightened air-mass penetration from either mT or cT sources into south Texas.

The explanation of an enhanced cT air-mass penetration into south Texas during the Early and middle Holocene fits an enhanced westerly air-flow model of North Hemispheric GAC of the Cooperative Holocene Mapping Project (COHMAP) for time intervals at 9000 and 6000 uncal. B.P. (Brian Huntley, personal communication 1996, cf. COHMAP members 1988). Further empirical affirmation of a GAC (cT) hypothesis derives from mesic soil formation phases defined in Southern Coahuila (north Mexico), after a chronology controlled by more than 154 radiometric and AMS assays on soil humates and charcoal (Karl W. Butzer personal communication, 2002). Contemporaneous changes in temperature and/or atmospheric circulation are suggested in this inter-regional evidence.

Given the data-point density of the southern Coahuila database, soil-formation phases as well as data gaps may *both* be significant. Interestingly, then, certain complexities of the latter data have precise analogs in Zones P1:6-10 at Buckeye Knoll in south Texas. For example, from a sample of ca. twenty soil assays from south Coahuila, a series of two clusters of soil dates and two data gaps are bracketed between 5000 and 3750 B.P.. Within this period, an initial mesic phase (Early "Soil 5" ponding) of longer reconstructed duration (5000 to 4500 cal. B.P.) in north Mexico has a near-temporal analog in dual aforested Zones P1:6 and 7 (5125-4830 cal. B.P.) at Buckeye Knoll, followed by a "soil-gap" at 4500 to 4250 cal. B.P. (cf. Buckeye Knoll sub-xeric Zone P1:8, ca. 4445 cal. B.P.). A secular return to mesic conditions at Buckeye Knoll (Zone P1:9) around 4250 cal. B.P. aligns well with a further cluster of soil dates of "Soil 5," with 2-sigma ranges of between 4250 and 4000 cal. B.P.. Finally, a 250-year "soil-gap" in the middle of the composite "Soil 5" formation, ca. 4000 to 3750 cal. B.P. fits neatly into Zone P1:10 at Buckeye Knoll, of ca. 3900 cal. B.P. date.

A continued close proxy paleo-climate fit between regions characterizes the entire post-3000 cal. B.P. sequence of largely wet conditions expressed up to 1000 cal. B.P., followed by a distinct xeric pulse after A.D. 1000. Where a major data gap exists at Buckeye Knoll (the 2600-1800 cal. B.P. "hiatus"), a shorter sub-xeric phase is traceable in both southern Coahuila and the central Texas coast (cf. minor marine-high-stand conditions ca. 2000 cal. B.P. after morphologic data in Ricklis and Albert 1998). Notably, an emphatic, but potentially non-enduring sub-xeric phase of ca. sixteenth-century date appears at Buckeye Knoll in Zone P2:4, which may be obscured by 2-sigma overlap in north Mexico, although both regions express evidence for more mesic conditions during the Little Ice Age of early-modern date (cf. Buckeye Knoll, Zone P2:5). Due to the establishment of modern boundary conditions for GAC after 3000 uncal. B.P. (cf. COHMAP members 1988), it is likely that these latter alignments of inter-regional climatic oscillations are determined significantly by variations of 1 to 2° C in mean inter-regional temperatures, and not major transforms of GAC.

Earlier Holocene climate change is more likely to be modulated by GAC transforms, wherein MJTs are generally higher than those of the later Holocene. Within dating limits, then, perceived less mesic or subxeric episodes at Buckeye Knoll corresponding to periods of ca. 9000 to 8300 (extrapolated), 7335 to 6995, and 5575 cal. B.P. align with "soil-gaps" in southern Coahuila as follows: 9000-8750, 7750 to 7000, and 5750 to 5000 cal. B.P.. However, based on the Buckeye Knoll geo-botanical data, intervening mesic episodes appear to be less emphatically expressed in south Texas.

More emphatic inter-regional paleo-climatic discrepancies exist with respect to the highest-amplitude change expressed at the Zone P1:4/5 boundary at Buckeye Knoll. The following zone of 5425 to 5200 cal. B.P. provides very strong pollen evidence for cooler and wetter conditions in south Texas, although this oscillation is not evident in north Mexico, where xeric conditions continue.

Differences in the inter-regional experience of cT may help to explain the inter-regional pattern of climate change ca. 9000 to 5200 cal. B.P.. Should north Mexican precipitation be modulated by the penetration of cT airmasses, a lower penetration of such masses to south Texas might be expressed in less emphatic positive changes in its precipitation levels. Finally, a combination of lower temperatures *and* reduced GAC can explain the inter-regional data pattern of 5500/5400 to 5200 cal. B.P., whereby a weakened GAC also reduces cT inputs into north Mexico, when south Texas will also have been more prone to polar systems that might induce increased precipitation in some ill-defined way. Significantly, severe interruptions of heat transfer to the middle latitudes are also well-supported for this period in the "Piora II" or "Rotmoos II" Alpine neoglaciations (Grove 1988).

### *Settlement and Subsistence Inferences*

Changes in vegetation in the lower Guadalupe River valley have markedly affected conditions for human settlement and subsistence over the course of the Holocene. Reconstructions of variations in potential floral resources concentrate on the history of pecan due to the very high levels of Kcalorie (Kcal) productivity derived from the fleshy nuts of this species (judging by bio-geographic context, *Carya* pollen almost certainly derives from *C. illinoensis*). Indeed, Grant Hall (1981, 1995a, 1995b) has long suggested a correlation between human population density, aspects of social complexity, and pecan abundances on the Texas coastal plain. Changes in ungulate biomass availability might also be estimated on the basis of the mesic vs.

sub-xeric quality of NAP assemblages, wherein high forb ratios typify less-productive short-grass prairies, while high *Gramineae* ratios typify more productive, tall-grass prairies (Bartlein et al. 1986).

Surveys of modern pecan-rich overstory vegetation in north-central Texas bottomland forests provide an approximate analog for pecan productivity per unit area. From the Aquilla Lake project area, a bottomland forest overstory consisted of approximately 20 percent pecan that produced 87.5 percent of its total human-usable resources (Brown 1988a), in addition to providing its most efficiently harvested resource according to Optimal Foraging Theory.

In terms of Kcal production per unit area, bottomland forests in the region of Hill County will provide 1,153.5 x $10^6$ Kcals per 1,015 hectares, while, in terms of individual caloric needs, one hectare of such forests might provide 516 person-days of base subsistence. Conceivably, then, about 20 hectares of such forests would be sufficient to provide for the caloric (but not protein) needs of a ca.-100-member group for a period of 100 days during the autumnal pecan season.

A prevalence of faunal resources, such as deer or bison, will be favored by more wooded and more open environments, respectively, as will be reconstructed below. In general, it may also be said that an open woodland, rather than a closed woodland or open grassland, will provide the greatest general resource variability. Such resource variability of both flora and fauna is promoted by the maintenance of a vegetation "mosaic" rather than "monolithic" biotic zones. Most likely, an aforestation level of ca. 50 to 60 percent up to the valley margins would have provided the greatest general subsistence variability for aboriginal hunter-gatherer populations.

With respect to potential ungulate biomass, it can be said that mesic grasslands will support a density ten times greater than sub-xeric grasslands or short-grass prairies. For the American Great Plains, Butzer (1964) cites observed ungulate densities of up to 3,000 kg/km$^2$ in tall-grass regions, falling to only 350 kg/km$^2$ in sub-xeric zones. In palynological terms, mesic grassland-to-forb ratios of between 2.0+:1 and 0.1:1 may define these ecological extremes, with ratios of ca. 0.5:1 defining a mean ungulate biomass availability.

Diachronic reconstructions of general aforestation levels, variations in *Carya* maxima, and fluctuations of moisture availability in the interfluvial prairies of the lower Guadalupe River valley can now be made on the basis of regionally significant, pre-2600 cal. B.P. pollen data from Core P1 alluvium (Table B-16). Note in Table B-16 that "LO±" designates a potentially more or less pervasive live-oak complex towards the valley margins. Such environments typically have less biotic productivity than floodplain woodlands, and thus are less optimal for human subsistence.

Beginning with PI:1A-D (possible latest Paleo-Indian to earliest Archaic period), conditions are favorable for plant-based subsistence, judging by the pecan values in P1:1A. Subsequently, increased MJTs reduce the pecan groves during the ninth millennium B.P. (calibrated). Inferably, moisture in interfluvial grasslands during the Late Paleo-Indian period was greater than today, although there was a trend toward dryness with increasing temperatures as indicated in sub-Zones P1:1C-D. A subsistence shift toward animal resources might be posited for this period, as pecans and other arboreal elements became less abundant.

In the Early Archaic (Zone P1:2, 7335-6995 cal. B.P.), a major denudation of woodlands and a low (0.3) ratio of mesic to forbic grassland taxa characterize a warm, sub-xeric phase. The Early Archaic cemetery at Buckeye Knoll was established during this time interval. Compared to subsequent sub-xeric phases with very low mesic-to-forbic ratios of 0.1 to 0.2:1, Zone P1:2 grasslands are biotically productive, a reflection perhaps of subtropical conditions (as suggested by the presence of palm pollen). It is unlikely, however, that the inferable palm were expansive enough to provide a major resource base.

A Zone P1:3 mesic interval ca. 6315 to 5750 cal. B.P. appears to be comparable to biotic conditions of sub-Zone P1:1A times, although maximal *Carya* values and mesic grassland ratios are lower. As such, Zone P1:3 *K*-capacities may be ca. 70 to 80 percent of those of the initial sub-zone. The Early Archaic cemetery ceased to be used during this interval.

Zone P1:4 (5575 cal. B.P.) presents a profoundly sub-xeric vegetation picture of very dry grassland (mesic-to-forbic ratio=0.1:1, an absolute minimum), low ungulate biomass density, and severely denuded woodlands (probably dominated by live-oaks) with small stands of pecan. Most likely, Zone P1:4 corresponds to a nadir in aboriginal population density in the area.

Zone P1:5 times (5425-5200 cal. B.P.) exhibit moist floral conditions in the grassy interfluves (mesic/forbic ratio=2.5), probably corresponding to condi-

**Table B-16.** Relative Woodland Extent (After Table B-3), Pecan Abundance, and Wet/Dry-Grassland Composition in the Lower Guadalupe River Valley, ca. 9300 to 2600 Cal. B.P.

| Pollen Zone | Cal. Yrs. B.P. (Range) | Aforestation (%) to Valley Margin | *Carya* Max. (%TLP) | Mesic Grassland/ Forbic Floral Ratio |
|---|---|---|---|---|
| P1:1A | ~9340? | 45-55 | 8.8 | 0.7 |
| P1:1B | ~9000? | 40-50 | 0.0 | 0.7 |
| P1:1C | ~8360? | 25-35 | 0.0 | 0.6 |
| P1:1D | ~8020? | 35-45 | 1.5 | 0.6 |
| P1:2 | 7335-6995 | 15-25 | 4.0 | 0.3 |
| P1:3 | 6315-5750 | 45-65 (LO-) | 5.8 | 0.6 |
| P1:4 | 5575 | 5-15 | 0.8 | 0.1 |
| P1:5 | 5425-5200 | 50-75 | 4.2 | 2.5 |
| P1:6 | 5125-4830 | 65-75 | 19.6 | 1.0 |
| P1:7 | 4575 | 75-85 (LO+) | 5.2 | 0.5 |
| P1:8 | 4445 | 15-25 | 0.5 | 0.2 |
| P1:9 | 4250 | 55-65 | 9.9 | 0.7 |
| P1:10 | 3900 | 15-25 | 1.0 | 0.2 |
| P1:11 | 3215-2930 | 45-65 | 10.8 | 0.4 |
| P1:12 | 2780-2630 | 55-65 | 18.0 | 1.2 |

tions for the support of optimal ungulate biomass densities on the order of 3,000 kg/km$^2$. Suggestively, this period may correspond to the archaeological expression of the Bell/Andice or Calf Creek techno-complex in south Texas (cf. Ricklis 1988, 1994), thought to be associated with a bison-hunting cultural ecology (Collins 1994). Woodlands expanded steadily during this period, excluding grasses from parts of the valley as *Carya* values rose to 4.2 percent of TLP.

Zone P1:6 (5125-4830 cal. B.P.) corresponds archaeologically to the Middle Archaic period, when Early Triangular and Refugio dart points were being manufactured. Palynologically, a luxuriant oak-pecan woodland was in evidence, with an absolute maximum of *Carya* of 19.6 percent TLP. Intuitively, such high values might correspond to pecan density levels observed recently in the Hill County bottomland forests (although analogs will be required to test this hypothesis, cf. Toomey 1993). If such were the case, floodplain pecan woodland areas as small as 20 hectares may have been sufficient to support a population of ca. 100 people for 100 days during this period.

Zone P1:7 (ca. 4575 cal. B.P.) times saw a decline of *Carya* with an expanded oak woodland of much lower biotic productivity. Grassland to forbic vegetation ratios also declined from 1.0 to 0.5:1 during this period, signifying a lower ungulate biomass availability on the interfluves even as dry forests expanded to their pan-Holocene maximum. Species diversity and variegation of the woodland mosaic were inferably low during this period of maximal aforestation.

The Zone P1:8 to 10 period of ca. 4425 to 3900 cal. B.P. may be described as environmentally variable, but generally sub-xeric, with a phase (of ca. 200-year duration) of aforestation intervening (Zone P1:9) at ca. 4250 cal. B.P. (with a higher *Carya* abundance). Mesic-to-forbic grassland ratios are low in Zones P1:8 and 10, corresponding to ungulate biomass densities perhaps on the order of 400-500 kg/ $km^2$.

The Late Archaic (Zones P1:11-12) witnessed an enduring rise of *Carya* to values of ca. 18 percent, beginning sometime between 3900 and 3200 cal. B.P., and continuing in all probability into the latter part of the third millennium cal. B.P. (although data are lacking here, Zones P1:13 and P2:1, which bracket the pertinent interval, both express high, if local, values of *Carya*). Given a timespan of pecan abundance of ca. 1,000 years (or more), regional population levels may have seen a long-term increase, possibly reaching maximum carrying capacity during this period.

Once again, high-density pecan groves typified the regional vegetation picture of the Late Archaic, so that a year-round group of around 100 people might subsist off about 75 hectares of prime floodplain woodland, should facilities for year-round storage be available (facilities comparable to Features 13 and 17 at Buckeye Knoll). High population densities inhabiting highly concentrated and defensible resource patches might then promote a degree of "tribal territoriality" and "raiding or warfare" in defense of these territories.

Regarding faunal resources and variegation of the vegetation mosaic during the Late Archaic, a mesic tendency in the interfluvial grassland composition is indicated as mesic-to-forbic ratios rise from 0.4:1 to 1.2:1. Trophic conditions for ungulates were, thus, inferably favorable, possibly with the maintenance of biomass densities of ca. 2,000 $kg/km^2$. The woodland-grassland mix fluctuated between 45 and 65 percent to the valley margin, open woodland conditions that may be described as optimal for increased variation in the floral assemblage, factors that reduced baseline total-resource fluctuation, and thus the risks of overall subsistence failure. Populations of both deer and bison might thrive in the totality of this Late Archaic regional environment, as reflected in Core P1 alluvium.

From oxbow deposits of Cores P1 and P2, a more *localized* terminal Late Archaic and Initial Late Prehistoric flora witnessed a continued importance of *Carya* in the environs of the Buckeye Knoll site. It seems likely that both the north and western slopes of the knoll supported stands of minimally four hectares within dual 500 m radii of site zones P1:13 and P2:1, all suggestive of a sufficient local resource base for an autumnal basecamp/macroband population. The relative abundance of Scallorn arrow points at Buckeye Knoll may reflect relatively intensive occupation of the site during this interval.

Drier, more sub-xeric conditions with denuded local *Carya* stands characterize coeval Zones P1:14 and P2:2 approaching A.D. 1000 in chronologic terms. A forbic and halophytic high is locally notable, signifying a local deforestation broadly coeval perhaps with a sandy lens (eolian [?] Zone 1-A) observed in overlying Zone 2 in the Knoll-Top block excavation. Inferably, food resources, both floral and faunal, were reduced during this period. Terminal archaeological midden accumulation at the Buckeye Knoll site may relate to a final *Carya* fluorescence in coeval Zones P1:15 and P2:3, beginning at ca. 895 cal. B.P., with waning values thereafter correlating to midden termination as pecans either out-migrated locally or were denuded regionally.

At ca. 370 cal. B.P. (A.D. 1580), a severe subxeric phase expressing a maximum of salt-bush in Core P2 is expressed in a solitary spectrum reflecting ca. 10 years of sediment accumulation. It is possible that this spectrum reflects dry conditions such as those observed by Cabeza de Vaca in the early sixteenth century (cf. Hester 1999; Brown 1988b). As such, "ethnohistoric" observations made by de Vaca during this period need not be representative of the Late Prehistoric period in general. Significantly more mesic environmental conditions follow upon this phase in Zone P2:5, broadly coeval with observations of Minet (1987) of the Matagorda Bay area during the 1680s. Notably, the latter's memoirs give an impression of a more mesic environment of "inland lakes" on the central Texas Gulf coastal plain.

### *Final Remarks*

Significant climate and floral change, as well as changing conditions for human subsistence in the lower Guadalupe River Valley, are indicated during the course of the Holocene. This composite record is conformable with inter-regional evidence for environmental change in the lower Nueces (NB) and southern Coahuilan databases (Butzer n.d.; Ricklis and Albert 1998).

Complexities of the pan-Holocene record reflect upon a uniformitarian condition, wherein a sufficient data-point density allows for the perception of century-level-time-scale environmental variability in the distant past like that recorded in abundant sources for the last millennium. Notions of a pan-Holocene, gradualistic environmental continuum, drawn from small bogs such as Hershop, are not affirmed (see Footnote 1). Importantly, the aerodynamic pollen recruitment characteristics of small bogs greatly favors the over-representation of local flora, much like the situation in Core P2, a situation that tends to mask the secular climatic/vegetational oscillations revealed for the Buckeye Knoll environment. Unlike spectra from Core P2, the local flora from small bogs that are fed by underground aquifers are *not* at equilibrium with climate, but rather reflect upon a local geo-hydrological condition. Regional pollen spectra recruited from more general terrestrial areas, such as those found in Core P1 alluvium, are indicative of a greater variability that accords well with the floral *and* faunal biostratigraphies of more climatically sensitive records, such as those from Hall's Cave in central Texas (Toomey et al. 1993).

### *References*


Albert, B. M. W.
1999 Early and Protohistoric Agents of Vegetation Change in the Environs of Mission Rosario (41GD2), as Reflected in Palynological Data. *Bulletin of the Texas Archeological Society* 70:189-95.

________
2005 Natural Environment Later Prehistoric Settlement of Central Europe. Unpublished Ph.D. Dissertation, Department of Archaeology, University of Durham, England.

Anderson, S. T.
1974 Wind Conditions and Pollen Dispersion in a Mixed Deciduous Forest. *Grana* 4:57-77.

Bartlein, P. J., I. C. Prentice, and T. Webb
1986 Climatic Response Surfaces from Pollen Data for Some Eastern North American Taxa. *Journal of Biogeography* 13:35-57.

Bonny, A. P.
1976 Recruitment of Pollen to the Seston and Sediment of Some Lake District Lakes. *Journal of Ecology* 64:859-887.

________
1978 The Effect of Pollen Recruitment Processes on Pollen Distribution over the Sediment Surface of a Small Lake in Cumbria. *Journal of Ecology* 66:385-416.

Brown, K. M.
1988a Prehistoric Subsistence Strategies in Northeastern Central Texas. *Bulletin of the Texas Archeological Society* 59:201-244.

Brown, K. M.
1988b Some Annotated Excerpts from Alonso de Leon's History of Nuevo Leon. *La Tierra* 15(2):5-20.

Bryant, V. M., and R. G. Holloway
1985 A Late-Quaternary Paleoenvironmental Record of Texas: An Overview of the Pollen Evidence. In *Pollen Records of Late-Quaternary North American Sediments*, edited by V. M. Bryant and R. G. Holloway, pp. 40-70. American Association of Stratigraphic Palynologists, Dallas.

Butzer, K. W.
1964 *Environment and Archaeology.* Aldine, Chicago.

________
n.d. Frequency of AMS (Charcoal) and $^{14}C$ (Humate) Dates Per 250 Years (Calibrated). Notes on file, Geo-Archaeology Laboratory, Department of Geography and Environment, University of Texas at Austin.

Collins, M. B.
1994 Evidence of Early Archaic Occupations. In *Archaic and Late Prehistoric Human Ecology in the Middle Onion Creek Valley, Hays County, Texas,* by R. A. Ricklis and M. B. Collins, pp. 67-100. Studies in Archaeology No. 19. Texas Archaeological Research Laboratory, University of Texas at Austin.

Faegri, K., J. Iversen, P. E. Kaland, and K. Krzywisnki
1989 *Textbook of Pollen Analysis*. John Wiley & Sons, Chichester, England.

Firbas, F.
1949 *Waldgeschichte Mitteleuropas*. Gustav Fischer, Jena, Germany.

Grove, J. B.
1988 *The Little Ice Age*. Methuen, London.

Hall, G. D.
1981 *Allen's Creek: A Study in the Cultural Prehistory of the Lower Brazos River Valley, Texas*. Research Report No. 61. Texas Archeological Survey, University of Texas at Austin.

———
1995a A Perspective on Some Prehistoric Cemeteries in Texas: Loma Sandia in the Regional Setting. In *Archeological Investigations at the Loma Sandia Site (41KL28), A Prehistoric Cemetery and Campsite in Live Oak County, Texas*, by A. J. Taylor and C. L. Highley, pp. 47-68. Studies and Archeology No. 20. Texas Archeological Research Laboratory, University of Texas at Austin.

———
1995b Interpretations and Hypotheses of Some Prehistoric Cemeteries in Texas. In *Archeological Investigations at the Loma Sandia Site (41KL28), A Prehistoric Cemetery and Campsite in Live Oak County, Texas*, by A. J. Taylor and C. L. Highley, pp. 633-648. Studies and Archeology No. 20. Texas Archeological Research Laboratory, University of Texas at Austin.

Hester, T. R.
1999 Artifacts, Archeology, and Cabeza de Vaca in Southern Texas and Northeastern Mexico. *Bulletin of the Texas Archeological Society* 70:17-28.

Jacobson, G., and R. H. W. Bradshaw
1981 The Selection of Sites for Palaeovegetational Studies. *Quaternary Research* 16:80-96.

Lange, E.
1971 Botanische Beitra/ge Zur Mitteleuropa/Ischen Siedlungsgeschichte. *Schriften zur Ur- und Fru/hgeschichte* No. 27. Humboldt University, Berlin.

Larson, D. A., V. M. Bryant, and T. S. Patty
1972 Pollen Analysis of a Central Texas Bog. *American Midland Naturalist* 88:358-367

Minet
1987 Voyage Made from Canada Inland Going Southward during the Year 1682, translated by Ann Linda Bell and annotated by Patricia Galloway. In *LaSalle, the Mississippi, and the Gulf: Three Primary Documents,* edited by Robert S. Weddle, Mary Christine Morkovsky, and Patricia Galloway, pp. 29-68. Texas A&M University Press, College Station.

Pennington, W.
1979 The Origins of Pollen in Lake Sediments: An Enclosed Lake Compared to One Receiving Inflow Streams. *New Phytologist* 83:189-213.

Ricklis, R. A.
1988 Archeological Investigations at the McKinzie Site (41NU221), Nueces County, Texas: Description and Contextual Interpretations. *Bulletin of the Texas Archeological Society* 58:1-76.

———
1994 *Aboriginal Life and Culture on the Upper Texas Coast: Archaeology at the Mitchell Ridge Site, 41GV66, Galveston Island*. Coastal Archaeological Research, Inc., Corpus Christi.

Ricklis, R. A., and B. M. Albert
1998 Response of Fluvial and Barrier Island Systems to Climate and Sea Level Change, Central Texas Coast: The Geoarchaeological and Palynological Evidence. Final report submitted to the National Science Foundation, NSF Grant No. SBR-942-3650.

Ricklis, R. A., and M. D. Blum
1997 The Geoarchaeological Record of Holocene Sea Level Change and Human Occupation of the Texas Gulf Coast. *Geoarchaeology* 12:287-304.

Shelby, M. J.
1985 *Earth's Changing Surface*. Clarendon Press, Oxford.

Tauber, H.
1965 Differential Pollen Dispersion and the Interpretation of Pollen Diagrams. *Danmarks Geologiske Undersøgelse*. Vol. 2, no. 89, pp. 1-69. National Museum, Copenhagen.

Tauber, H.
1967 Investigations of the Mode of Pollen Transfer in Forested Areas. *Review of Palaeobotany and Palynology* 3:277-286.

Tharp, B. C.
1926 The Structure of Texas Vegetation East of the 98th Meridian. *University of Texas Bulletin* No. 2606. University of Texas at Austin.

Toomey, R. S., M. D. Blum, and S. Valastro
1993 Late Quaternary Climates and Environments of the Edwards Plateau, Texas. *Global and Planetary Change* 7:299-320.

## Appendix C

# Pollen, Phytolith, Macrofloral, and Protein Residue Analyses

**Kathryn Puseman**
**Linda Scott Cummings**

### *Introduction*

Two separate main areas were excavated at the Buckeye Knoll site (41VT98), near Victoria, Texas. Each of these areas had a stratified sequence of prehistoric occupation. The Knoll Top Excavation Block contained a cemetery dated to the Early Archaic period as defined in Texas, as well as hearth features and midden deposits dating to other periods. Strata in this excavation block represent the Late Paleo-Indian to Late Prehistoric cultural periods. A milling stone fragment found in the Knoll Top Excavation Block was washed for both pollen/starches and protein residues, while flotation samples from general fill, hearth fill, and burial fill were examined for macrofloral remains. Two burned-clay nodules from a hearth (Feature 15) in the Knoll Top Excavation Block also were washed to recover pollen/starches, if present. Soil matrix from the upper portion of Zone 2 (Analytical Unit 1) was examined for pollen and phytoliths. This sample also served as a control for the wash of the milling stone. Lithic artifacts from the burials were examined for possible protein residues to provide information concerning animal resources that might have been procured using these tools.

The West Slope Excavation Block was located about 25 meters west of the Knoll Top Excavation Block and contained a cache of "tested" chert cobbles (in 2-by-2-m Unit S54W123, southwest of the actual excavation block), a large slab of basketry-impressed asphaltum (natural beach tar), a fairly large pit (Feature 17), and six hearths or hearth remnants consisting of clusters of burned-clay nodules and/or sandstone clasts. The strata in this area represent Middle Archaic to Late Prehistoric occupations.

Soil matrix samples from the lower midden, Zone 3 (West Slope Analytical Unit 3), and the upper midden, Zone 2 (West Slope Analytical Unit 2), were examined for pollen and phytoliths. In addition, these samples served as soil controls for a pollen/starch wash from a second sandstone milling stone, as well as for the burned-clay nodules from three of the hearth/hearth-remnant features. The milling stone also was examined for possible protein residues. Fill samples from five of the hearth/hearth-remnant features and from the Feature 17 pit were examined for macrofloral remains, as were general fill samples. Pollen, starch, phytolith, and macrofloral analyses are used to provide information concerning plant resources available to, and utilized by, the prehistoric occupants of the site, which is believed to have experienced frequent, recurrent, multifunctional occupations.

### *Methods*

#### *Pollen, Phytoliths, and Starch*

A chemical-extraction technique based on flotation is the standard preparation technique used in this laboratory for the removal of pollen grains from the large volumes of sand, silt, and clay with which they are mixed. This particular process was developed for extraction of pollen from soils where preservation has been less than ideal and pollen density is lower than in peat. The soil samples from this project were small, so our normal methods were modified.

The samples were screened through 150-micron mesh and then rinsed with reverse osmosis water. Following this, samples were dried and then mixed with sodium polytungstate (density 2.3) for the heavy-liquid process. Samples were centrifuged at 1500 rpm for 10 minutes to separate organics and phytoliths from heavier inorganic remains. The supernatants containing pollen and organic remains were decanted. This process was repeated. The fraction containing the organics (and pollen) and phytoliths was rinsed, then acetolated for 3 to 5 minutes to remove any extraneous organic matter. At that point, the phytolith portion of the samples was examined and counted. The remaining portion of the sample was returned to the laboratory for silica destruction using a short (20 to 30 minute) treatment in hot hydrofluoric acid to remove any remaining inorganic particles.

A light microscope was used to count the pollen grains at a magnification of 500x. Pollen preservation in these samples was poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

Pollen aggregates were recorded during identification of the pollen. Aggregates are clumps of a single type of pollen, and may be interpreted to represent pollen dispersal over short distances, or the introduction of portions of the plant into an archaeological setting. Aggregates were included in the pollen counts as single grains, as is customary. The presence of aggregates is noted by an "A" next to the pollen frequency on the pollen diagram. A plus sign (+) on the pollen diagram indicates that the pollen type was observed in a sample that did not yield sufficient pollen to calculate percentages. Pollen diagrams are produced using the Tilia program, which was developed by Dr. Eric Grimm of the Illinois State Museum.

Indeterminate pollen includes pollen grains that are folded, mutilated, and otherwise distorted beyond recognition. These grains are included in the total pollen count, as they are part of the pollen record.

Concentrations of pollen and/or starch and phytoliths recovered from grinding surfaces might represent plants ground on milling stones. Microscopic remains recovered from burned-clay nodules might represent foods cooked in liquids if these clay nodules were heated, then used to heat liquids or foods. All surfaces to be washed first were cleaned using pressurized air to remove modern contaminants. Then the surfaces were washed with a Triton X-100 solution and reverse osmosis water using a sonicating toothbrush to recover pollen from the ground-stone surface or surface of the clay nodules. The sonicating toothbrush facilitates removal of pollen/starch and phytoliths embedded in irregularities of the surface of the artifacts. Once the surface was washed, the material recovered was concentrated in a centrifuge tube and dried in preparation for heavy-liquid separation. In addition to a surface wash, a scrape was collected from the interior of one of the burned-clay nodules. The wash and scrape samples were processed in the same manner as the soil samples, since all were small.

Pollen analysis also included identification of starch granules to general categories. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, eccentric). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

***Macrofloral***

The macrofloral samples were floated by personnel at Coastal Environments, Inc., using a 50-gallon drum with an attached 3/4-inch water hose. Samples were placed in the drum and the lighter fraction allowed to float to the surface where the water flowed out through a sheet-metal spout and captured in an attached nylon stocking. The sediment at the bottom of the drum was stirred to release residual light-fraction solids (Robert Ricklis, personal communication 2005). The light fractions were dried and submitted to PaleoResearch Institute for analysis.

At PaleoResearch, the light fractions were weighed then passed through a series of graduated screens (U.S. Standard Sieves with 2-mm, 1-mm, 0.5-mm and 0.25-mm openings) to separate charcoal debris and to initially sort the remains. The contents of each screen then were examined. Charcoal pieces in the 2-mm, 1-mm, and/or 0.5-mm screens were separated from the rest of the light fraction and the total charcoal weighed. A representative sample of these charcoal pieces was broken to expose a fresh cross-section and examined under a binocular microscope at a magnification of 70x. The weights of each charcoal type within the representative sample also were recorded. The material that remained in the 2-mm, 1-mm, 0.5-mm, and 0.25-mm sieves was scanned under a binocular stereo microscope at a magnification of 10x, with some identifications requiring magnifications of up to 70x. The material that passed through the 0.25-mm screen was not examined. Remains were recorded as charred and/or uncharred, whole and/or fragments. The term "seed" is used to represent seeds, achenes, caryopses, and other disseminules. Macrofloral remains are identified using manuals (Martin and Barkley 1973; Musil 1978; Schopmeyer 1974) and by comparison with modern and archaeological references.

Samples from archaeological sites commonly contain both charred and uncharred remains. Many ethnobotanists use the basic rule that unless there is a specific reason to believe otherwise, only charred remains will be considered prehistoric (Minnis 1981:147). Minnis (1981:147) states that it is "improbable that many prehistoric seeds survive uncharred through common archaeological time spans." Few seeds live longer than a century, and most live for a much shorter period of time (Harrington 1972; Justice and Bass 1978; Quick 1961). It is presumed that once seeds have died, decomposing organisms act to decay the seeds. Sites in caves, water-logged areas, and in very arid areas, however, can contain uncharred prehistoric remains. Interpretation of uncharred seeds to represent presence in the prehistoric record is considered on a sample-by-sample basis. Extraordinary conditions for preservation are required.

***Protein Residue***

The artifacts submitted for protein residue analysis were tested using an immunologically based technique referred to as cross-over immunoelectrophoresis (CIEP or COE). The method for CIEP is based on forensic work by Culliford (1964, 1971) with changes made by Newman and Julig (1989) following the procedure used by the Royal Canadian Mounted Police Serology Laboratory in Toronto. Further changes were made at PaleoResearch Institute following the advice of Dr. Richard Marlar at the Thrombosis Research Laboratory in the Denver VA Medical Center and the University of Colorado Health Sciences Center.

Smaller artifacts were washed using 2 ml of a 0.02M Tris hydrochloride, 0.5M sodium chloride, and 0.5 percent Triton X-100 solution. Artifacts were placed in an ultrasonic bath for 30 minutes, on a rotating mixer for 30 minutes, then in the ultrasonic bath for an additional 30 minutes. A portion of one larger artifact and the two milling stones were washed using 20 ml of a 0.02M Tris hydrochloride, 0.5M sodium chloride, and 0.5 percent Triton X-100 solution. Dirt was removed using centrifugation, and the resulting solution was concentrated down to approximately one ml using a Centriprep-10 centrifugal concentrator device with a 10,000 molecular weight cut-off membrane.

Soils contain compounds including chlorophyll, bacteria, and metal cations such as manganese, copper and iron oxide (Evershed, et al. 1996) that can cause false-positive results for artifacts buried in the soil. False-positive results also can occur from proteins in urine and feces from animal activity in the area. As a result, soil control samples also are tested. One gram of soil is added to 1 ml of the Tris/NaCl/Triton solution, then refrigerated for several days prior to testing.

The residues extracted from the artifacts and the soil controls first are tested against pre-immune goat serum (serum from a non-immunized animal) to detect non-specific binding of proteins. Samples testing negative against pre-immune serum then are tested against prepared animal antisera obtained from ICN Pharmaceuticals, Inc., and Sigma Chemical Company, and against antisera raised under the direction of Robert Sargeant in Lompoc, California, and Dr. Richard Marlar. Appropriate positive and negative controls were run for each antisera. A positive control consists of the blood of an animal for which the antiserum is known to test positively, and a negative control consists of the serum/blood of the animal in which the antiserum was raised, either rabbit or goat.

CIEP is performed using agarose gel as the medium. Two holes are punched in the gel about 5 mm apart. The protein extract from the artifact is placed in the cathodic well and the antiserum is placed in the anodic well. The sample is electrophoresed in Barbital buffer (pH 8.6) for 45 minutes at a voltage of 130v to drive the antigens and antibodies towards each other. Positive reactions appear as a line of precipitation between the two wells. Gels are stained with coomassie blue to make the precipitate line easier to see. Positive reactions are re-tested with dilute antisera to determine between true and false positives. Antisera are diluted to increase specificity of reactions, usually 1:10 or 1:20. Positive reactions obtained after this step are reported.

Identification of animals represented by positive results is usually made to the family level. Identification of fish is made to the family or order level. Fish and animal species have serum protein antigenic determinations in common; therefore, some cross reactions will occur between closely, and sometimes distantly, related animals (Gaensslen 1983:241). For example, bovine antiserum will react with bison blood, and deer antiserum will react with other members of the Cervidae (deer) family, such as elk and moose.

### *Phytolith Review*

Phytoliths are silica bodies produced by plants when soluble silica in the ground water is absorbed by the roots and carried up to the plant via the vascular system. Evaporation and metabolism of this water result in precipitation of the silica in and around the cellular walls. Opal phytoliths, which are distinct and decay-resistant plant remains, are deposited in the soil as the plant or plant parts die and break down. They are, however, subject to mechanical breakage and erosion and deterioration in high pH soils. Phytoliths are usually introduced directly into the soils in which the plants decay. Transportation of phytoliths occurs primarily by animal consumption, man's gathering of plants, or by erosion or transportation of the soil by wind, water, or ice.

The three major types of grass short-cell phytoliths include festucoid, chloridoid, and panicoid. Smooth elongate phytoliths are of no aid in interpreting either paleoenvironmental conditions or the subsistence record because they are produced by all grasses. Phytoliths tabulated to represent "total phytoliths" include the grass short-cells, buliform, trichome, elongate, and dicot forms. Frequencies for all other bodies recovered are calculated by dividing the number of each type recovered by the "total phytoliths."

The festucoid class of phytoliths is ascribed primarily to the subfamily Pooideae and occur most abundantly in cool, moist climates. However, Brown (1984) notes that festucoid phytoliths are produced in small quantity by nearly all grasses. Therefore, while they are typical of phytoliths produced by the subfamily Pooideae, they are not exclusive to this subfamily. Chloridoid phytoliths are found primarily in the subfamily Chloridoideae, a warm-season grass that grows in arid to semi-arid areas and requires less available soil moisture. Chloridoid grasses are the most abundant in the American Southwest (Gould and Shaw 1983:120). Bilobates and polylobates are produced mainly by panicoid grasses, although a few of the festucoid grasses also produce these forms. Panicoid phytoliths occur in warm-season or tall grasses that frequently thrive in humid conditions. Twiss (1987:181) also notes that some members of the subfamily Chloridoideae produce both bilobate (Panicoid) and Festucoid phytoliths. "According to Gould and Shaw (1983:110), more than 97 percent of the native U.S. grass species (1,026 or 1,053) are divided equally among three subfamilies—Pooideae, Chloridoideae, and Panicoideae" (Twiss 1987:181).

Buliform phytoliths are produced by grasses in response to wet conditions and are to be expected in wet habitats of floodplains and other places. Trichomes represent silicified hairs, which can occur on the stems, leaves, and the glumes or bran surrounding grass seeds.

Diatoms and sponge spicules also were noted. Long diatoms are ubiquitous and do not provide any microenvironmental information. Sponge spicules represent the remains of freshwater sponges. Their presence in these samples probably indicates the presence of water either in wet sediments or perhaps used in cooking pots.

### *Ethnobotanic Review*

It is a commonly accepted practice in archaeological studies to reference ethnological (historic) plant uses as indicators of possible or even probable plant uses in prehistoric times. It gives evidence of the exploitation, in historic times, of numerous plants, both by broad categories, such as greens, seeds, roots, and tubers, etc., and by specific example, i.e., seeds parched and ground into meal which was then formed into cakes and fried in grease. Repetitive evidence of the exploitation of resources indicates a widespread utilization and strengthens the possibility that the same or similar resources were used in prehistoric times.

Ethnographic sources outside the study area have been consulted to permit a more exhaustive review of potential uses for each plant. Ethnographic sources do document that, with some plants, the historic use was developed and carried over from the past. A plant with medicinal qualities very likely was discovered in prehistoric times and the usage persisted into historic times. There is, however, likely to have been a loss of knowledge concerning the utilization of plant resources as cultures moved from subsistence to agricultural economies and/or were introduced to European foods during the historic period.

The ethnobotanic literature serves only as a guide indicating that the potential for utilization existed in prehistoric times—not as conclusive evidence that the resources were used. Pollen and macrofloral remains, when compared with the material culture (artifacts and features) recovered by archaeologists, become indicators of use. Plants represented by pollen and charred macrofloral remains will be discussed in the following paragraphs in order to provide an ethnobotanic background for discussing the remains.

***Native Plants***

***Apiaceae (Umbel Family)***

Members of the Apiaceae family, including, but not limited to, *Cymopterus, Lomatium,* and *Pseudocymopterus*, are noted to have been used by many Native American groups. The roots, stems, and leaves of these plants may be used for food, seasoning, and medicine (Harrington 1967; Kindscher 1987; Kirk 1975). *Cicuta* (water-hemlock) is noted to be poisonous, but medicinal uses are reported, including as a contraceptive. The Eskimos are reported to eat the leaves. All species of *Lomatium* (biscuitroot, prairie parsley) are edible. The young leaves and greens may be eaten in the spring. *Lomatium* produces an edible root that was widely used on the Plains. The roots can be eaten raw, cooked, or peeled, dried, and ground into a flour. The small seeds also can be parched and ground into a flour (Kindscher 1987:147-178; Kirk 1975:123).

**Celtis *(Hackberry)***

*Celtis* (hackberry) are medium-sized trees with edible berry-like drupes that can be orange-brown to dark purple in color. Hackberries are small and round with thin, sweet, dry flesh and a single seed. The berries can be eaten raw, dried, or cooked. Hackberry bark or leaf infusion can be used to make a gargle for sore throats and as a pain reliever. The berries were used to treat dysentery. Hackberry trees are noted to be plentiful throughout North America and can be found growing in city parks, yards, empty lots, woods, and floodplains (Angell 1981:162-164; Brill and Dean 1994:170-171; Gould 1962:36; Peattie 1953:465-466; Petrides and Petrides 1992:171).

***Cheno-ams***

Cheno-ams refer to a group representing the Chenopodiaceae (goosefoot) family and the genus *Amaranthus* (pigweed). These plants are weedy annuals or perennials, often growing in disturbed areas such as cultivated fields and site vicinities. Cheno-ams, including a variety of plants such as *Amaranthus*, *Atriplex*, *Chenopodium*, *Monolepsis*, and *Suaeda*, are noted to have been used as food and for processing other foods. These plants were exploited for both their greens (cooked as potherbs) and seeds. The seeds were eaten raw or ground and used to make pinole and/or sometimes mixed with cornmeal to make a variety of mushes and cakes. The seeds usually are noted to have been parched prior to grinding. The greens are most tender when young, in the spring, but can be used at any time. The greens can be harvested and cooked either alone or with other foods. Various parts of the Cheno-am plants are noted to have been gathered from early spring through the fall (Burlage 1968:2-3, 29-31; Kindscher 1987:18-22, 79-83; Kirk 1975:56, 63; Sweet 1976:48).

**Chenopodium *(Goosefoot, Lamb's Quarters)***

*Chenopodium* (goosefoot) "seeds are about equal to corn in the number of calories they contain, but have significantly more protein and fat (Asch and Asch 1978:307). The cooked greens contain more than three times as much calcium as cooked spinach and also have more vitamin A and C (Watt and Merrill 1963:37, 59)" (Kindscher 1987:82). The leaves were eaten to treat stomachaches and to prevent scurvy. Leaf poultices were applied to burns, swellings, and arthritis, and a tea made from the whole plant was used to treat diarrhea and toothaches. A leaf decoction was used as a bath for rheumatism. Oil of *Chenopodium* is obtained from *C. ambrosioides* (wormseed goosefoot), which is a good cure for intestinal worms (Angier 1978:191-193; Krochmal and Krochmal 1973:66-67; Moore 1990:42).

**Nelumbo *(Lotus)***

*Nelumbo* (lotus) is a large, aquatic herb with widespreading, horizontal, thickened rhizomes rooted in mud. Lotus tubers and seeds both are edible. Numerous Native American groups are noted to have processed *Nelumbo* seeds and tubers. The tubers were used with acorns, cooked with meat, or boiled and eaten as vegetables. Shoots were collected and cooked with meat or other vegetables. They also were dried and kept for winter food. Seeds were gathered and roasted like chestnuts or cooked with meat to make soup. Karankawa groups are noted to have gathered tubers of yellow lotus (*Nelumbo lutea*) from coastal lagoons. *Nelumbo* is found in ponds and quiet streams (Bailey and Bailey 1976:757; Moerman 1998:353; Newcomb 1983:363; Niering 1985:429-430).

***PET Fruity***

Remains called PET (processed edible tissue) fruity also were recovered. This term was originated by Nancy Stenholm (1993) and refers to softer tissue types, such as starchy parenchymoid or fruity epitheloid tissues. PET fruity tissues resemble sugar-laden fruit or berry tissue without the seeds. Fruits and berries were eaten fresh, cooked, or dried. Fruits were dried whole, or mashed and formed into cakes which were sun-dried. Dried fruits and berries were eaten plain, ground into a meal, boiled, added to stews or meat, or used to flavor other foods. Native peoples made pemmican from a variety of native berries. Pemmican was made from dried meat, berries, and animal fat mixed together. Fruits and berries often provided essential vitamins and were collected in late summer and fall, with some fruits remaining on the plants into the winter (Angell 1981; Harrington 1967:229-297; Kirk 1975).

**Phytolacca americana**
***(Pokeweed)***

*Phytolacca americana* (pokeweed, pokeberry) is a non-woody, native herbaceous perennial with reddish or purplish stems. The young stems are thick and succulent like asparagus, and young stems and shoots can be collected in the spring and cooked as potherbs. The young shoots and leaves contain beta carotene, which is not destroyed by boiling. The ripe, dark purple berries also can be cooked and eaten. Berries ripen in the fall and can persist on the plants well into the winter. The roots, mature stems and leaves, seeds, and unripe berries contain the alkaloid phytolaccine and are noted to be poisonous. Indian groups used the root as a medicinal resource. The root was valued as an emetic and used to treat fever and other illnesses. The phytolaccine is reported to have laxative and narcotic effects. *Phytolacca* is native from Maine to Minnesota and south to Texas and Florida. It is found in thickets, meadows, clearings, cultivated fields, pasture lands, waste places, and open places, mostly on rich, gravelly soils (Angell 1981:142-143; Brill and Dean 1994:39-41; Martin 1972:50; Medsger 1966:142-143; Millspaugh 1974:557-561; Peterson 1977:46).

***Poaceae (Grass Family)***

Members of the Poaceae (grass) family have been widely used as a food resource, including *Agropyron* (wheatgrass), *Hordeum* (barley), *Elymus* (ryegrass), *Eragrostis* (lovegrass), *Achnatherum* (ricegrass), *Poa, Sporobolus* (dropseed), and others. Grass grains were normally parched and ground into a meal to make various mushes and cakes. Several species of grass contain hairs (awns) that were singed off by exposing the seeds to flame. Young shoots and leaves were cooked as greens. Roots were eaten raw, roasted, or dried and ground into a flour. Grass also is reported to have been used as a floor covering, tinder, basketry material, and to make brushes and brooms. Some species of grass were used medicinally. *Andropogon glomeratus* (bushy bluestem) was used by the Catawba Indians to treat backache. *Hordeum jubatum* (foxtail barley) is used as an eye medicine. A decoction of *Oryza sativa* (rice) is used in fevers and inflammatory infections of the stomach, lungs, and kidneys. Grass seeds ripen from spring to fall, depending on the species, providing a long-term available resource (Burlage 1968:81-85; Chamberlin 1964:372; Harrington 1967:322; Kirk 1975:177-190).

**Prosopis *(Mesquite)***

*Prosopis* (mesquite) is a xerophytic shrub or small tree. The pods of both *P. juliflora* (honey mesquite) and *P. pubescens* (screwpod mesquite) were utilized for food. The pods are sweet (*P. juliflora* pods are noted to contain about 25 percent sugar), and they were eaten fresh, boiled, or fermented to make a mild alcoholic drink. The pods also were dried and ground into flour. Pods boiled in water yield molasses. Pottery paddles and cradleboards also were made from mesquite wood. The gum was applied to sores and wounds, or boiled in water to make an eyewash, candy, pottery paint, or hair dye. The bark was used for tanning and dying. Mesquite wood burns slowly, with an intense heat, and burns down to a long-lasting bed of coals (Burlage 1968:105; Kearney and Peebles 1960:402; Loughmiller and Loughmiller 1994:135; Peattie 1953:561-563; Sweet 1976:24).

***Rosaceae (Rose Family)***

The Rosaceae family includes several shrubs/trees that produce edible fruits or berries, such as Crataegus (hawthorn), *Prunus* (cherry, plum), and *Rubus* (blackberry/dewberry). The fruits were eaten fresh, cooked, or dried for storage. A mixture of dried, pounded berries, dried meat, and fat called pemmican commonly was made. The bark, leaves, and seeds of *Prunus* species contain a cyanide-like glycoside called prunasin that converts to the highly toxic hydrocyanic acid when digested. *Rosa* (wild rose) produces a fruit referred to as rosehips that can be consumed either raw or cooked. Rose hips are very high in vitamin C and can be used to make a tea. *Rosa* commonly was used by native groups. Seeds were cooked and eaten to treat muscular pains. Roots were used top stop bleeding and as an astringent for diarrhea, sore throat, and conjunctivitis. Flower petals were used as a bandage for burns and wounds, and as a treatment for colic and heartburn. Insect bites and stings were treated with a leaf poultice. *Rosa* shrubs prefer consistently moist soils (Angell 1981:42, 44-48; Burlage 1968:155; Foster and Duke 1990:290; Kirk 1975:94-100; Peterson 1977:106, 218; Tilford 1997:122, 162).

**Typha *(Cattail)***

*Typha* (cattail) are perennial marsh or aquatic plants with creeping rhizomes. This plant is a rich source of nutrients and is noted to be one of the most important and common wild foods. Cattails were a staple for many American Indian groups. Various parts of the cattail plant can be used throughout the year. In the spring, young shoots can be peeled and the white inner core eaten raw or cooked like asparagus. Cattail shoots provide beta carotene, niacin, riboflavin, thiamin, potassium, phosphorus, and vitamin C. During the summer, young flower stalks were taken out of their sheaths and cooked. The male portions of the immature, green flower head can be steamed or simmered and eaten like corn. Flowers were eaten alone or added as a flavoring or thickening for other foods. Pollen-producing flowers and the pollen itself were collected and used as flour, either alone or mixed with other meal. In the fall, the rootstalks were collected, the outer peel removed, and the white inner cores of almost pure starch were eaten raw, boiled, baked, or dried and ground into flour. Cattail roots are richer in starch during the fall. Cattail starch flour is noted to be similar in quantities of fats, proteins, and carbohydrates to flour from rice and corn. The seed-like fruits also were collected and eaten in the fall. Indian groups are noted to process these "seeds" by burning off the bristles. The seeds were then parched and could be more easily rubbed off the spike. The slightly astringent flower heads were sometimes used to relieve diarrhea and other digestive disorders. The "jelly" from between the young leaves and from pounded roots was applied to wounds, sores, carbuncles, boils, external inflammations, burns, scalds, and to soothe pain. Cattail down was used as dressing for wounds and padding in cradleboards and moccasins. Leaves and stems were used for weaving mats and baskets, to make toys, and to thatch roofs. Cattails form dense stands in marshes, swamps, ponds, sloughs, ditches, shallow stagnant water, and edges of streams (Brill and Dean 1994:67-71; Foster and Duke 1990:312; Medsger 1966:196; Niering 1985:431-432; Peterson 1977:158).

**Vitis *(Wild Grape)***

*Vitis* (wild grape) are thornless, high-climbing vines that often climb to the tops of large forest trees. Some vines can be parasitic. Grape leaves are an excellent source of beta carotene and niacin, and can be collected in the summer and boiled as potherbs. The fruits ripen in the late summer and fall and are round, few-seeded, juicy berries that can be purple, blue, black, red, or amber. Wild grapes are less sweet than commercial varieties but contain more flavor. Grapes were eaten fresh and were dried for future use. They provide potassium, beta carotene, fructose, tartaric acid, quercitrin, tannin, malic acid, gum, and potassium bitartrate. A grape leaf or seed infusion is noted to be astringent and used to treat bleeding and diarrhea. Indian groups used it for stomachaches and hepatitis. The fruit, leaves, and tendrils also were used to treat diarrhea and snakebite. Leaves were used for poultices, bandages, and for wrapping foods. Wild grapes are reported to be diuretic and can be used to treat urinary tract infections. The skins contain resveratrol, which can prevent cardiovascular disease by reducing blood clots and raising high-density lipoprotein cholesterol. Wild grape vines are found in woods, thickets, in wetlands, and along streams and riverbanks (Angell 1981:156; Brill and Dean 1994:165-168; Medsger 1966:53-59; Meuninck 1988:15-16; Peterson 1977:198).

***Wood Charcoal***

Charcoal recovered from archaeological samples most often represents use of that type of wood as fuel; however, several trees and shrubs had utilitarian and medicinal uses as well. The presence of charcoal indicates that the trees and shrubs represented were present at the time of occupation. If these resources were present and collected as fuel, it also is possible that they were exploited for other purposes. The following paragraphs discuss plants represented only by charcoal in the macrofloral record.

**Ehretia anacua *(Anaqua, Anacua, Sandpaper-tree)***

*Ehretia anacua* (Anaqua) are evergreen trees that can grow up to 50 feet high. The tree produces edible, yellow-orange, fleshy fruits about one-quarter inch in diameter that contain two seeds. *Ehretia anacua* trees grow in dry soils of central and southeast Texas, as well as eastern Mexico (Gould 1962:74; Petrides and Petrides 1992:256-257).

**Fraxinus *(Ash)***

*Fraxinus* (ash) was utilized for a variety of medicinal purposes. Native peoples used a bud tea to treat snakebite. A strong leaf tea was given to women after childbirth. Chewed bark was applied to sores as a poultice. The sap from some species of ash was used to make a dark bitter sugar (Krochmal and Krochmal 1973:104; Petrides and Petrides 1992:80).

**Morus rubra *(Red Mulberry)***

The native *Morus rubra* (red mulberry) is a deciduous tree that can range from 20 to 70 feet in height, depending on the location. The berries are red until they ripen in early summer, when they turn a dark purple color. Mulberries are large, juicy, and sweet, and were eaten fresh or dried for future use. The young, unopened leaves and young shoots can be collected in the spring and boiled as a vegetable. The bark has been used as a laxative and to expel tapeworms. Fruits are also gently laxative. Red mulberries are native to the eastern United States and prefer rich, moist soil (Angell 1981:164-167; Brill and Dean 1994:126-128; Burlage 1968:125; Gould 1962:36-37; Medsger 1966:6-9; Peterson 1977:210).

**Platanus *(Sycamore)***

Species of *Platanus* (sycamore) are large floodplain or lowland trees. The American sycamore is found in the eastern United States and west into central Texas. The leaves are noted to be opthalmic, and the bark is said to be antiscorbutic (Burlage 1968:139; Gould 1962:47; Petrides and Petrides 1992:166-167).

**Quercus *(Oak)***

*Quercus* (oak) are deciduous or evergreen shrubs or trees (some quite large), and the various species are widespread throughout the United States. All species of *Quercus* produce edible acorns, although the presence of tannin results in varying degrees of bitterness. White oak acorns generally are less bitter than black oak (including red oak) acorns. *Quercus virginiana* (live oak) is noted to have sweet, palatable acorns. Acorns were gathered, shelled, roasted, and ground into a meal. The ground meal often was leached with water in various ways to remove any bitter taste. Wood ashes could be used like lye in the leaching process. The ground meal was used alone or mixed with cornmeal (a foodstuff not available to the prehistoric occupants of Buckeye Knoll) to make mush, thicken soup, or to make breads and cakes. Acorn meal also could be mixed with meat or animal fat. Oak wood was used for a variety of utilitarian purposes including making bows, arrows, rabbitsticks, digging sticks, clubs, and other utensils. Oak wood is strong and hard, and it was valued as firewood because a large piece of oak would burn slowly all night long. Oak bark was the principal source of tanning materials (Burlage 1968:79; Elmore 1976:23; Gallagher 1977:113; Harrington 1967:239-241; Kirk 1975:104-106; Vines 1960:162).

**Ulmus *(Elm)***

The inner bark of *Ulmus* (elm) trees was used as an emergency food, as well as an astringent, tonic, and a diuretic. The wood is hard, heavy, and strong and was burned as fuel. Elm wood also was used to make mortars and pestles. *U. americana* (American elm) grows throughout much of Texas in bottomlands, along stream banks, and on the boarders of swamps, but it also can be found on rocky hillsides in the open. The inner bark of *U. alata* (winged elm, cork elm, wahoo elm) was used as a poultice for inflammations. It grows in eastern and central Texas. (Burlage 1968:176-177; Gould 1962:36; Moerman 1998:576-577).

***Discussion and Results***

The Buckeye Knoll site is located at an elevation of 30 to 50 feet above mean sea level on a promontory overlooking the floodplain of the lower Guadalupe River in the central Texas coastal plain. Buckeye Knoll is found at the western end of the promontory. This area is a mosaic of intact and highly disturbed locales. The extensive floodplain is mainly undeveloped and uninhabited, while the uplands around Buckeye Knoll have experienced, in places, extensive development. The floodplain is dominated by large trees such as pecan (*Carya*), ash (*Fraxinus*), and willow (*Salix*) that form a dense woodland with an understory of short grasses (Poaceae). Grasses and forbs dominate the upland areas, with prickly pear cactus (*Opuntia*) found individually and in clumps. The sandy areas of the uplands support oak (*Quercus*) and anaqua (*Ehretia anacua*) trees. Mesquite (*Prosopis*) and hackberry (*Celtis*) grow in the heavier clay soils of the uplands away from the valley wall, while huisache (*Acacia farnesiana*) can be found in the moisture-collecting depressions (Ricklis 2002:10).

Pollen/starch, phytolith, macrofloral, and protein residue samples were examined from the Knoll Top Excavation Block and the West Slope Excavation Block at the site. Each area exhibited a unique stratified sequence. Each stratum or vertical segment of a stratum was assigned to an Analytical Unit (AU), based on stratigraphic position and the presence of time-diagnostic points and radiocarbon dates.

Both areas contained hearth features consisting of small clusters of burned-clay nodules and/or sandstone fragments that are believed to have been used as hearth stones. Hearths are thought to have been built on the ground level or possibly in very shallow basins. Soils at the site consist of silty sand; therefore, the clay for the nodules is presumed to have been intentionally brought to the site and formed into lumps that "were then used as surrogate stone for cooking and/or heating tasks" (Ricklis 2002:98).

***Knoll Top Findings***

Four analytical units (AUs) were assigned to the Knoll Top Excavation Block. Diagnostic artifacts in AU 4 include late Paleo-Indian lanceolate points and stemmed Wilson-type points. The terminal Middle to Late Archaic, about 1800-250 B.C. (possibly to 500 B.C.), is represented by AU 3. Radiocarbon dates place AU 2 in the Late Archaic, about 150 B.C. to A.D. 400. AU 1 represents the early part of the Late Prehistoric, about A.D. 700 to 1300. The Knoll Top Excavation Block also contains a cemetery that is well dated by human bone collagen to the Texas Early Archaic, around 7,000-6,200 cal B.P. Over 65 Early Archaic burials were recorded in this area, with a few additional burials assigned the Middle Archaic and Late Archaic periods.

Sample KTZ2 represents Zone 2 (AU 2) midden fill and was examined for pollen/starches and phytoliths (Table C-1). The pollen record was scant and co-dominated by Low-spine Asteraceae and High-spine Asteraceae (Figure C-1, Table C-2), representing members of the sunflower family. Other pollen recorded included *Ulmus* and Poaceae, representing local elm trees and grasses. The phytolith record from this sample exhibited grass short cells from all three of the groups (cool season, short, and tall grasses) (Figure C-2). None have a clear dominance within this record. In addition, buliforms were notable, indicating that grasses growing in this area probably received sufficient water for good growth. Elongate forms are not of help when determining vegetation, other than to indicate grasses in general. Cyperaceae forms were present, indicating the presence of sedges. Parallelepiped forms probably represent a dicot, although they are a generalized form and could not be associated with any particular plant. No starches were observed in this sample, and sponge spicules were rare.

Sample KTZ2 also serves as a soil control sample for the pollen/starch and phytolith wash of a sandstone milling stone fragment (Lot No. 1655) from the northern portion of the Knoll Top Excavation Block. This milling stone fragment also was washed for protein residues and tested against the various antisera listed in Table C-3. The protein wash yielded negative results to all antisera tested. The pollen/starch record from the milling stone yielded a large quantity of Low-spine Asteraceae and a smaller quantity of High-spine Asteraceae pollen, reflecting the presence of members of the sunflower family. In addition, this wash yielded *Carya* pollen, reflecting local presence and availability of pecans or hickory. Small quantities of Caryophyllaceae and Nyctaginaceae pollen were recorded, indicating local growth of members of the pink and four o'clock families. Finally, a small quantity of *Typha* pollen was noted, indicating nearby growth of cattails and possibly processing of cattails on this milling stone. It is interesting that no other samples from this project contained *Typha* pollen, which strengthens the interpretation that cattails were ground on this milling stone. [Editor's Note: the present authors did not have access to Bruce Albert's pollen analysis (Appendix B), which shows *Typha* pollen in both Cores P1 and P2 (see Figures B-3 and B-5). *Typha* pollen is most common between 6000 B.P. and 2700 B.P. in Core P1 (see Figure B-3), corresponding to the Texas Middle Archaic.] The phytolith record from this milling stone yielded rather undiagnostic, elongate, smooth-grass forms, which might have been introduced from the surrounding sediments. "Woven" tracheary elements were noted, suggesting contact with a woody plant. Recovery of *Typha* raphids from the grinding surface strengthens the interpretation from the pollen record of grinding cattails. This sample yielded a few starch with centric hila, suggesting grinding of grass seeds, as well.

In addition, Sample KTZ2 is a control for the pollen/starch and phytolith washes of two burned-clay nodules (samples 15.1 and 15.2) from Feature 15, a small, tight cluster of burned-clay nodules found at a depth of 90-100 cm below the surface in Units S12W86/S14W86. No AU was assigned to Feature 15, although it was found in the upper-middle part of Zone 2 and thus probably can be assigned to AU 2, or if it was set into a dug basin, perhaps to AU 1. The pollen/starch record for Sample 15.1 was disappointing in that only a single *Carya* (pecan or hickory) pollen was noted. The phytolith record was similarly disappointing, with only elongate smooth forms and *Typha* raphids present. The starch record, however, was exciting since the only starches noted were diagnostic for *Nelumbo* (lotus) root. These eccentric starches are not found in other food items from the area. Therefore, the clay nodule represented by Sample 15.1 is

**Table C-1.** Provenience Data for Samples from the Buckeye Knoll Site.

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| Knoll Top | KTZ2 | | | | Zone 2 midden fill and soil control for milling stone fragment #1655 and Feat. 15 clay nodules | Pollen/Starch Phytolith |
| | 1655 | | 2 | 110/ Level 11 | S12 W84; Sandstone milling stone fragment from N portion of excavation block | Pollen/Starch Phytolith Protein |
| | 1655.S | | 2 | 110/ Level 11 | S12W84; Soil control for sandstone milling stone | Protein |
| | 15.1 | 15 | | 90-100 | S12W86/S14W86; Wash of burned-clay nodule from hearth in northern portion of excavation block | Pollen/Starch Phytolith |
| | 15.2 | 15 | | 90-100 | S12W86/S14W86; Wash of burned-clay nodule from hearth | Pollen/Starch Phytolith |
| | 15.3 | 15 | | 90-100 | S12W86/S14W86; Floated light fraction (FLF) from hearth fill | Macrofloral |
| | 23 | Burial 23 | 2 | | S12W84; Abdominal fill from Late Archaic burial of adult in northern portion of cemetery | Macrofloral |
| | 25 | Burial 25 | 2 | Level 13 | S12W84; FLF from fill of a Late Archaic burial of adult in N portion of cemetery | Macrofloral |
| | 12/82.7 | | 1 | 60-70/ Level 7 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.8 | | 1 | 70-80/ Level 8 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.9 | | 2 | 80-90/ Level 9 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.10 | | 2 | 90-100/ Level 10 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.11 | | 2 | 100-110/ Level 11 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.12 | | 3 | 110-120/ Level 12 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.13 | | 3 | 120-130/ Level 13 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |

continued.

**Table C-1.** (continued)

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| Knoll Top | 12/82.14 NE | | 3 | 130-140/ Level 14 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 12/82.14 SW | Burial 1 | 4 | 130-140/ Level 14 | S12W82 SW quad; FLF from fill around three groups of Early Archaic adult crania and incomplete long bones | Macrofloral |
| | 12/82.15 | | 4 | 140-150/ Level 15 | S12W82 NE quad; FLF from fill in NE portion of excavation block | Macrofloral |
| | 16/82.6 SW | | 1 | 50-60/ Level 6 | S16W82 SW quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 16/82.6 SE | | 1 | 50-60/ Level 6 | S16W82 SE quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 16/82.7 | | 1 | 60-70/ Level 7 | S16W82 SE quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 16/82.8 | | 2 | 70-80/ Level 8 | S16W82 SE quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 16/82.10 | | 3 | 90-100/ Level 10 | S16W82 SE quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 16/82.11 | | 3 | 100-110/ Level 11 | S16W82 SE quad; FLF from fill in SE portion of excavation block | Macrofloral |
| | 7 | 7 | 3 | | S16W88; FLF from feature fill, in southwest portion of excavation block | Macrofloral |
| | 9 | 9 | 3 | 71-81 | S20W90; FLF from hearth fill; southwest of main excavation block | Macrofloral |
| | 11 | 11 | 2 | | S12W74; FLF from hearth fill, east of main excavation block | Macrofloral |
| | 2220 | Burial 6 | | 141/ Level 14 | S12W86; Purple quartzite rooved stone from an Earl-yArchaic burial of adult male in the northern portion of an Archaic cemetery | Protein |
| | 2240 | Burial 65 | | 151/ Level 16 | S12W86; Quartzite grooved stone from Early Archaic burial in northern portion of cemetery | Protein |

continued.

**Table C-1.** (continued)

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| Knoll Top | 3043 | Burial 8 | | 168/ Level 17 | S12W84; Lanceolate dart point with tool kit from Early Archaic burial of adult male in N portion of cemetery | Protein |
| | 3105 | Burial 8 | | 169/ Level 17 | S12W84; Lanceolate dart point with tool kit from Early Archaic burial of adult male in N portion of cemetery | Protein |
| | 8.S | Burial 8 | | | S12W84; Soil from around artifacts, control for samples 3043 and 3105 | Protein |
| | 3176 | Burial 26 | | 137/ Level 14 | S10W84; Distal fragment of lanceolate dart point from Early Archaic burial of adult in N portion of cemetery | Protein |
| | 26.S | Burial 26 | | | S12W84; Soil control for sample 3176 | Protein |
| | 2232 | Burial 61 | | 149/ Level 15 | S12W84; Lanceolate dart point from Early Archaic burial of possible juvenile in northern portion of cemetery | Protein |
| | 2283 | Burial 61 | | 148/ Level 15 | S12W84; Quartzitegrooved stone from Early Archaic burial of possible juvenile | Protein |
| | 2284 | Burial 61 | | 148/ Level 15 | S12W84; Quartzite grooved stone from Early Archaic burial of possible juvenile | Protein |
| | 2289 | Burial 61 | | Level 15 | S12W84; Quartzite grooved stone from Early Archaic burial of possible juvenile | Protein |
| | 2277 | | | 150/ Level 15 | S12W84; Quartzite grooved stone from northern portion of cemetery | Protein |
| | 2141 | Burial 43 | | 115/ Level 12 | S16W86; Lanceolate dart point from Early Archaic burial of adult in southern portion of cemetery | Protein |
| | 43.S | Burial 43 | | | Soil control for sample 2141 | Protein |
| | 2186 | Burial 49 | | 145/ Level 15 | S16W84; Lanceolate dart point from Early Archaic burial of adult in southern portion of cemetery | Protein |
| | 2213 | Burial 49 | | 147/ Level 15 | S16W84; Lanceolate dart point from Early Archaic burial of adult | Protein |
| | 49.S | Burial 49 | | 130-140/ Level 14 | S16W84; Soil from abdominal cavity; control for samples 2186 and 2213 | Protein |

continued.

**Table C-1.** (continued)

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| **Knoll Top** | 3049 | Burial 74 | | 115/ | S16W86; Large stemmed biface from Early Archaic burial of adult in southern portion of cemetery | Protein |
| | 74.S | Burial 74 | | | Soil from pedestal, control for sample 3049 | Protein |
| | 1711 | | | 120-130/ Level 13 | S14W82; Chert chopper from eastern portion of excavation block | Protein |
| | 1711.S | | | Level 13/ | S14W82; Soil control for chert chopper | Protein |
| **West Slope** | WSZ3 | | | | Zone 3 midden fill and soil control for milling stone #2297 and Feat. 12, 8, 16 | Pollen/Starch Phytolith |
| | 2297 | | | 164/ Level 17 | S29W116; Small sandstone milling stone fragment from N. portion of excav. block | Pollen/Starch Phytolith Protein |
| | WSZ2 | | | | Zone 2 midden fill and soil-control for clay nodules from Features 12, 8, and 16 | Pollen/Starch Phytolith |
| | 12.1 | 12 | 2? | Level 14 | S33W116; Wash of burned-clay nodule from hearth remnant in southern portion of excavation block | Pollen/Starch Phytolith |
| | 12.2 | 12 | 2? | Level 14 | S33W116; Wash of burned-clay nodule from hearth remnant | Pollen/Starch Phytolith |
| | 12.4 | 12 | 2? | 130-140/ Level 14 | S33W116; FLF from hearth remnant | Macrofloral |
| | 12.3 | 12 | 2? | Level 14 | S33W116; Wash of burnedclay nodule from hearth remnant | Pollen/Starch Phytolith |
| | 8.1a | 8 | 2 | | S31W118; Wash of burned-clay nodule from hearth fill | Pollen/Starch Phytolith |
| | 8.1b | 8 | 2 | | S31W118; Scrape from interior of burned-clay nodule | Pollen/Starch Phytolith |
| | 8.2 | 8 | 2 | | S31W118; Wash of burned-clay nodule from hearth fill | Pollen/Starch Phytolith |
| | 8.3 | 8 | 2 | | S31 W118; FLF from hearth fill | Macrofloral |
| | 16.1 | 16 | 2 | | S29W118; Wash of burned-clay nodule from fill of hearth in northern portion of excavation block | Pollen/Starch Phytolith |
| | 16.2 | 16 | 2 | 159-190/ | S29W118; FLF from hearth fill | Macrofloral |
| | 17.18 | 17 | 2 | 170-180/ Level 18 | S29W118; FLF from fill of a pit in northern portion of excavation block | Macrofloral |

continued.

**Table C-1.** (continued)

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| West Slope | 17.19 | 17 | 2 | 180-190/ Level 19 | S29W118; FLF from pit fill | Macrofloral |
| | 19 | 19 | 2 | Level 18 | S29W116; FLF from fill of hearth remnant in northern portion of excavation block | Macrofloral |
| | 10 | 10 | 2 | 50-60/ Level 6 | S33W116; FLF from hearth remnant in southern portion of excavation block | Macrofloral |
| | 31/116.6 | | 1 | 50-60/ Level 6 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116.7 | | 1, 2 | 60-70/ Level 7 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116.8 | | 1, 2 | 70-80/ Level 8 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116.9 | | 1, 2 | 80-90/ Level 9 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116. 10 | | 2 | 90-100/ Level 10 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116. 11 | | 2 | 100-110/ Level 11 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116. 14 | | 2,3,4 | Level 14 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116. 15 | | 3, 4 | 140-150/ Level 15 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 31/116. 16 | | 4 | 150-160/ Level 16 | S31W116; FLF from E portion of excavation block | Macrofloral |
| | 32/117.6 | | 4 | Level 6 | S32W117; FLF from SW portion of excavation block | Macrofloral |
| | 33/118.6 | | 1, 2 | 53-63/ Level 6 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| | 33/118.7 | | 1, 2 | 63-73/ Level 7 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| | 33/118.8 | | 1, 2 | 73-83/ Level 8 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| | 33/118. 10 | | 2 | 93-100/ Level 10 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| | 33/118. 11 | | 2 | 103-113/ Level 11 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| | 33/118. 12 | | 2 | 113-123/ Level 12 | S33W118; FLF from SW portion of excavation block | Macrofloral |
| SW of West Slope | 54/123.7 | | No AU* | 90-100/ Level 7 | S54W123; FLF from unit fill; southwest of the West-Slope excavation block | Macrofloral |

continued.

**Table C-1.** (concluded)

| Excavation Block | Sample No. | Feature No. | Analysis Unit | Depth (cm)/ Level | Provenience/ Description | Analysis |
|---|---|---|---|---|---|---|
| SW of West Slope | 54/123.9 | | No AU* | 110-120/ Level 9 | S54W123; FLF from unit fill; southwest of the West-Slope excavation block | Macrofloral |
| | 4 | 4 | | 110-120/ Level 12 | S54W123; FLF from fill of hearth remnant; SW of the West-Slope excavation block | Macrofloral |

**Notes/Abbreviations:**

FLF = Floated Light Fraction
N = Northern
NE = Northeast
SE = Southeast
E = East
SW = Southwest
*Probably Middle to Late Archaic, ca. 5000-1500 B.P.

interpreted to have been used in the cooking of cattail and lotus root. Sample 15.2 yielded many more pollen types including much smaller quantities of Low-spine Asteraceae and High-spine Asteraceae. Poaceae pollen was present, and *Rosa*-type pollen was abundant. In addition, small quantities of *Carya*, *Corylus*, *Fraxinus*, *Quercus*, *Artemisia*, Cheno-am, Malvaceae, Nyctaginaceae, *Persicaria*-type, *Plantago*, and Rosaceae pollen were observed. Most of these pollen types represent trees, shrubs, and herbaceous plants expected as part of the local vegetation. Recovery of the large quantity of *Rosa*-type pollen suggests cooking a member of the rose family, probably rosehips, which are high in vitamins B and C, as well as other nutrients. The phytolith record contained elongate, smooth-grass forms and *Typha* raphids, indicating that cattails also were cooked.

Macrofloral Sample 15.3 represents the floated light fraction from the fill of Feature 15. This sample contained one charred Poaceae caryopsis (Tables C-4 and C-5), suggesting processing of grass seeds and/or use of grasses for other purposes such as tinder, buffering material, or for weaving mats and baskets. One charred PET fruity tissue fragment might reflect processing of a fleshy fruit/berry resource. A few small fragments of *Ehretia anacua*, *Fraxinus*, and *Quercus* charcoal indicate that anaqua, ash, and oak wood were burned as fuel. One fragment of charcoal was too vitrified for identification. Vitrified material has a shiny, glassy appearance due to fusion by heat. Recovery of a few uncharred seeds and leaf fragments indicates introduction of some modern material into this area. A few insect chitin fragments and worm casts reflect some subsurface disturbance from insect and earthworm activity. The sample also contained one uncharred bone fragment and numerous snail shells.

Macrofloral Sample 23 consists of abdominal fill from Burial 23 in the northern portion of the cemetery. This burial consists of the entire skeleton of an adult, possibly male, AMS-dated to the Late Archaic. Mortuary goods found with this individual include seven bifaces, including one Lange projectile point, red ochre, and yellow ochre. Sample 23 contained numerous uncharred *Avena sativa* seeds, representing cultivated oats. Oats are believed to have been domesticated in Europe during the early Christian era, possibly from the wild *Avena fatua* that invaded the fields of early farmers as weeds. Oats were introduced to the United States with the early Pilgrims, and are noted to have been planted on the Elizabeth Islands, Massachusetts, in 1602 (Hedrick 1972:77-78; Heiser 1990:108; McGee 1984:237). Sample 23 also contained two uncharred *Avena fatua*-type seeds, reflecting wild oats. It is likely that both cultivated and wild oat seeds were cached in this area by a modern burrowing animal.

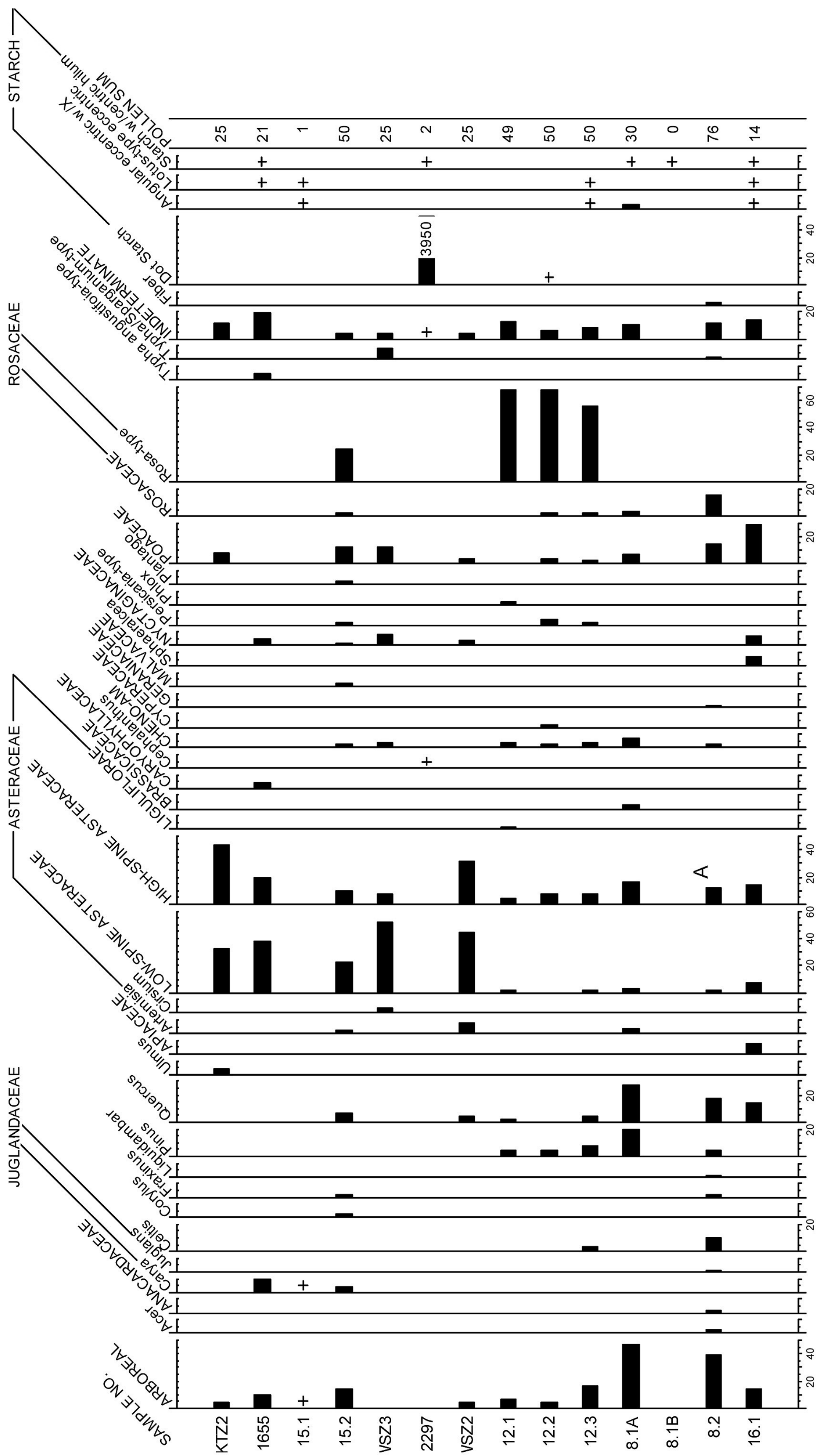



**Figure C-1.** Pollen Diagram for Buckeye Knoll.

**Table C-2.** Pollen Types Observed in Samples from the Buckeye Knoll Site.

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| **Aboreal Pollen:** | |
| *Acer* | Maple |
| Anacardiaceae | Sumac family |
| *Corylus* | Hazel |
| Juglandaceae: | Walnut family |
| *Carya* | Hickory, Pecan |
| *Juglans* | Walnut |
| *Celtis* | Hackberry |
| *Corylus* | Hazel |
| *Fraxinus* | Ash |
| *Liquidambar* | Gum |
| *Pinus* | Pine |
| *Quercus* | Oak |
| *Ulmus* | Elm |
| **Non-Aboreal Pollen:** | |
| Apiaceae | Parsley/Carrot family |
| Asteraceae: | Sunflower family |
| *Artemisia* | Sagebrush |
| *Cirsium* | Thistle |
| Low-spine | Includes ragweed, cocklebur, sumpweed |
| High-spine | Includes aster, rabbitbrush, snakeweed, sunflower, etc. |
| Liguliflorae | Chicory tribe, includes dandelion and chicory |
| Brassicaceae | Mustard family |
| Caryophyllaceae | Pink family |
| Cephalanthus | Buttonbush |
| Cheno-am | Includes the goosefoot family and amaranth |
| Cyperaceae | Sedge family |
| Malvaceae: | Mallow family |
| *Sphaeralcea* | Globe mallow |
| Nyctaginaceae | Four o’clock family |
| *Persicaria* | Knotweed |
| *Phlox* | Phlox |
| *Plantago* | Plantain |
| Poaceae | Grass family |

continued.

**Table C-2.** (concluded)

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| **Non-Aboreal Pollen:** (cont.) | |
| Rosaceae: | Rose family |
| *Rosa* | Wild rose |
| *Typha angustifolia* | Cattail |
| *Typha/Sparganium*-type | Cattail/Burreed |
| Indeterminate | Too badly deteriorated to identify |
| **STARCHES:** | |
| Dot | Includes cattail |
| Angular eccentric | |
| Lotus-type eccentric | |
| Starch with centric hilum | |

One uncharred *Celtis* seed fragment, one uncharred *Euonymous americana* seed, a few Poaceae leaf/stem fragments, an anther, an uncharred bark fragment, a few uncharred leaf fragments, and a few roots and rootlets also represent modern plants. No charcoal fragments or other charred plant material were present in this sample. Two charred bone fragments suggest meat-processing activities and likely were present in the midden deposit found in this area. Four small animal vertebra fragments might reflect a small animal that was eaten by the buried individual or might be intrusive in this area. Several uncharred, unidentified bone fragments also were present. Indicators of subsurface disturbance in this area include insect chitin fragments, three insect puparia fragments, a cockroach egg, a pillbug, an uncharred termite fecal pellet, and a few worm casts.

Macrofloral Sample 25 was recovered from Burial 25, a Late Archaic burial of an adult male. Am Ensor-like dart point is noted to be the cause of death for this individual. Sample 25 contained two charred *Chenopodium* seeds, suggesting processing of goosefoot seeds by the site occupants. A few small fragments of probable *Ehretia* charcoal and unidentified hardwood charcoal too small for further identification reflect wood burned as fuel. One charred insect fecal pellet suggests that some of the burned wood contained termites. The sample also contained a variety of uncharred remains from modern plants, a few insect chitin fragments, several snail shells, and a few worm casts.

Nine macrofloral samples were taken from a soil column in the northeast quadrant of Unit S12W82 in the northeast portion of the excavation block. In addition, one macrofloral sample (12/82.14SW) was recovered from Burial 1 in the southwest quadrant of this unit. Burial 1 represents three sets of Early Archaic adult crania and incomplete longbones. Sample 12/82.14SW from Level 14, at a depth of 130-140 cm, yielded one uncharred *Ulmus* samara (fruit) from a modern elm tree, numerous uncharred leaf fragments, a few uncharred rootlets, and a few snail shell fragments.

Sample 12/82.15 represents the deepest sample examined from the soil column at a depth of 140-150 cm below the surface (Level 15). This level is assigned to AU 4, which is believed to date to the Late Paleo-Indian period. Sample 12/82.15 contained two small fragments of *Fraxinus* charcoal, reflecting ash wood burned as fuel. This level appears to have experienced a significant amount of subsurface disturbance as evidenced by the recovery of numerous insect chitin fragments, eight insect puparia fragments, four cockroach egg fragments, an uncharred termite fecal pellet, a few worm casts, as well as a variety of uncharred seeds, a few uncharred buds, and numerous uncharred leaf fragments from modern plants.

Macrofloral Sample 12/82.14NE was collected from Level 14 (130-140 cm), which is also assigned to AU 4. Several types of uncharred seeds and other plant remains were present in this sample, indicating

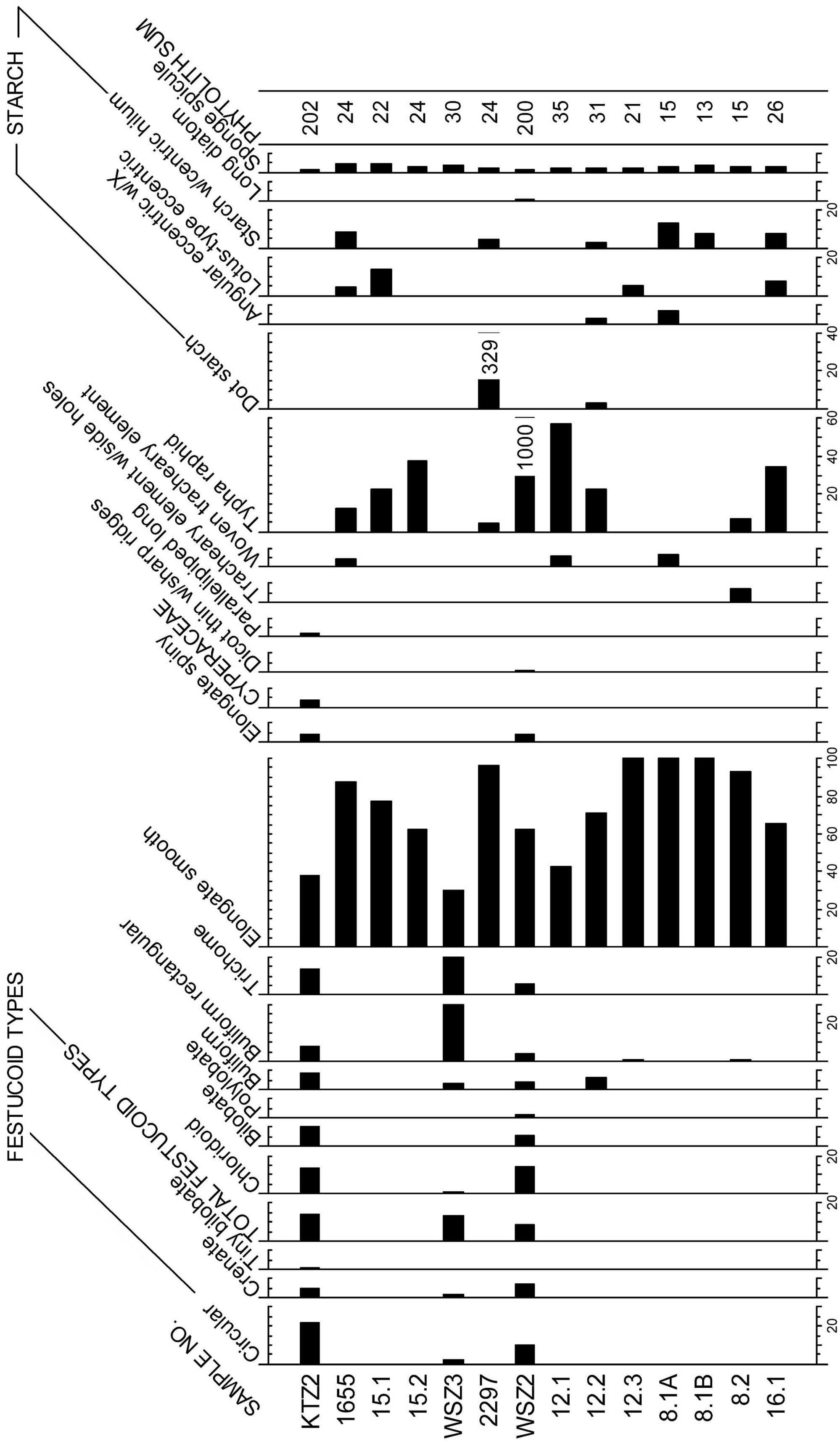



**Figure C-2.** Phytolith Diagram for Buckeye Knoll.

**Table C-3.** List of Antisera Used in Testing Artifacts from the Buckeye Knoll Site, 41VT98.

| ANTISERA | SOURCE | POSSIBLE RESULTS |
|---|---|---|
| **Animals:** | | |
| Bear | ICN Pharmaceuticals, Inc. | Black bear, Brown bear, Grizzly, Polar bear |
| Bison | Prepared under the direction of Dr. Richard Marlar at the University of Colorado Health Sciences Center | Bison, Domestic bovids |
| Bovine | Sigma Chemical Company | Domestic bovids, Bison |
| Cat | Sigma Chemical Company | Domestic cat, Mountain lion, Bobcat, Lynx, other wild cat species |
| Chicken | Sigma Chemical Company | Domestic chicken, Pheasant, Partridge, Quail, Grouse, Ptarmigan |
| Deer | ICN Pharmaceuticals, Inc. | White tail deer, Mule deer, Elk, Moose, Caribou |
| Dog | Sigma Chemical Company | Domestic dog, Coyote, Wolf, Fox |
| Goat | Sigma Chemical Company | Pronghorn, Mountain goat, Goat |
| Guinea pig | Sigma Chemical Company | Guinea pig, Porcupine, Beaver, Squirrel, Marmot, Ground squirrel |
| Human | ICN Pharmaceuticals, Inc. | Human |
| Mouse | Sigma Chemical Company | Members of the New World rats and mice family, Members of the Old World rats and mice family |
| Rabbit | Sigma Chemical Company | Rabbit, Jackrabbit (hare) |
| Rat | Sigma Chemical Company | Members of the New World rats and mice family, Members of the Old World rats and mice family |
| Sheep | ICN Pharmaceuticals, Inc. | Domestic sheep, Bighorn sheep |
| Turkey | Sigma Chemical Company | Domestic turkey, Wild turkey, Ducks |
| **Fish:** | | |
| Catfish | Sigma Chemical Company | Catfish, Sea catfish, Carp |
| Striped bass | Robert Sargeant | Perciformes order (Spiny-rayed or percoid fish) |
| Trout | Sigma Chemical Company | Salmonidae family (Trout and salmon) |

**Table C-4.** Macrofloral Remains from the Knoll Top Excavation.

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **15.3 (Feature 15, 90-100 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 4.47 g |
| | FLORAL REMAINS: | | | | | | |
| | Poaceae | Caryopsis | | 1 | | | |
| | PET Fruity | Tissue | | 1 | | | <0.01 g |
| | *Celtis* | Seed | | | 2 | 7 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | *Phytolacca americana* | Seed | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.06 g |
| | *Ehretia anaqua* | Charcoal | | | | | 0.04 g |
| | *Fraxinus* | Charcoal | | | | | <0.01 g |
| | *Quercus* | Charcoal | | | | | 0.01 g |
| | Unidentifiable - vitrified | Charcoal | | | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 20 | |
| | Insect | Puparia | | | | 1 | |
| | Snail shell | | | | 46* | 136* | |
| | Worm casts | | | | X | X | Few |
| **23 (Burial 23)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.40 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 1 | |
| | *Euonymous americana* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Avena fatua*-type | Floret | | | 2 | | |
| | *Avena sativa* | Floret | | | 55 | 5 | |
| | *Avena sativa* | Caryopsis | | | | 1 | |
| | Anther | | | | 1 | | |
| | Bark | | | | 1 | | |
| | Leaf | | | | | X | Few |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| 23 (cont.) | FLORAL REMAINS: (cont.) | | | | | | |
| | Roots/Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone ≥ 1 mm | | | 2 | | 41 | |
| | Vertebra - small animal | | | | | 4 | |
| | Insect | Chitin | | | | 40 | |
| | Insect | Puparia | | | | 3 | |
| | Cockroach | Egg | | | 1 | | |
| | Pillbug | | | | 1 | | |
| | Snail shell ≥ 1 mm | | | | 2 | 27 | |
| | Snail shell < 1 mm | | | | | X | Few |
| | Termite fecal pellet | | | | 1 | | |
| | Worm casts | | | | | X | Few |
| **25 (Burial 25)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.84 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 2 | | | | |
| | *Argemone* | Seed | | | | 2 | |
| | *Euonymous americana* | Seed | | | 1 | 3 | |
| | *Euphorbia* | Seed | | | 3 | | |
| | *Mollugo verticillata* | Seed | | | 3 | | |
| | *Portulaca* | Seed | | | | 1 | |
| | *Sambucus* | Seed | | | 2 | 1 | |
| | Unidentified G | Seed | | | 9 | 6 | |
| | Anther | | | | 50 | 7 | |
| | Bud | | | | X | X | Few |
| | Leaf | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.02 g |
| | cf. *Ehretia* | Charcoal | | 6 | | | 0.02 g |
| | Unidentified hardwood – small | Charcoal | | 3 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 18 | |
| | Insect fecal pellet | | 1 | | | | |
| | Snail shell ≥ 0.50 mm | | | | 28 | 43 | |
| | Snail shell < 0.50 mm | | | | | X | Few |
| | Worm casts | | | | X | X | Few |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/82.14SW (Burial 1, S16W82 130-140 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.29 g |
| | FLORAL REMAINS: | | | | | | |
| | *Ulmus* | Samara | | | 1 | | |
| | Leaf | | | | | X | Numerous |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Snail shell | | | | 7 | 10 | |
| **12/82.15 (S12W82, Level 15, 140-150 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 7.87 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 2 | |
| | Cheno-am | Seed | | | 2 | | |
| | *Euonymous americana* | Seed | | | | 8 | |
| | *Euphorbia* | Seed | | | 1 | | |
| | *Phytolacca americana* | Seed | | | 2 | 1 | |
| | *Sambucus* | Seed | | | | 1 | |
| | *Ulmus* | Samara | | | 4 | 5 | |
| | *Ulmus* | Seed | | | | 3 | |
| | *Vitis* | Seed | | | | 1 | |
| | Bud | | | | X | X | Few |
| | Leaf | | | | | X | Numerous |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | <0.01 g |
| | *Fraxinus* | Charcoal | | 2 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 3 | |
| | Insect | Chitin | | | | 86 | |
| | Insect | Puparia | | | | 8 | |
| | Cockroach | Egg | | | | 4 | |
| | Snail shell | | | | 1 | 18 | |
| | Termite fecal pellet | | | | 1 | | |
| | Worm casts | | | | X | X | Few |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/81.14NE (S12W82, Level 14, 130-140 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 4.26 g |
| | FLORAL REMAINS: | | | | | | |
| | *Argemone* | Seed | | | 4 | 2 | |
| | *Celtis* | Seed | | | 1 | | |
| | *Chenopodium* | Seed | | | 15 | 3 | |
| | *Euonymous americana* | Seed | | | 5 | 25 | |
| | *Euphorbia* | Seed | | | 5 | 5 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | *Passiflora* | Seed | | | 1 | | |
| | *Phytolacca americana* | Seed | | | 2 | 5 | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Portulaca* | Seed | | | 1 | | |
| | *Sambucus* | Seed | | | 1 | 1 | |
| | *Ulmus* | Samara | | | 1 | | |
| | *Vitis* | Seed | | | | 3 | |
| | Unidentified E | Seed | | | 1 | | |
| | Unidentified G | Seed | | | 1 | | |
| | Anther | | | | 3 | | |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 2 mm | | | | | | 0.01 g |
| | Unidentifiable - central pith | Charcoal | | 1 | | | 0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 2 | |
| | Insect | Chitin | | | | 18 | |
| | Cockroach | Egg | | | | 2 | |
| | Snail shell | | | | | 7 | |
| | Worm casts | | | | X | X | Few |
| **12/82.13 (S12W82, Level 13, 120-130 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.40 g |
| | FLORAL REMAINS: | | | | | | |
| | Rootlets | | | | | X | Few |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/82.13** (cont.) | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 1 | |
| | Snail | | | | 1 | 4 | |
| **12/82.12 (S12W82, Level 12, 110-120 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.87 g |
| | FLORAL REMAINS: | | | | | | |
| | *Avena sativa* | Floret | | | 2 | | |
| | Anther | | | | 2 | 1 | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Ant | | | | 1 | | |
| | Snail Shell | | | | 2 | | |
| **12/82.11 (S12W82, Level 11, 100-110 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 6.84 |
| | FLORAL REMAINS: | | | | | | |
| | *Argemone* | Seed | | | 1 | 1 | |
| | *Chenopodium* | Seed | | | 1 | | |
| | *Euonymous americana* | Seed | | | 3 | 7 | |
| | *Euphorbia* | Seed | | | 5 | 1 | |
| | *Molluga verticillata* | Seed | | | 2 | | |
| | *Opuntia* | Seed | | | | 1 | |
| | *Phytolacca americana* | Seed | | | 1 | 3 | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Sambucus* | Seed | | | 1 | 1 | |
| | *Solanum* | Seed | | | 2 | 1 | |
| | *Ulmus* | Samara | | | | 7 | |
| | *Vitis* | Seed | | | | 2 | |
| | Unidentified E | Seed | | | | 2 | |
| | Unidentified G | Seed | | | 2 | | |
| | Anther | | | | | 1 | |
| | Leaf | | | | | X | Numerous |
| | Monocot | Stem | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/82.11** (cont.) | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | <0.01 g |
| | cf. *Acacia* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | | |
| | Bone - calcined | | | 1 | | | |
| | Insect | Chitin | | | | 7 | |
| | Snail shell | | | | 6 | 11 | |
| | Worm casts | | | | X | X | Few |
| **12/82.10** **(S12W82, Level 10, 90 -100 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.74 g |
| | FLORAL REMAINS: | | | | | | |
| | Poaceae | Caryopsis | 1 | | | | |
| | *Celtis* | Seed | | | 1 | | |
| | *Chenopodium* | Seed | | | | 1 | |
| | *Euonymous americana* | Seed | | | 1 | 1 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Ulmus* | Samara | | | | 2 | |
| | Unidentified G | Seed | | | 1 | | |
| | Unidentified | Seed | | | 1 | | |
| | Anther | | | | 4 | | |
| | Leaf | | | | | X | Numerous |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 2 mm | | | | | | 0.01 g |
| | Ulmaceae | Charcoal | | 1 | | | 0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 21 | |
| | Insect | Puparia | | | | 2 | |
| | Insect (ant-like) | | | | 93 | | |
| | Cockroach | Egg | | | 5 | 1 | |
| | Snail Shell | | | | 2 | 5 | |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/82.9 (S12W82, Level 9, 80-90 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.61 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | | 1 | | | |
| | cf. *Vitis* | Seed | | 1 | | | |
| | *Euonymous americana* | Seed | | | | 1 | |
| | *Euphorbia* | Seed | | | | 1 | |
| | Anther | | | | 2 | | |
| | Bud | | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | <0.01 g |
| | *Quercus* | Charcoal | | 2 | | | <0.01 g |
| | Unidentified hardwood - small | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone ≥ 1 mm | | | 9 | | 80 | |
| | Bone - calcined ≥ 1 mm | | | 2 | | | |
| | Bone < 1mm | | | X | | X | Few |
| | Fish vertebra | | | | 2 | 2 | |
| | Fish scale | | | | | 1 | |
| | Flake | | | | | 1 | |
| | Insect | Chitin | | | | 12 | |
| | Snail shell | | | | 1 | 46 | |
| **12/82.8 (S12W82, Level 8, 70-80 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 4.44 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 2 | | 3 | | |
| | *Euonymous americana* | Seed | | | 1 | 3 | |
| | *Euphorbia* | Seed | | | 4 | | |
| | *Oxalis* | Seed | | | 1 | | |
| | *Sambucus* | Seed | | | 2 | | |
| | *Solanum* | Seed | | | 1 | | |
| | *Ulmus* | Samara | | | 1 | 1 | |
| | *Vitis* | Seed | | | | 8 | |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **12/82.8** (cont.) | Bud | | | | | X | Few |
| | Leaf | | | | 1 | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.04 g |
| | *Quercus* | Charcoal | | 4 | | | 0.01 g |
| | Ulmaceae | Charcoal | | 1 | | | 0.01 g |
| | Unidentified hardwood | Charcoal | | 6 | | | 0.02 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 2 | | 1 | |
| | Fish vertebra | | | | | 1 | |
| | Insect | Chitin | | | | 36 | |
| | Insect | Puparia | | | 1 | 3 | |
| | Cockroach | Egg | | | 1 | 1 | |
| | Rodent fecal pellet - small | | | | X | X | Few |
| | Snail shell | | | | 1 | 32 | |
| | Termite fecal pellet | | 3 | | | | |
| | Worm casts | | | | X | X | Few |
| **12/82.7** **(S12W82, Level 7, 60-70 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 5.09 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 1 | | 3 | | |
| | *Euonymous americana* | Seed | | | | 5 | |
| | *Euphorbia* | Seed | | | 10 | 1 | |
| | *Mollugo verticillata* | Seed | | | 2 | | |
| | *Sambucus* | Seed | | | 1 | | |
| | *Solanum* | Seed | | | 5 | | |
| | *Ulmus* | Samara | | | 1 | 1 | |
| | *Vitis* | Seed | | | | 26 | |
| | Anther | | | | 1 | | |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.02 g |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| 12/82.7 (cont.) | *Ehretia anacua* | Charcoal | | 3 | | | 0.01 g |
| | *Quercus* | Charcoal | | 1 | | | <0.01 g |
| | Unidentifiable | Charcoal | | 2 | | | 0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 24 | |
| | Bone - calcined | | | 1 | | | |
| | Fish vertebra | | | 1 | 2 | | |
| | Insect | Chitin | | | | 9 | |
| | Cockroach | Egg | | | 1 | | |
| | Snail shell | | | | 6 | 8 | |
| 16/82.11 (S16W82, Level 11, 100-110 cmbs) | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 10.72 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 1 | | 2 | 1 | |
| | Unidentified | Seed | 1 | | | | |
| | *Celtis* | Seed | | | 1 | | |
| | *Cyperus* | Seed | | | 1 | | |
| | *Euonymous americana* | Seed | | | | 3 | |
| | *Euphorbia* | Seed | | | 5 | | |
| | *Helianthus* | Seed | | | 1 | | |
| | *Malva* | Seed | | | 1 | | |
| | *Mollugo verticillata* | Seed | | | 2 | | |
| | *Opuntia* | Seed | | | 1 | | |
| | *Oxalis* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | Poaceae | Stem base | | | | X | Few |
| | Poaceae | Floret | | | 2 | | |
| | *Panicum* | Floret | | | 1 | | |
| | *Ulmus* | Samara | | | 2 | | |
| | *Verbena* | Seed | | | 1 | | |
| | *Vitis* | Seed | | | | 5 | |
| | Unidentified E | Seed | | | 4 | 11 | |
| | Anther | | | | 33 | | |
| | Bud | | | | X | X | Moderate |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Moderate |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **16/82.11** (cont.) | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | <0.01 g |
| | cf. *Platanus* | Charcoal | | 1 | | | <0.01 g |
| | Unidentified hardwood | Charcoal | | 5 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 3 | |
| | Insect | Chitin | | | | 47 | |
| | Ant | | | | 9 | | |
| | Pillbug | | | | | | |
| | Rodent fecal pellet | | | | 1 | | |
| | Snail ≥ 1 mm | | | | 20 | 30 | |
| | Snail <1 mm | | | | X | X | |
| | Worm casts | | | | X | X | Moderate |
| **16/82.10** **(S16W82, Level 10, 90-100 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.61 g |
| | FLORAL REMAINS: | | | | | | |
| | PET Fruity | Tissue | | 1 | | | <0.01 g |
| | *Celtis* | Seed | | | 1 | 8 | |
| | Poaceae | Floret | | | 1 | | |
| | *Solanum* | Seed | | | | 1 | |
| | Bark | | | | | X | Few |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | 0.01 g |
| | *Ehretia anacua* | Charcoal | | 2 | | | 0.01 g |
| | *Quercus* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 2 | | | |
| | Insect | Chitin | | | | 100* | |
| | Rodent fecal pellet | | | | X | X | Few |
| | Snail ≥ 1 mm | | | | 15 | 28 | |
| | Snail < 1mm | | | | 128* | 168* | |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **16/82.8 (S16W82, Level 8, 70-80 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 9.82 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | 1? | | | | Gray color |
| | *Chenopodium* | Seed | 3 | | 3 | | |
| | *Phytolacca americana* | Seed | 1 | | 1 | 7 | |
| | *Vitis* | Seed | 1 | 1 | | 2 | |
| | Parenchymous tissue | | | 1 | | | <0.01 g |
| | *Argemone* | Seed | | | 2 | 2 | |
| | *Euonymous americana* | Seed | | | 7 | 14 | |
| | *Mollugo verticillata* | Seed | | | 4 | | |
| | *Opuntia* | Seed | | | 1 | 2 | |
| | *Polygonum* | Seed | | | 1 | 1 | |
| | *Sambucus* | Seed | | | 1 | | |
| | *Solanum* | Seed | | | 1 | | |
| | Anther | | | | 7 | | |
| | Bud | | | | | X | Moderate |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.41 g |
| | Conifer | Charcoal | | 1 | | | <0.01 g |
| | *Ehretria anacua* | Charcoal | | 4 | | | 0.33 g |
| | *Fraxinus* | Charcoal | | 1 | | | 0.01 g |
| | *Quercus* | Charcoal | | 1 | | | 0.02 g |
| | *Quercus virginiana* | Charcoal | | 2 | | | 0.01 g |
| | Unidentified hardwood | Charcoal | | 7 | | | 0.03 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 4 | |
| | Insect | Chitin | | | | 39 | |
| | Cockroach | Egg | | | 1 | | |
| | Snail ≥ 2 mm | | | | 27 | 15 | |
| | Snail < 2 mm | | | | X | X | Numerous |
| | Termite fecal pellet | | 6 | | | | |
| | Worm casts | | | | | X | Moderate |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **16/82.7 (S16W82, Level 7, 60-70 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 8.06 g |
| | FLORAL REMAINS: | | | | | | |
| | Cheno-am | Seed | | 1 | 4 | | |
| | *Avena sativa* | Floret | | | 2 | 2 | |
| | *Celtis* | Seed | | | 1 | | |
| | *Euonymous americana* | Seed | | | | 1 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | *Phytolacca americana* | Seed | | | | 1 | |
| | Bud | | | | 3 | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 2 mm | | | | | | 0.07 g |
| | *Celtis* | Charcoal | | 4 | | | 0.03 g |
| | *Ehretia anacua* | Charcoal | | 3 | | | 0.02 g |
| | cf. *Morus rubra* | Charcoal | | 1 | | | <0.01 g |
| | Quercus virginiana | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 6 | |
| | Insect | Chitin | | | | 22 | |
| | Snail shell ≥ 1 mm | | | | 129 | 26 | |
| | Snail shell < 1 mm | | | | X | X | Numerous |
| | Termite fecal pellet | | 1 | | | | |
| | Worm casts | | | | X | X | Numerous |
| **16/82.6SE (S16 W82, Level 6, 53-60 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 7.79 g |
| | FLORAL REMAINS: | | | | | | |
| | *Argemone* | Seed | | | 1 | | |
| | *Celtis* | Seed | | | | 8 | |
| | *Chenopodium* | Seed | | | 5 | | |
| | *Euonymous americana* | Seed | | | | 1 | |
| | *Euphorbia* | Seed | | | 3 | | |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Moderate |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| | Rootlets | | | | | X | Moderate |
| **16/82.6SE** (cont.) | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.03 g |
| | *Quercus* | Charcoal | | 5 | | | 0.01 g |
| | *Quercus virginiana* | Charcoal | | 1 | | | <0.01 g |
| | *Ulmus* | Charcoal | | 3 | | | <0.01 g |
| | Unidentified hardwood | Charcoal | | 8 | | | 0.01 g |
| | Unidentifiable - vitrified | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 1 | |
| | Insect | Chitin | | | | 32 | |
| | Snail ≥ 1 mm | | | | 77 | 35 | |
| | Snail < 1 mm | | | | X | X | Moderate |
| **16/82.6 SW (S16W82, Level 6, 50 - 60 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 17.24 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | 2? | | | Gray color |
| | *Chenopodium* | Seed | 1 | 1 | | | |
| | *Cyperus* | Seed | | | 1 | | |
| | *Ulmus* | Samara | | | 1 | | |
| | Anther | | | | 6 | 2 | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.03 g |
| | cf. *Morus* - slightly vitrified | Charcoal | | 1 | | | <0.01 g |
| | *Quercus virginiana* | Charcoal | | 6 | | | 0.02 g |
| | *Ulmus* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone ≥ 2 mm | | | 14 | | 151 | |
| | Bone - calcined ≥ 2 mm | | | 6 | | | |
| | Bone < 2 mm | | | | | X | Numerous |
| | Bone - calcined < 2 mm | | | X | | | Moderate |
| | Fish vertebra | | 2 | 5 | 11 | 11 | |
| | Non-fish vertebra | | | | 1 | | |

continued.

**Table C-4.** (continued)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **16/82.6 SW** (cont.) | Tooth | | | | 1 | | |
| | Fishscale | | | | | 1 | |
| | Flake | | | | | 33 | |
| | Insect | Chitin | | | | 13 | |
| | Snail shell ≥ 2 mm | | | | 6 | 113 | |
| | Snail shell < 2 mm | | | | X | X | Numerous |
| | Rodent fecal pellet | | | | | X | Few |
| | Worm casts | | | | X | X | Moderate |
| **7 (Feature 7)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 11.68 g |
| | FLORAL REMAINS: | | | | | | |
| | cf. Cheno-am | Seed | | | 1 | | |
| | *Celtis* | Seed | | | | 25 | |
| | *Euphorbia* | Seed | | | 1 | | |
| | *Ulmus* | Samara | | | 1 | | |
| | Unidentified B | Seed | | | 1 | | |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal | | | | | | <0.01 g |
| | *Quercus* | Charcoal | | 2 | | | <0.01 g |
| | Unidentified hardwood - small | Charcoal | | 2 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1pc | | 3 | |
| | Bone - calcined | | | 1 | | | |
| | Fish vertebra | | | | 1 | | |
| | Insect | Chitin | | | | 12 | |
| | Snail shell | | | | 30 | 40 | |
| | Termite fecal pellet | | 1 | | | | |
| **9 (Feature 9)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 4.47 g |
| | FLORAL REMAINS: | | | | | | |
| | *Setaria* | Floret | | | | 1 | |
| | Bud | | | | 2 | X | Few |
| | Thorn | | | | 1 | | |
| | Roots | | | | | X | Few |

continued.

**Table C-4.** (concluded)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **9** (cont.) | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | cf. *Platanus* | Wood | | | | 18 | 0.07 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 5 | | 2 | |
| | Insect | | | | | 5 | |
| | Ant | | | | 38 | 1 | |
| | Cockroach | Egg | | | 1 | 3 | |
| | Snail | | | | 5 | 8 | |
| **11 (Feature 11)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.24 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 2 | | 13 | |
| | Fish vertebra | | | | 1 | | |
| | Flake | | | | | 2 | |
| | Insect | Chitin | | | | 13 | |
| | Snail | | | | 8 | 23 | |
| | Worm casts | | | | X | X | Few |

**Notes/Abbreviations**

W = Whole
F = Fragment
X = Presence Noted in Sample
L = Liters
g = Grams
* = Estimated Frequency
pc = Partially Charred

that this area has experienced significant introduction of tiny modern materials. One piece of charcoal consisting only of the unidentifiable central pith indicates that a woody dicot twig was burned. The sample also contained two uncharred bone fragments, a few insect chitin fragments, two cockroach egg fragments, a few snail shells, and a few worm casts.

Macrofloral Sample 12/82.13 was recovered from Level 13 at a depth of 120-130 cm (AU 3). This sample consisted only of a few uncharred rootlets from modern plants, one insect chitin fragment, and a few snail shells.

Level 12, at a depth of 110-120 cm, is represented by Macrofloral Sample 12/82.12 (AU 3). This

**Table C-5.** Index of Macrofloral Remains Recovered from Buckeye Knoll.

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| **Floral Remains:** | |
| *Celtis* | Hackberry |
| Cheno-am | Includes goosefoot and amaranth families |
| *Chenopodium* | Goosefoot |
| *Cyperus* | Flatsedge |
| *Euonymous americana* | Brook euonymous, Strawberry-bush, Bursting-heart |
| *Euphorbia* | Spurge |
| *Helianthus* | Sunflower |
| *Lactuca* | Lettuce |
| *Malva* | Mallow, Cheeseweed |
| *Mollugo verticillata* | Carpetweed |
| *Morus rubra* | Red mulberry |
| *Opuntia* | Prickly pear cactus |
| *Oxalis* | Wood sorrel |
| Papaveraceae | Poppy family |
| *Argemone* | Prickly poppy |
| *Phytolacca americana* | Pokeweed |
| Poaceae | Grass family |
| *Avena fatua*-type | Wild oat |
| *Avena sativa* | Common oat |
| *Digitaria* | Crabgrass |
| *Panicum* | Panic grass, Witchgrass |
| Polygonaceae | Buckwheat family |
| *Polygonum* | Smartweed; Knotweed |
| *Portulaca* | Purslane |
| *Prosopis* | Mesquite |
| *Quercus* | Oak |
| *Sambucus* | Elderberry |
| *Setaria* | Bristlegrass, millet |
| *Silene* | Catchfly |
| *Solanum* | Nightshade |
| *Ulmus* | Elm |
| *Verbena* | Verbena |
| *Vitis* | Grape |

continued.

**Table C-5.** (concluded)

| SCIENTIFIC NAME | COMMON NAME |
|---|---|
| Parenchymous tissue | Relatively undifferentiated tissue composed of many similar thin-walled cells–occurs in different plant organs in varying amounts, especially large fleshy organs such as roots and stems. |
| PET fruity tissue | Fruity epitheloid tissues; resemble sugar-laden fruit or berry tissue without the seeds, or succulent plant tissue such as cactus pads |
| Vitrified tissue | Represents charred material with a shiny, glassy appearance due to fusion by heat |
| **Wood Charcoal:** | |
| *Acacia* | Acacia |
| Conifer | Cone-bearing, gymnospermous trees and shrubs, mostly evergreens, including the pine, spruce, fir, juniper, cedar, yew, and cypress |
| *Ehretia anacua* | Anaqua |
| *Fraxinus* | Ash |
| *Morus rubra* | Red mulberry |
| *Platanus* | Sycamore |
| *Quercus* | Oak |
| *Quercus virginia* | Live oak |
| Ulmaceae | Elm family |
| *Celtis* | Hackberry |
| *Ulmus* | Elm |

sample contained two uncharred *Avena sativa* florets, reflecting cultivated oats that most probably were introduced into this area through modern burrowing animal activity. The sample also contained a few uncharred anther, leaf, root, and rootlet fragments, as well as an uncharred bone fragment, one ant, and two snail shells.

Macrofloral Sample 12/82.11 collected from Level 11 at a depth of 100-110 cm (AU 2) yielded one small piece of possible *Acacia* charcoal, suggesting that acacia wood might have been burned as fuel. One charred bone fragment and one calcined bone fragment suggest meat-processing activities. A variety of uncharred seeds and other plant remains indicate introduction of material from modern plants into this area. A few insect chitin fragments and worm casts indicate that insect and earthworm activity contributed some subsurface disturbance.

One charred Poaceae caryopsis was present in Macrofloral Sample 12/82.10 from Level 10 at a depth of 90-100 cm (AU 2). Grass seeds might have been processed and/or grasses used for other purposes. One small piece of Ulmaceae charcoal reflects use of *Celtis* or *Ulmus* wood as fuel. One uncharred bone fragment also was present. Subsurface disturbance indicators include several types of uncharred seeds and other modern plant remains, twenty-one insect chitin fragments, two insect puparia fragments, numerous insects that resemble a small, winged ant in appearance, five cockroach eggs, and one cockroach egg fragment.

Macrofloral Sample 12/82.9 from Level 9 at a depth of 80-90 cm (AU 2) contained one charred *Chenopodium* seed fragment, suggesting that goosefoot seeds were processed. One charred probable *Vitis* seed fragment also suggests use of wild grapes. Two small fragments of *Quercus* charcoal reflect oak wood burned as fuel. One piece of hardwood charcoal was too small for further identification. Recovery of a few charred and calcined bone fragments, numerous uncharred bone fragments, two fish vertebrae, two fish vertebral fragments, and one fish scale fragment indicate that fish and other meat resources were eaten. One lithic flake also was present, possibly indicating resharpening of lithic tools. In addition, the sample contained a few uncharred seed fragments and other remains from modern plants, a few insect chitin fragments, a snail shell, and several snail shell fragments.

Macrofloral Sample 12/82.8 was collected at a depth of 70-80 cm and assigned to AU 1. This sample contained two charred *Chenopodium* seeds, suggesting that goosefoot seeds were processed. Small fragments of *Quercus* and Ulmaceae charcoal reflect use of oak and either hackberry or elm wood as fuel. A few fragments of hardwood charcoal were too small for further identification. Three charred termite fecal pellets suggest that some of the burned wood contained termites. Two charred bone fragments, one uncharred bone fragment, and one uncharred fish vertebra fragment suggest that fish and possibly other meat resources were utilized. Indicators of subsurface disturbance and introduction of modern material in this area include several insect chitin fragments, a few insect puparia fragments, one cockroach egg and one egg fragment, a few small rodent fecal pellets, a few worm casts, and several types of uncharred seeds and other plant remains.

Macrofloral Sample 12/82.7 from a depth of 60-70 cm (AU 1) represents the uppermost sample in the soil column. One charred *Chenopodium* seed was present, again suggesting processing of goosefoot seeds. Very small fragments of *Ehretia anacua* and *Quercus* charcoal reflect local anaqua and oak wood burned as fuel. Two unidentifiable fragments of charcoal also were present. In addition, the sample yielded one charred bone fragment, one calcined bone fragment, several uncharred bone fragments, a few insect chitin fragments, a cockroach egg, a few snail shells, and several types of uncharred seeds and other remains from modern plants.

A soil column also was excavated in the southeast portion of the Knoll Top Excavation Block and floated to recover macrofloral remains. Five samples were taken from the southeast quadrant of Unit S16 W82, and a single sample was collected from the southwest quadrant of this unit in Level 6. In general, this unit appears to have experienced a significant amount of subsurface disturbance from insect, rodent, and earthworm activity, which introduced several types of uncharred remains from modern plants into the deposits.

Macrofloral Sample 16/82.11 represents the bottom of the Zone 2 portion of the column. This sample was taken from Level 11 at a depth of 100-110 cm and is assigned to AU 3. One charred *Chenopodium* seed was present, suggesting that goosefoot seeds were processed. One charred unidentified seed fragment might also reflect seed processing activities. One small fragment of probable *Platanus* charcoal was recovered, suggesting that sycamore wood was burned as fuel. Five hardwood charcoal fragments were too small for further identification. Of the six macrofloral samples examined from this column, Sample 16/82.11 contained the greatest variety of uncharred seeds and other remains from modern plants. Other indicators of subsurface disturbance include several insect chitin fragments, a pillbug, a few ants, a rodent fecal pellet, and a moderate amount of worm casts. The sample also contained three uncharred bone fragments and several snail shells.

Macrofloral Sample 16/82.10 was recovered from Level 10 at a depth of 90-100 cm (AU 3). This sample yielded one small fragment of charred PET fruity tissue, suggesting use of a fleshy fruit/berry resource or a succulent plant part such as a cactus pad. Local anaqua and oak wood appear to have been burned as fuel as evidenced by recovery of two small fragments of *Ehretia anacua* charcoal and one small fragment of *Quercus* charcoal. Two charred bone fragments might reflect meat-processing activities. In addition, the sample contained numerous insect chitin fragments, a few rodent fecal pellets, and numerous snail shells, as well as a few uncharred seeds and other remains from modern plants.

Macrofloral Sample 16/82.8 from Level 8 at a depth of 70-80 cm is assigned to AU 2. This sample contained a *Celtis* seed that is gray in color and might reflect a seed that had been modified by heat. Uncharred *Celtis* seeds typically turn white, not gray. Hackberry fruits might have been utilized by the prehistoric occupants of this site. Three charred *Chenopodium* seeds, one charred *Phytolacca americana* seed, and one charred *Vitis* seed and seed fragment suggest processing of goosefoot seeds, pokeweed, and grapes. One small fragment of charred parenchymous tissue also was present. "Parenchyma is the botanical term for relatively undifferentiated tissue, composed of many similar thin-walled cells...which form a ground tissue that surrounds other tissues. Parenchyma occurs in many different plant organs in varying amounts.

Large fleshy organs such as...roots and stems are composed largely of parenchyma. ...The vegetative storage parenchyma in swollen roots and stems stores starch and other carbohydrates and sugars..." (Hather 2000:1). Recovery of parenchymous tissue might indicate processing of a root or tuber resource, or possibly charred stem tissue. A variety of uncharred seeds and other remains represent modern plants. The charcoal record consisted of a few fragments of conifer, *Ehretia anacua*, *Fraxinus*, *Quercus*, *Quercus virginiana*, and unidentified hardwood charcoal. Six charred termite fecal pellets suggest that some of the burned wood contained termites. One charred bone fragment and four uncharred bone fragments might reflect meat-processing activities. Evidence for subsurface disturbance in this area from insect and earthworm activity includes several insect chitin fragments, a cockroach egg, and a moderate amount of worm casts. Numerous small snail shells also were present.

Macrofloral Sample 16/82.7 was collected from Level 7 at a depth of 60-70 cm and assigned to AU 1. One charred Cheno-am seed fragment was present in this sample, suggesting processing of Cheno-am seeds. A few small fragments of *Celtis*, probable *Morus rubra*, *Ehretia anacua*, and *Quercus virginiana* charcoal reflect hackberry, probable mulberry, anaqua, and live oak wood burned as fuel. The sample also contained one charred termite fecal pellet, one charred and six uncharred bone fragments, several insect chitin fragments, numerous snail shells, numerous worm casts, a few uncharred seeds, and other uncharred remains from modern plants.

Macrofloral Sample 16/82.6SE from Level 6 at a depth of 53-60 cm (AU 1) contained a few small fragments of *Quercus*, *Quercus virginiana*, *Ulmus*, unidentified hardwood, and unidentifiable charcoal too vitrified for identification. Oak, live oak, elm, and another type of hardwood appear to have been burned as fuel. A few uncharred seeds, a moderate amount of leaf fragments, and a moderate amount of rootlets represent modern plants. Non-floral remains in this sample include one charred and one uncharred bone fragment, several insect chitin fragments, and numerous snail shells.

Macrofloral Sample 16/82.6SW was recovered from Level 6 at a depth of 50-60 cm in the southwest quadrant of Unit S16W82. This sample was assigned to AU 1. Two *Celtis* seed fragments that were gray in color could reflect seeds that were heat modified and, therefore, might indicate processing of hackberry fruits. One charred *Chenopodium* seed and one seed fragment suggest processing of goosefoot seeds. A few small fragments of probable *Morus rubra*, *Quercus virginiana*, and *Ulmus* charcoal reflect probable mulberry, live oak, and elm wood burned as fuel. Recovery of a moderate amount of charred bone fragments, a few calcined bone fragments, and numerous uncharred bone fragments, including fish vertebrae, a fish scale, a non-fish vertebra and a tooth, indicate processing of fish and other meat resources. Several small lithic flakes also were present. A few insect chitin fragments, a few rodent fecal pellets, and a moderate amount of worm casts indicate some subsurface disturbance from insect, rodent, and earthworm activity. The sample also contained a few uncharred remains from modern plants and numerous snail shells.

Feature 7 is not a true feature, but rather a basin-shaped depression in the bottom of Zone 1 in Unit S16 W88. This depression was filled with a light-colored sandy sediment that was part of a more widespread layer, Zone 1-A, believed to be natural eolian deposition. The feature fill yielded a few small fragments of *Quercus* charcoal and hardwood charcoal too small for further identification. One charred termite fecal pellet reflects use of fuelwoods containing termites. A few uncharred seeds and a moderate amount of roots and rootlets represent modern plants. One partially charred bone fragment, one calcined bone fragment, three uncharred bone fragments, and a fish vertebra indicate processing of fish and other meat resources. In addition, the sample yielded a few insect chitin fragments and several snail shells.

Feature 9 was a hearth consisting of an oval-shaped, tight cluster of burned sandstone fragments and clay nodules found in Unit S20W90 and assigned to AU 3. Macrofloral Sample 9 was taken from the hearth fill and contained five charred bone fragments and two uncharred bone fragments, suggesting meat-processing activities. No other charred remains were recovered. A few uncharred plant remains and small pieces of uncharred probable *Platanus* wood reflect components of the modern vegetation community. Recovery of a few insect chitin fragments, several winged ants, and a cockroach egg and three egg fragments indicate subsurface disturbance from insect activity.

Macrofloral Sample 11 was collected from the fill of Feature 11, a hearth noted in Unit S12W74 and assigned to AU 2. Probable cultural material present in Sample 11 includes two charred bone fragments, thirteen uncharred bone fragments, a fish vertebra, and two small lithic flakes. The sample also contained an uncharred *Celtis* seed fragment, a few roots and

**Table C-6.** Positive Protein Residue Results for Samples from Buckeye Knoll.

| Sample No. | Description | Positive Result (Antiserum Type) | Possible Animal(s) Represented |
|---|---|---|---|
| 3105 | Lanceolate dart point with tool kit from Burial 8 | Turkey | Soil contamination |
| 8.S | Soil control from Burial 8 | Turkey | Soil contamination |
| 3176 | Distal fragment of lanceolate dart point from Burial 26 | Trout | Fish |
| 2141 | Lanceolate dart point from Burial 43 | Chicken | Soil contamination |
| 43.S | Soil control from Burial 43 | Chicken | Soil contamination |
| 2186 | Lanceolate dart point from Burial 49 | Chicken | Tetraonidae family (Chicken/ Ptarmigan/Grouse) Phasianidae family (Pheasants/Partridge/Quail). |
| 2213 | Lanceolate dart point from Burial 49 | Catfish | Ictaluridae family (Catfish) Ariidae family (Sea catfish) |

rootlets, and a few insect chitin fragments, snails, and worm casts.

### *Lithic Artifact Residue Analysis*

A total of 15 artifacts recovered from burials in the Early Archaic cemetery in the Knoll Top Excavation Block were washed to recover possible protein residues. Artifacts tested included six quartzite grooved stones, seven lanceolate dart points, an oversized stemmed biface, and a chert chopper (see Table C-1). Sample 3105 represents a lanceolate dart point found with a tool kit in Burial 8 in the northern portion of the cemetery. The wash from this dart point and the soil control from Burial 8 both tested positive to turkey antiserum (Table C-6). These positive results suggest soil contamination either from activity of modern turkey, possibly wild, in the area, since proteins are present in all body fluids and tissues including urine and feces (Newman et al. 1993), or from compounds in the soil such as chlorophyll, bacteria, and metal cations including manganese, copper, and iron oxide (Evershed et al. 1996).

Sample 3176 represents the distal fragment of a dart point from Burial 26 in the northern portion of the cemetery. Sample 3176 tested positive to trout antiserum. The soil control for Burial 26 yielded negative results to trout antiserum, suggesting that the positive result for the artifact is not due to soil contamination. Trout antiserum is known to react positively with members of the Salmonidae. The Salmonidae family contains species of salmon (*Oncorhynchus*) and trout (*Salmo*), as well as brook trout (*Salvelinus fontinalis*), lake trout (*Salvelinas namaycush*), lake whitefish (*Coregonus clupeaformis*), round whitefish (*Prosopium cylindraceum*), and arctic grayling (*Thymallus arcticus*). Many salmonids are important food and game fish (Boschung et al. 1983:388-398). Salmonids are not native to south Texas. The present sample might be inferred to represent marine (sea) trout (*Cynoscion nebulosis*), which are presently abundant in the Texas coastal estuaries (Hoese and Moore 1977) and which are indicated archaeologically to have been abundant during Archaic and Late Prehistoric times (Ricklis 1996). *Cynoscion nebulosis* is, however, a Scieanid, not a Salmonid. Trout antiserum has not been tested against all fish species. Because fish are noted to have serum protein antigenic determinations in common, cross reactions will occur between closely and sometimes distantly related species. It is possible that trout antiserum will cross react with other fish species that have not yet been tested/identified. At the least, a positive result to trout antiserum for Sample 3176 suggests use of fish by the Early Archaic occupants [Editor's note: The results of stable isotope analyses on human bone from the cemetery indicate significant use of marine resources by the people buried therein, suggesting the likelihood that the residue indicated may, in fact, be sea trout or some other Sciaenid].

Fishing was important for Karankawa groups, and they are reported to have exploited a wide variety of fish. Newcomb (1983:363-364) notes that the bow and arrow was the main weapon used in fishing, although cane wiers also were utilized. The fish residue on Sample 3176 suggests the use of stone-tipped darts or spears for fishing during the Early Archaic. Fish could be cooked and eaten immediately or dried for future use.

Sample 2141 represents a lanceolate dart point from Burial 43 in the southern portion of the cemetery. The wash from this dart point and the soil control from Burial 43 both tested positive to chicken antiserum, again suggesting soil contamination.

Samples 2186 and 2213 are lanceolate dart points from Burial 49, also in the southern portion of the cemetery. Sample 2186 tested positive to chicken antiserum, while Sample 2213 yielded a positive result to catfish antiserum. The soil control tested negative to both chicken and catfish antiserum. Positive results to chicken antiserum are obtained with all members of the Tetraonidae family (chicken/ptarmigan/grouse), as well as with members of the Phasianidae family (pheasants/partridge/quail). Pheasants were introduced from Asia, and partridge were a Eurasian introduction (Peterson 1961:80-89). Members of these families native to southeast Texas include the common bobwhite (*Colinus virginianus*) as well as the "Attwater" race of the greater prairie chicken (*Tympanuchus cupido*) which is now extinct (Peterson 1980:144-149; Pough 1951:174-186).

Many native groups believed that all birds had some spiritual power. Birds were hunted with featherless arrows, netted, or snared. Meat and eggs were eaten, and the feathers were used to fletch arrows, for various decorations, in medicine bundles, and as horse charms (Mails 1991). Birds and their eggs are reported to have been seasonally important for Karankawa groups (Newcomb 1983:363-364). Caddo people are noted to have used turkey, along with prairie chicken, heron, duck, quail, and partridges (McCormick 1973:7; Swanton 1942:134-139).

A positive result to catfish antiserum for Sample 2213 suggests use to hunt/process a member of the order Siluriformes, which includes the Ictaluridae (bullhead catfish family) and the Ariidae (sea catfish family). Catfish in the United States are native to fresh waters east of the Rocky Mountains, although channel catfish and bullhead catfish have been widely introduced outside their normal range and currently can be found in many parts of the west. Members of the Ictaluridae and Ariidae native to the Texas coastal estuaries include a variety of catfish (*Ictalurus* sp.), tadpole madtom (*Noturus gyrinus*), flathead catfish (*Pyllodictis olivaris*), hardhead catfish (*Arius felis*), and gafftopsail catfish (*Bagre marinus*) (Boschung et al. 1983).

***West Slope Findings***

The West Slope Excavation Block is represented by four analytical units. No diagnostic artifacts or datable material was recovered from AU 4; however, this stratum may represent the Early Archaic prior to ca. 4000 B.C. The Middle Archaic from about 4000-2000 B.C. is represented by AU 3. AU 2 is estimated to contain material from the early part of the Late Archaic, from about 2150 to 850 B.C. AU 1 represents the Late Archaic to the Late Prehistoric, about 800 B.C. to A.D.1200.

Sample WSZ3 represents Zone 3 midden fill and was examined for pollen/starches and phytoliths. The pollen record is sparse and comprised primarily of Low-spine Asteraceae pollen, representing members of the sunflower family, such as marsh elder or cocklebur. In addition, a few High-spine Asteraceae pollen were noted, representing other members of the sunflower family. Small quantities of *Cirsium*, Nyctaginaceae, Cheno-am, and Poaceae pollen were noted, indicating the presence of thistle, spiderling, Cheno-ams, and grasses in the local vegetation. Recovery of *Typha*/*Sparganium*-type pollen indicates the presence of cattails and/or burreed in a nearby wetland community (presumably within the nearby Guadalupe River floodplain). The phytolith record from this sediment exhibits primarily festucoid (cool season) grass short cells. Buliforms are abundant, suggesting that the grasses that grew in this area received sufficient water to grow well. Elongate smooth forms were abundant, representing grasses. No starches were observed.

Sample WSZ3 also serves as a soil control sample for the pollen/starch, phytolith, and protein residue wash of a small sandstone milling stone fragment (Sample 2297) from Zone 2 (AU 2) in the northern portion of the West Slope Excavation Block. The protein wash of the milling stone yielded negative results to all antisera tested. The pollen/starch record from the milling stone yielded primarily small dot starches, which are typical of those produced by cattails. These starches occurred in aggregates or clusters, which is also typical of those in cattail roots. The phytolith record yielded a few *Typha* raphids. The phytolith record is comprised primarily of elongate smooth forms, reflecting grasses. Dot starches also were noted while examining the phytolith portion of this sample and are far more abundant than were the phytoliths. In addition, a single starch with a centric hilum was present, which might reflect processing either grass seeds or lotus root. Sponge spicules were present.

Zone 2 midden fill (Sample WSZ2) also was examined for pollen/starches and phytoliths. The pollen record was dominated by Low-spine Asteraceae and High-spine Asteraceae pollen, reflecting the presence of various members of the sunflower family. In addition, small quantities of *Quercus*, *Artemisia*, Nyctaginaceae, and Poaceae pollen were noted, indicating the presence of oak, sagebrush, spiderling, and grasses. The phytolith record from this sample yielded a wide variety of phytoliths. Although elongate smooth forms were abundant, many short cells also were present and included festucoid forms (representing cool season grasses), chloridoid forms (representing short grasses), bilobates (representing tall grasses), buliforms, and trichomes. Buliforms represent leaf-rolling cells that tend to silicify more regularly when grasses are receiving sufficient moisture. Trichomes represent hairs on glumes that surround grass seeds. *Typha* raphids were abundant in this sample, indicating the presence of cattail debris in the midden fill. Diatoms and sponge spicules were present in small quantities.

Because Features 8, 12, and 16 were found at the interface of Zones 2 and 3, Samples WSZ3 and WSZ2 also function as soil-control samples for pollen/starch and phytolith washes of burned-clay nodules found in the fill of these three features. Feature 12 is a small hearth remnant that is associated with AU 2. This feature consisted of a small, loose cluster of tabular sandstones and burned-clay nodules found in Unit S33W116 in the southern portion of the excavation block. Three burned-clay nodules from Level 14 were washed for pollen, starches, and phytoliths. Pollen recovered from these nodules was very similar and dominated by *Rosa*-type pollen. This suggests either discard of wild rose or rose hips in the midden or use of these clay nodules in cooking wild rose or rose hips. It is interesting to note that all three of the burned-clay nodules from this location exhibit large quantities of this pollen type, suggesting that they might have been used together. Other elements of the pollen record from these samples include small quantities of *Pinus*, High-spine Asteraceae, and Cheno-am, representing pine, members of the sunflower family, and Cheno-ams. In addition, some of these samples exhibited *Celtis*, *Quercus*, Low-spine Asteraceae, Liguliflorae, Cyperaceae, *Persicaria*-type, *Phlox*, Poaceae, and Rosaceae pollen, reflecting the local presence of hackberry, oak, members of the sunflower family, sedges, knotweed, phlox, grasses, and members of the rose family. The phytolith record from these three clay nodules exhibits varying quantities of *Typha* raphids and elongate smooth forms from grasses. It is most likely that the elongate smooth forms are present as a result of contact with midden sediments. It also is possible that the *Typha* raphids were present through the same action, since the midden sample examined as a control exhibited the largest quantity of *Typha* raphids observed at this site (an estimated 1000 percent calculated against the total quantity of pollen observed). Small quantities of buliforms and woven tracheary elements were observed in one or more of the clay nodule washes. Starches were not abundant but did include dot starches and eccentric angular starches in Sample 12.2, and an angular starch with a centric hilum and a *Lotus*-type eccentric starch in Sample 12.3. The starch record points to cooking lotus root in the same container with one or more of these clay nodules.

Macrofloral Sample 12.4 represents the floated light fraction from Level 14 fill of Feature 12. This sample contained a few uncharred leaf, root, and rootlet fragments from modern plants (Table C-7; see also Table C-5). No charred remains indicative of economic activities associated with this hearth were present. A few insect chitin fragments and a few snail shells were the only other remains recovered.

Feature 8 is a fairly dense, oval concentration of burned-clay nodules believed to represent a hearth in Unit S31W118. This hearth is assigned to AU 2. Two of the burned-clay nodules were washed to recover pollen, starches, and phytoliths (samples 8.1A and 8.2). In addition, a scrape was collected from the interior of one of the clay nodules (Sample 8.1B). The sample representing the interior of the clay nodule (Sample 8.1B) was absolutely barren of pollen, which is consistent with heating the clay nodule to a high temperature in preparation for using it to heat liquids. Pollen analysis was undertaken to see if any pollen survived this heating process. It did not, at least not in this particular nodule, meaning that pollen recovered from all clay nodules is interpreted to represent pollen that adhered to the surface during its use or after it was buried in the ground, not pollen that was present in the clay used to form the nodule. The pollen record from the washes of the two clay nodules (8.1A and 8.2) reveal moderate quantities of *Pinus* and *Quercus* pollen in Sample 8.1A and smaller quantities of these two pollen types in Sample 8.2. Sample 8.1A exhibits

**Table C-7.** Macrofloral Remains from the West Slope Excavation.

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **12.4 (Feature 12, Level 14, 130-140 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.81 g |
| | FLORAL REMAINS: | | | | | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 9 | |
| | Snail shell | | | | 2 | 3 | |
| **8.3 (Feature 8)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.10 g |
| | FLORAL REMAINS: | | | | | | |
| | cf. Cheno-am | Perisperm | | 1 | | | |
| | *Celtis* - friable | Seed | | | 1 | 16* | |
| | *Euonymous americana* | Seed | | | 1 | | |
| | *Mollugo verticillata* | Seed | | | 2 | | |
| | Papaveraceae | Seed | | | 1 | | |
| | Unidentified G | Seed | | | 1 | | |
| | Leaf | | | | | X | Moderate |
| | Thorn | | | | 1 | | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | Conifer | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 42* | |
| | Insect | Puparia | | | | 8* | |
| | Snail shell | | | | 65* | 264* | |
| | Termite fecal pellet | | 7 | | | | |
| **16.2 (Feature 16, 159-190 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 5.57 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | | | 1 | | |
| | *Digitaria* | Floret | | | 1 | | |
| | *Helianthus* | Seed | | | | 1 | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **16.2** (cont.) | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 9 | |
| | Bone - calcined | | | 2 | | | |
| | Insect | Chitin | | | | 15 | |
| | Ostracod shell | | | | 1 | | |
| | Snail shell | | | | 34 | 258 | |
| **17.19** **(Feature 17, Level 19, 180-190 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 3.34 g |
| | FLORAL REMAINS: | | | | | | |
| | *Silene* | Seed | | | | 1 | |
| | Unidentified B | Seed | | | | 1 | |
| | Leaf | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 7 | |
| | Insect | Chitin | | | | 5 | |
| | Snail shell | | | | 8 | 27 | |
| **17.18** **(Feature 17, Level 18, 170-180 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 3.12 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 18 | |
| | *Cyperus* | Seed | | | 1 | | |
| | *Helianthus* | Seed | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Thorn | | | | | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 2 | |
| | Insect | Chitin | | | | 3 | |
| | Snail shell | | | | 5 | 8 | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **19 (Feature 19, Level 18, 170-180 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.95 g |
| | FLORAL REMAINS: | | | | | | |
| | Cheno-am | Seed | | | 1 | | |
| | *Celtis* | Seed | | | | 48 | |
| | *Portulaca* | Seed | | | 1 | | |
| | *Quercus* | Root | | | | 2 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | Unidentified hardwood - small | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 2 | |
| | Insect | Chitin | | | | 13 | |
| | Insect | Puparia | | | | 1 | |
| | Snail shell | | | | 25 | 46 | |
| **10 (Feature 10, Level 6, 50-60 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.45 g |
| | FLORAL REMAINS: | | | | | | |
| | *Mollugo verticillata* | Seed | | | | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 10 | |
| | Cockroach | Egg | | | 2 | | |
| | cf. Insect fecal pellet | | | | 2 | 2 | |
| **31/116.16 (31SW116, Level 16, 150-160 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.94 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | | | 1 | | |
| | *Celtis* | Seed | | | 4 | 1 | |
| | *Euonymous americana* | Seed | | | | 2 | |
| | *Euphorbia* | Seed | | | 2 | | |
| | *Oxalis* | Seed | | | 1 | | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **31/116.16** (cont.) | *Panicum* | Floret | | | 1 | | |
| | cf. Anther | | | | 2 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.12 g |
| | cf. *Ehretia* | Charcoal | | 6 | | | 0.12 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 12 | |
| | Insect | Puparia | | | | 1 | |
| | Snail shell | | | | 13 | 21 | |
| | Termite fecal pellet | | | | 1 | | |
| | Worm casts | | | | X | X | Few |
| **31/116.15** **(S31W116, Level 15, 140-150 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 5.29 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 33 | |
| | *Chenopodium* | Seed | | | 6 | | |
| | *Cyperus* | Seed | | | 1 | | |
| | *Euonymous americana* | Seed | | | | 1 | |
| | *Euphorbia* | Seed | | | | 2 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Solanum* | Seed | | | 4 | | |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | Unidentified hardwood - small | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 5 | |
| | Flake | | | | | 1 | |
| | Insect | Chitin | | | | 13 | |
| | Insect | Puparia | | | | 2 | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **31/116.15** (cont.) | Snail shell ≥ 1 mm | | | | 14 | 7 | |
| | Snail shell < 1 mm | | | | X | X | Moderate |
| | Worm casts | | | | X | X | Few |
| **31/116.14** **(S31W116, Level 14, 130-140 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.44 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | 2 | 27 | |
| | *Euphorbia* | Seed | | | | 1 | |
| | Poaceae | Floret | | | 1 | | |
| | *Portulaca* | Seed | | | 1 | | |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | *Fraxinus* | Charcoal | | 1 | | | <0.01 g |
| | *Quercus* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 5 | |
| | Snail shell ≥ 1 mm | | | | 15 | 2 | |
| | Snail shell < 1 mm | | | | X | X | Moderate |
| **31/116.11** **(S31W116, Level 11, 100-110 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.68 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 1 | | | | |
| | *Celtis* | Seed | | | | 20 | |
| | cf. Anther | | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Thorn | | | | | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.03 g |
| | cf. *Ehretia* | Charcoal | | 8 | | | 0.03 g |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **31/116.11** (cont.) | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 12 | |
| | Snail shell ≥ 0.5 mm | | | | 31 | 45 | |
| | Snail shell < 0.5 mm | | | | | X | Moderate |
| | Worm casts | | | | X | X | Moderate |
| **31/116.10** **(S31W116, Level 10, 90-100 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.71 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | | 20 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | Leaf | | | | | X | Moderate |
| | Thorn | | | | | 1 | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 5 | |
| | Snail shell ≥ 0.5 mm | | | | 2 | 19 | |
| | Snail shell < 0.5 mm | | | | | X | Few |
| **31/116.9** **(S31W116, Level 9, 80-90 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 3.15 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | | | 1 | | |
| | *Helianthus* | Seed | | | | 1 | |
| | *Mollugo verticillata* | Seed | | | 3 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | Leaf | | | | | X | Few |
| | *Quercus* | Root | | | | X | Few |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 10 | |
| | Snail shell | | | | 10 | 4 | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **31/116.8 (S31W118, Level 8, 70-80 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.69 g** |
| | FLORAL REMAINS: | | | | | | |
| | *Euonymous americana* | Seed | | | | 1 | |
| | *Mollugo verticillata* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | cf. Anther | | | | 3 | | |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 14 | |
| | Snail shell < 1 mm | | | | 10 | 36 | |
| | Termite fecal pellet | | 1 | | | | |
| | Worm casts | | | | X | X | Few |
| **31/116.7 (S31W116, Level 7, 60-70 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 5.87 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | 1 | | 2 | 1 | |
| | *Celtis* twig with thorn | | | | | 1 | |
| | *Celtis* | Seed | | | | 10 | |
| | *Euonymous americana* | Seed | | | 2 | 6 | |
| | *Euphorbia* | Seed | | | 1 | 1 | |
| | *Lactuca* | Seed | | | 1 | | |
| | *Mollugo verticillata* | Seed | | | 3 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Portulaca* | Seed | | | 1 | | |
| | *Solanum* | Seed | | | | 2 | |
| | Unidentified F | Seed | | | 2 | | |
| | cf. Anther | | | | 1 | | |
| | Leaf | | | | | X | Moderate |
| | Thorn (thinner than *Celtis*) | | | | 1 | | |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | *Quercus* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **31/116.7** (cont.) | Insect | Chitin | | | | 45 | |
| | Insect | Puparia | | | | 15 | |
| | Cockroach | Egg | | | 1 | 6 | |
| | Rodent fecal pellet | | | | X | X | Few |
| | Snail shell | | | | 20 | 12 | |
| | Termite fecal pellet | | 3 | | | | |
| | Worm casts | | | | X | X | Moderate |
| **31/116.6** **(S31W116, Level 6, 50-60 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.03 g |
| | FLORAL REMAINS: | | | | | | |
| | "Spongy", leaf-type tissue | | | 1 | | | <0.01 g |
| | *Chenopodium* | Seed | | | 2 | | |
| | *Cyperus* | Seed | | | 1 | | |
| | *Euonymous americana* | Seed | | | 1 | 1 | |
| | *Euphorbia* | Seed | | | 2 | | |
| | *Mollugo verticillata* | Seed | | | 2 | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Panicum* | Floret | | | 1 | | |
| | Polygonaceae | Seed | | | 1 | | |
| | *Solanum* | Seed | | | | 1 | |
| | Unidentified F | Seed | | | 2 | 1 | |
| | cf. Anther | | | | 1 | | |
| | Bud | | | | | X | Few |
| | Leaf | | | | | X | Moderate |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | Unidentified - small | Charcoal | | 2 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 23 | |
| | Cockroach | Egg | | | | 1 | |
| | Rodent fecal pellet - small | | | | X | X | Few |
| | Snail shell | | | | 9 | 19 | |
| | Termite fecal pellet | | | 1 | | | |
| | Worm casts | | | | X | X | Moderate |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **32/117.6 (S32W117, Level 6, 50-60 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 5.75 g |
| | FLORAL REMAINS: | | | | | | |
| | *Celtis* | Seed | | | 3 | 1 | |
| | Bud | | | | 1 | | |
| | Leaf | | | | | X | Few |
| | *Quercus* | Roots | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 18 | |
| | Snail shell | | | | 36 | 76 | |
| **33/118.12 (S33W118, Level 12, 113-123 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.34 g |
| | FLORAL REMAINS: | | | | | | |
| | Poaceae | Leaf/Stem | | | | X | Few |
| | *Verbena* | Seed | | | 1 | | |
| | Bud | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | *Quercus* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 3 | |
| | Fish scale | | | | | 1 | |
| | Insect | Chitin | | | | X | Few |
| | Insect | Puparia | | | | 5 | |
| | Mollusk shell | | | | | 1 | |
| | Snail shell | | | | X | X | Few |
| | Termite fecal pellet | | 4 | | | | |
| **33/118.11 (S33W118, Level 11, 103-113 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 6.03 g |
| | FLORAL REMAINS: | | | | | | |
| | *Chenopodium* | Seed | | | 3 | | |
| | cf. Anther | | | | 1 | | |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **33/118.11** (cont.) | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | *Ehretia anacua* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 1 | |
| | Insect | Chitin | | | | 7 | |
| | Insect | Puparia | | | | 2 | |
| | Snail shell ≥ 0.5 mm | | | | 4 | 19 | |
| | Snail shell < 0.5 mm | | | | | X | Few |
| **33/118.10** **(S33W118, Level 10, 93-103 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.95 g |
| | FLORAL REMAINS: | | | | | | |
| | *Prosopis* | Seed | | 1 | | | |
| | *Oxalis* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | 1 | |
| | Leaf | | | | 1 | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal ≥ 1 mm | | | | | | 0.03 g |
| | cf. *Ehretia* | Charcoal | | 2 | | | 0.03 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 18 | |
| | Insect | Puparia | | | | 18 | |
| **33/118.8** **(S33W118, Level 8, 73-83 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 2.74 g |
| | FLORAL REMAINS: | | | | | | |
| | Vitrified tissue | | | 1 | | | 0.02 g |
| | *Helianthus* | Seed | | | 1 | | |
| | Poaceae | Leaf/Stem | | | | 2 | |
| | Unidentified | Seed | | | | 1 | |
| | Bud | | | | | X | Few |
| | Leaf | | | | | X | Few |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **33/118.8** (cont.) | Thorn | | | | | 1 | |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Few |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | 0.01 g |
| | cf. *Morus rubra* | Charcoal | | 2 | | | <0.01 g |
| | *Quercus virginiana* | Charcoal | | 2 | | | 0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 11 | |
| | Fish vertebra | | | | | 2 | |
| | Flake | | | | | 2 | |
| | Insect | Chitin | | | | 12 | |
| | Cockroach | Egg | | | | 13 | |
| | Rodent fecal pellet | | | | | X | Few |
| | Snail shell | | | | | 1 | |
| | Termite fecal pellet | | 3 | | | | |
| **33/118.7** **(S33W118, Level 7, 63-73 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.32 g |
| | FLORAL REMAINS: | | | | | | |
| | Poaceae | Floret | | | | 2 | |
| | Roots | | | | | X | Moderate |
| | Rootlets | | | | | X | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 4 | |
| | Snail shell | | | | | 1 | |
| **33/118.6** **(S33W118, Level 6, 53-63 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.86 g |
| | FLORAL REMAINS: | | | | | | |
| | Asteraceae | Seed | | | 1 | | |
| | *Helianthus* | Seed | | | | 1 | |
| | *Chenopodium* | Seed | | | 1 | | |
| | cf. Anther | | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |

continued.

**Table C-7.** (continued)

| Sample No. | Identification | Part | Charred | | Uncharred | | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| | | | W | F | W | F | |
| **33/118.6** (cont.) | NON-FLORAL REMAINS: | | | | | | |
| | Insect | Chitin | | | | 4 | |
| | Cockroach | Egg | | | 2 | | |
| | Worm casts | | | | X | X | Few |
| **4** **(Feature 4, S54W123, Level 12, 110-120 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.78 g |
| | FLORAL REMAINS: | | | | | | |
| | *Euphorbia* | Seed | | | | 1 | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Few |
| | Sclerotia | | | | X | | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | | | 4 | |
| | Insect | Chitin | | | | 7 | |
| | Cockroach | Egg | | | 1 | 3 | |
| **54/123.9** **(S54W123, Level 9, 110-120 cmbs)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 1.31 g |
| | FLORAL REMAINS: | | | | | | |
| | *Mollugo verticillata* | Seed | | | 3 | 1 | |
| | Unidentified C | Fruit | | | 1 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | Sclerotia | | | | X | | Moderate |
| | CHARCOAL/WOOD: | | | | | | |
| | Total charcoal weight | | | | | | <0.01 g |
| | *Ehretia anacua* | Charcoal | | 1 | | | <0.01 g |
| | NON-FLORAL REMAINS: | | | | | | |
| | Flake | | | | | 1 | |
| | Insect | Chitin | | | | 11 | |
| | Cockroach | Egg | | | 2 | 6 | |
| | Snail shell | | | | 1 | | |
| | Rodent fecal pellet | | | | | X | Few |
| | Termite fecal pellet | | 2 | | | | |

continued.

**Table C-7.** (concluded)

| Sample No. | Identification | Part | Charred W | Charred F | Uncharred W | Uncharred F | Weights/ Comments |
|---|---|---|---|---|---|---|---|
| **54/123.7 (S54W123 Level 7)** | Liters Floated | | | | | | approx. 8 L |
| | Light Fraction Weight | | | | | | 0.98 g |
| | FLORAL REMAINS: | | | | | | |
| | Cheno-am | Seed | | | | 1 | |
| | *Mollugo verticillata* | Seed | | | 3 | | |
| | Leaf | | | | | X | Few |
| | Roots | | | | | X | Few |
| | Rootlets | | | | | X | Moderate |
| | Sclerotia | | | | X | | Few |
| | NON-FLORAL REMAINS: | | | | | | |
| | Bone | | | 1 | | 3 | |
| | Insect | Chitin | | | | 3 | |
| | Snail shell | | | | 1 | 3 | |

**Notes/Abbreviations**

W = Whole
F = Fragment
X = Presence Noted in Sample
L = Liters
g = Grams
* = Estimated Frequency
** = "Fine Flotation" only – no "Large Flotation"

small quantities of *Artemisia*, Low-spine Asteraceae, High-spine Asteraceae, Brassicaceae, Cheno-am, Poaceae, and Rosaceae pollen, indicating the presence of sagebrush, various members of the sunflower family, members of the mustard family, Cheno-ams, grasses, and members of the rose family. This sample also exhibited an angular starch with an eccentric hilum and starches with centric hila. Sample 8.2 yielded Rosaceae pollen, which might reflect processing a member of the rose family. The phytolith record from these three samples was very similar. Elongate smooth forms were abundant in all of these samples. Woven tracheary elements were noted in Samples 8.1A and 8.2, suggesting that they were introduced either at the time of cooking or later after abandonment. *Typha* raphids were rare in these samples, being noted only in Sample 8.2. Starches were present both in Samples 8.1A and 8.1B, indicating that some starches present in the clay used to make the clay nodules survived the heating process. Starches noted in these two samples are restricted to starches with centric hila, which are produced in both grass seeds and lotus roots, as well as in other plants. These are fairly generic starch types and not considered diagnostic here. Sample 8.2 did not yield starches.

Macrofloral Sample 8.3, from the fill of Feature 8, contained one charred unidentified seed fragment, suggesting seed-processing activities in this area. One small fragment of conifer charcoal might reflect use of conifer wood, such as pine, as fuel. Recovery of seven charred termite fecal pellets suggests that some of the burned wood contained termites. The sample yielded a variety of uncharred seeds and remains from modern plants in the area, reflecting introduction of recent material into these sediments. Several insect chitin fragments, a few insect puparia, and numerous snail shells also were present.

Feature 16 was a loose cluster of burned-clay nodules in Unit S29W118 in the northern portion of the excavation block and assigned to AU 2. No charcoal was associated with this feature. Sample 16.1 is the pollen/starch and phytolith wash of one of the burned-clay nodules. This pollen sample yielded the largest quantity of Poaceae pollen recorded at this site, suggesting the possibility that grass seeds were processed. In addition, small quantities of *Quercus*, Apiaceae, Low-spine Asteraceae, High-spine Asteraceae, Nyctaginaceae, and *Sphaeralcea* pollen were noted, indicating the local presence of oak, a member of the umbel family, members of the sunflower family, a member of the four o'clock family, and globe mallow. The phytolith record includes primarily elongate smooth forms and *Typha* raphids. Two types of starches were noted—Lotus-type and starches with centric hila. Both types are observed in lotus roots, but starches with centric hila also are common in grass seeds. This clay nodule appears to have been used in cooking lotus root and perhaps other foods such as grass seeds.

Macrofloral Sample 16.2 was taken from the hearth fill at a depth of 159-190 cmbs. Two small, calcined bone fragments were present in this sample, suggesting meat-processing activities. A few uncharred bone fragments might also represent meat processing. No charcoal or charred plant remains were recovered. A few uncharred seeds, leaf fragments, root fragments, and rootlets represent introduction of material from modern plants at the site. The sample also contained a few insect chitin fragments, an ostracod shell, and numerous snail shells. Ostracods are small, bivalved crustaceans widely distributed in fresh and saline water, normally under well oxygenated conditions in lakes, ponds, springs, and streams (Palacios-Fest et al. 1994:145).

Feature 17 is a pit in Unit S29W118 in the northern portion of the excavation block. This feature is assigned to AU 2. The pit was not fully excavated but is believed to measure approximately 80 to 90 cm in diameter and 60 cm in depth. Feature 17 might have functioned as a storage pit. The pit fill contained faunal bone fragments, rangia shell, chert debitage, and a Morhiss projectile point. Two macrofloral samples were examined from the pit fill. Sample 17.19 was recovered from Level 19 fill at a depth of 180-190 cmbs. This sample contained seven uncharred bone fragments, a few uncharred seed and leaf fragments from modern plants, a moderate amount of uncharred rootlets, a few insect chitin fragments, and several snail shells. Sample 17.18, from a depth of 170-180 cm, also contained uncharred seeds, leaf fragments, a thorn fragment, and a few roots and rootlets from modern plants, as well as two uncharred bone fragments, three insect chitin fragments, and a few snail shells. No charred remains indicative of economic activities associated with Feature 17 were present in either sample. If this feature functioned as a storage pit for foodstuffs, pollen and/or phytolith analysis of the pit fill might yield evidence for foods stored in the pit. Macrofloral evidence would be expected only if the pit had burned while it contained the stored foods.

Feature 19 is a hearth remnant assigned to AU 2 and located in Unit S29W116 in the northern portion of the excavation block. This feature consisted of an amorphous, loose cluster of burned-clay nodules. Macrofloral Sample 19 from a depth of 170-180 cm, contained one fragment of hardwood charcoal too small for further identification. No other charred remains were recovered. An uncharred Cheno-am seed, several uncharred *Celtis* seed fragments, an uncharred *Portulaca* seed, two uncharred *Quercus* root fragments, and a few roots and rootlets represent introduction of modern material into this area. The sample also yielded two uncharred bone fragments, thirteen insect chitin fragments, an insect puparia fragment, and several snail shells.

Feature 10 is a small, dense cluster of burned-clay nodules in Unit S33W116 in the southern portion of the excavation block. This feature is assigned to AU 2 and is believed to represent a hearth remnant. Macrofloral Sample 10 from the hearth fill contained one uncharred bone fragment, a few insect chitin fragments, a few insect fecal pellets, two cockroach eggs, an uncharred *Mollugo verticillata* seed fragment, a few uncharred root fragments, and a moderate amount of uncharred rootlets. No charred remains indicative of economic activities were present.

Macrofloral samples were collected from a soil column in Unit S31W116 in the eastern portion of the excavation block. Sample 31/116.16 represents the lowest sample examined from a depth of 150-160 cm (Level 16). This level is assigned to levels below those of AU 3, and thus dates to earlier than 3150 B.C. Sample 31/116.16 contained six fragments of probable *Ehretia anacua* charcoal, suggesting use of local anaqua wood as fuel. A few uncharred seeds from a variety of modern plants were present in this sample, indicating introduction of modern material. Recovery of a few insect chitin fragments, an insect puparia fragment, one uncharred termite fecal pellet, and a few worm casts indicates some subsurface disturbance from insect and earthworm activity in this area.

Macrofloral Sample 31/116.15, from a depth of 140-150 cm (Level 15), is assigned to AU 3 or slightly below AU 3. One small piece of hardwood charcoal was too small for further identification. One charred bone fragment and possibly five uncharred bone fragments reflect meat-processing activities in this area. One lithic flake also was present. Evidence for bioturbation in this level includes several uncharred seeds and seed fragments, a few uncharred Poaceae leaf/stem fragments, a moderate amount of uncharred leaf fragments, 13 insect chitin fragments, two insect puparia fragments, several snail shells, and a few worm casts.

Macrofloral Sample 31/116.14 was collected from a depth of 130-140 cm and is assigned to AU 2-3. This sample yielded one small fragment of *Fraxinus* charcoal and one small fragment of *Quercus* charcoal, suggesting that ash and oak wood were burned as fuel. In addition, the sample contained one uncharred bone fragment, five insect chitin fragments, a moderate amount of snail shells, and uncharred remains from modern plants consisting of two uncharred *Celtis* seeds and several seed fragments, an uncharred *Euphorbia* seed fragment, an uncharred Poaceae floret, an uncharred *Portulaca* seed, a moderate amount of leaf fragments, and a few roots and rootlets.

One charred *Chenopodium* seed was present in Macrofloral Sample 31/116.11 from a depth of 100-110 cm (AU 2), suggesting that goosefoot seeds might have been processed in this area by the Late Archaic occupants of the site. A few small fragments of probable *Ehretia anacua* charcoal suggest that local anaqua wood was burned as fuel. Recovery of 12 insect chitin fragments and a moderate amount of worm casts indicates some subsurface disturbance from insect and earthworm activity. The sample also contained uncharred remains from modern plants and a moderate amount of snail shells.

Macrofloral Sample 31/116.10, from a depth of 90-100 cm (AU 2), did not yield any charred remains indicative of economic activity in this area. The sample did contain uncharred *Celtis* seeds, an uncharred *Mollugo verrticillata* seed, a moderate amount of uncharred leaf fragments, a few roots and rootlets, and a thorn fragment from modern plants, as well as one uncharred bone fragment, five insect chitin fragments, and a few snail shells.

Macrofloral Sample 31/116.9 was collected from a depth of 80-90 cm (AU 1, 2). This sample contained modern plant remains consisting of an uncharred *Chenopodium* seed, an uncharred *Helianthus* seed fragment, three uncharred *Mollugo verticillata* seeds, a few uncharred Poaceae leaf/stem fragments, a few uncharred leaf fragments, a few uncharred *Quercus* root fragments, a moderate amount of unidentified root fragments, and a few rootlets. A few insect chitin fragments and snail shells were the only other remains to be recovered.

Macrofloral Sample 31/116.8 from a depth of 70-80 cm (AU 1, 2) also contained only uncharred remains from modern plants, as well as a few insect chitin fragments and snail shells. Even though no charcoal fragments were present in this sample, one charred termite fecal pellet was present and might reflect burning wood that contained termites. A few worm casts also were present.

Macrofloral Sample 31/116.7 was recovered from a depth of 60-70 cm (AU 1, 2). This sample contained one charred *Chenopodium* seed, suggesting that goosefoot seeds were processed. One small fragment of *Quercus* charcoal indicates local oak wood burned as fuel. Three charred termite fecal pellets might indicate that some of the burned wood contained termites. This level experienced subsurface disturbance and introduction of modern material as evidenced by recovery of several types of uncharred seeds, an uncharred *Celtis* twig with an adhering thorn, a few uncharred Poaceae leaf/stem fragments, a moderate amount of uncharred leaf fragments, an uncharred thorn that is thinner than *Celtis*, uncharred roots and rootlets, several insect chitin and puparia fragments, one cockroach egg and six egg fragments, a few rodent fecal pellets, and a moderate amount of worm casts. The sample also yielded one uncharred bone fragment and several snail shells.

Macrofloral Sample 31/116.6 represents the uppermost sample examined from the column. This sample was taken from a depth of 50-60 cm and is assigned to AU 1. One charred fragment of "spongy," leaf-type tissue was present, possibly reflecting a leaf that was adhering to a branch burned as fuel. Two pieces of charcoal were too small for identification. One charred termite fecal pellet also was recovered. A variety of uncharred remains from modern plants were present in this sample, as well as several insect chitin fragments, one cockroach egg fragment, a few small rodent fecal pellets, a moderate amount of worm casts, and a few snail shells.

Macrofloral Sample 32/117.6 was collected from Level 6 in Unit S32W118 in the southwest portion of the excavation block. This level is assigned to a period prior to AU 3. The sample contained a few uncharred *Celtis* seeds and other remains from modern plants, as well as a few insect chitin fragments and several snail shells. No charred remains were present.

Six macrofloral samples also were recovered from a soil column in Unit S33W118 in the southern portion of the excavation block. Sample 33/118.12, from a depth of 113-123 cm (Level 12), represents the lowest level examined and is assigned to AU 2. One small fragment of *Quercus* charcoal was present in this sample, reflecting oak wood burned as fuel. Four charred termite fecal pellets might indicate that some of the burned wood contained termites. One fish scale fragment suggests that fish were eaten. One mollusk shell fragment and three uncharred bone fragments might also reflect meat resources. In addition, the sample yielded a few uncharred remains from modern plants, a few insect chitin and puparia fragments, and a few snail shells.

Macrofloral Sample 33/118.11, from a depth of 103-113 cm (AU 2), contained one small fragment of *Ehretia anacua* charcoal, indicating that local anaqua wood was burned as fuel. Three uncharred *Chenopodium* seeds, a moderate amount of uncharred rootlets, and a few other uncharred remains represent modern plants in the area. Non-floral remains include one uncharred bone fragment, a few insect chitin and puparia fragments, and a few snail shells.

Macrofloral Sample 33/118.10 was collected from a depth of 93-103 cm (Level 10) and is assigned to AU 2. This sample contained a charred *Prosopis* seed, suggesting that mesquite pods and/or seeds were utilized. If mesquite pods were ground into flour, seeds extracted during the grinding process might have been discarded in a fire. Two small fragments of probable *Ehretia* charcoal suggest that local anaqua wood was burned as fuel. One uncharred *Oxalis* seed, one uncharred Poaceae leaf/stem fragment, a few leaf fragments, and a few roots and rootlets represent modern plants. A few insect chitin and puparia fragments also were present.

One charred piece of vitrified tissue was present in Macrofloral Sample 33/118.8 from a depth of 73-83 cm (AU 1, 2). Vitrified material has a shiny, glassy appearance due to fusion by heat. This tissue fragment might reflect charcoal or other plant tissue too vitrified for identification. The charcoal record consisted of two pieces of possible *Morus rubra* charcoal and two pieces of *Quercus virginiana* charcoal, reflecting live oak and possible mulberry wood burned as fuel. Three charred termite fecal pellets suggest that some of the burned wood contained termites. One charred bone fragment, two fish vertebra, and possibly eleven uncharred bone fragments reflect processing of fish and other meat resources. Two lithic flakes also were present. Uncharred remains from modern plants reflect introduction of modern material into these sediments, while recovery of 12 insect chitin fragments, 13 cockroach egg fragments, and a few rodent fecal pellets indicates subsurface disturbance from insect and rodent activity.

Macrofloral Sample 33/118.7 represents Level 7 at a depth of 63-73 cm (AU 1, 2). This sample contained two uncharred Poaceae floret fragments from modern grasses, a moderate amount of root fragments, a few rootlets, four insect chitin fragments, and one snail shell. No charred remains indicative of economic activities were present.

Macrofloral Sample 33/118.6, from a depth of 53-63 cm (AU 1, 2), is the uppermost sample examined from this column. The sample yielded a few uncharred seeds, leaf fragments, roots, and rootlets from modern plants, as well as four insect chitin fragments, two cockroach eggs, and a few worm casts.

Three macrofloral samples were collected from Unit S54W123 southwest of the main West Slope Excavation Block. These samples are not associated with an analytical unit, but are believed to represent the Middle to Late Archaic, about 5000-1500 B.P. Feature 4 was a hearth remnant consisting of a loose cluster of seven relatively large burned-clay nodules ranging in size from 4 to 8.5 cm, and found in Level 12 (110-120 cmbs). No charcoal was associated with this feature. Macrofloral Sample 4 from the fill of Feature 4 yielded no charred remains indicative of economic activities. The sample did contain an uncharred *Euphorbia* seed and a few leaf, root, and rootlet fragments from modern plants, as well as a few sclerotia, four uncharred bone fragments, seven insect chitin fragments, and a cockroach egg and three egg fragments.

Sample 54/123.9 was recovered from Level 9 in Unit S54W123. This sample contained one small fragment of *Ehretia anacua* charcoal, suggesting that local anaqua wood was burned as fuel. Two charred termite fecal pellets suggest that some of the burned wood contained termites. One lithic flake also was present. Recovery of a few rodent fecal pellet fragments, insect chitin fragments, and cockroach eggs indicates that this area has experienced subsurface disturbance from rodent and insect activity, which introduced uncharred remains from modern plants, including seeds and leaf fragments. The sample also contained a few roots, a moderate amount of rootlets, and a moderate amount of sclerotia.

Sample 54/123.7 represents Level 7 of Unit S54W123. One charred bone fragment was present in this sample, suggesting meat-processing activities. No other charred remains were recovered. The sample did contain three uncharred bone fragments, a few remains from modern plants, three insect chitin fragments, and a few snail shells.

### *Summary and Conclusions*

Pollen/starch, phytolith, macrofloral, and protein residue analysis of samples from the Buckeye Knoll site in south Texas yielded evidence for the use of a variety of resources by the various occupants of the site. Microscopic remains (pollen, starch, and phytoliths) point to exploitation of a number of resources, some of which may be collected from wet areas with slow-moving water. Lotus roots would have been cooked in containers using fired-clay nodules to transfer heat to the water so that it would boil. Evidence for cooking lotus (*Nelumbo*) roots is observed in Samples 1655, 12.3, 15.1, and 16.1, representing a milling stone and three clay nodules, one each from Features 12, 15 and 16. It is possible that recovery of sponge spicules from clay nodules is the result of using water in cooking, although the presence of sponge spicules in all of the samples suggests that they might be present in the soil in sufficient quantities to make their interpretation in the clay-nodule washes difficult. In addition, rose hips might have been processed using some of the clay nodules. Samples 15.2, 12.1, 12.2, and 12.3 all contained significant quantities of *Rosa*-type pollen, suggesting that these clay nodules probably were used to cook rose hips in liquid. Recovery of smaller quantities of Rosaceae pollen in Samples 8.1A and 8.2 also might be the result of the same activity, although this pollen could not be identified to the genus level. *Typha* pollen was recovered from sample 1655, suggesting the possibility that cattails were processed on this milling stone. In addition, cattail raphids were present in the same sample, lending support to this interpretation. Most of the samples examined for phytoliths exhibited at least a few *Typha* raphids, which raises the question as to whether they are present through cooking cattail or through the presence of raphids in the sediments, particularly the midden sediments, which were then transferred to the surface of the clay nodules in Sample 2297. This question is answered, in part, by recovery of large quantities of dot starches, which are interpreted to represent cattail roots. It is this recovery, in particular, that lends strength to the interpretation that cattail roots were cooked using fired-clay nodules. The starch record exhibits starch of several morphologies. Only the dot starch and lotus-type starch are considered diagnostic. Dot starches, particularly small starches that are recovered in aggregates, are considered to be diagnostic of cattail roots. Lotus-type starches are eccentric in shape with an eccentric hilum and also are considered diagnostic. The other starches recovered all have been found in lotus roots, although they are not considered to be diagnostic of lotus roots since they also may be found in grass seeds. There is no conclusive starch evidence of processing grass seeds, although the elevated Poaceae pollen frequency, combined with the presence of starch with centric hila, might be interpreted as evidence that grass seeds were cooked.

The macrofloral record from midden deposits and hearth fill at Buckeye Knoll suggest that the various prehistoric occupants of the site processed goosefoot seeds. Woods burned as fuel included conifer, anaqua, ash, oak, live oak, possible mulberry, and another unidentified hardwood. Several samples contained charred termite fecal pellets, suggesting that some of the burned wood contained termites. Recovery of charred, calcined, and uncharred bone fragments in these samples, as well as fish vertebrae and fish scale fragments, indicates that fish and other meat resources were utilized. Samples from the Knoll Top Excavation Block also contain charred evidence suggesting use of pokeweed, grass, wild grapes, and possibly hackberry. A charred PET fruity tissue fragment suggests processing of a fleshy fruit/berry resource, such as hackberry, while a piece of charred parenchymous tissue might reflect processing of a root or tuber resource, such as cattail or lotus. Additional charcoal types noted only in the Knoll Top samples include probable acacia and sycamore, hackberry/elm, hackberry, and elm. A charred mesquite seed in a midden sample from the West Slope Excavation Block might reflect use of mesquite pods. A piece of charred "spongy" tissue might represent a leaf that was adhering to branches burned as fuel, or possibly use of leaves to wrap foods for cooking or in a buffering vegetation layer when cooking foods.

It is likely that bioturbation is responsible for moving some macrofloral remains up and down through the cultural deposits. Several of the lower samples from the midden deposits contained uncharred remains from modern plants. Many samples contained evidence for subsurface disturbance from insect, earthworm, and rodent activity in the area.

Positive protein residue results for three lanceolate dart points found with Burials 26 and 49 from the cemetery in the Knoll Top Excavation Block indicate use of birds and fish by the Early Archaic occupants of the site. Positive results for lanceolate dart points and soil controls from Burials 8 and 43 reflect soil contamination. The remaining artifacts tested for protein residues yielded negative results to all antisera tested. It is possible that these artifacts were (1) not used to hunt/process animals, (2) were used to hunt/process animals other than those represented by the available antisera, or (3) that insufficient amounts of proteins were retained on the artifact surfaces.

## References


Angell, M.
1981 *A Field Guide to Berries and Berrylike Fruits*. The Bobbs-Merrill Company, New York.

Angier, B.
1978 *Field Guide to Medicinal Wild Plants*. Stackpole Books, Harrisburg, Pennsylvania.

Asch, D. L., and N. B. Asch
1978 The Economic Potential of *Iva annua* and Its Prehistoric Importance in the Lower Illinois Valley. In *The Nature and Status of Ethnobotany*, edited by R. I. Ford, pp. 301-342. Anthropological Papers Vol. 67. University of Michigan, Ann Arbor.

Bailey, L. H., and E. Z. Bailey
1976 *Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada*. MacMillan, New York.

Boschung, H. T. Jr., J. D. Williams, D. W. Gotshall, D. K. Caldwell, and M. C. Caldwell
1983 *The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins*. Audubon Field Guides. Alfred A. Knopf, New York.

Brill, S., and E. Dean
1994 *Identifying and Harvesting Edible and Medicinal Plants in Wild (and Not So Wild) Places*. Hearst Books, New York.

Brown, D. A.
1984 Prospects and Limits of Phytolith Key for Grasses in the Central United States. *Journal of Archeological Science* 11:345-368.

Burlage, H. M.
1968 *Index of Plants of Texas with Reputed Medicinal and Poisonous Properties*. Henry M. Burlage, Austin.

Chamberlin, R. V.
1964 The Ethnobotany of the Gosiute Indians of Utah. In *Memoirs of the American Anthropological Association* 2:329-405. Kraus Reprint, New York.

Culliford, B. J.
1964 Precipitation Reactions in Forensic Problems. *Nature* 201:1092-1094.

________
1971 *The Examination and Typing of Bloodstains in the Crime Laboratory*. Stock 2700-0083. United States Department of Justice, U.S. Government Printing Office,Washington, D.C.

Elmore, F. H.
1976 *Shrubs and Trees of the Southwest Uplands*. Southwest Parks and Monuments Association, Tuscon.

Evershed, R., C., Kolman, N. Tuross, and M. Wachowiak
1996 *Residue Analysis: How You Can Do It and How Much It Will Cost*. Workshop Presented at the 61st Annual Meeting of the Society for American Archaeology, New Orleans.

Foster, S. and J. A. Duke
1990 *A Field Guide to Medicinal Plants*. Houghton Mifflin Company, Boston.

Gaensslen, R. E.
1983 *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. United States Department of Justice, Washington. D.C.

Gallagher, M. V.
1977 *Contemporary Ethnobotany Among the Apache of the Clarkdale, Arizona Area, Coconino and Prescott National Forests*. Forest Service, United States Department of Agriculture, Southwest Region, Albuquerque.

Gould, F. N., and R. B. Shaw
1983 *Grass Systematics*. Texas A&M University Press, College Station.

Gould, F. W.
1962 *Texas Plants: A Checklist and Ecological Summary*. Texas Agricultural Experiment Station, M.P. 585, College Station.

Harrington, H. D.
1967 *Edible Native Plants of the Rocky Mountains*. University of New Mexico Press, Albuquerque.

Harrington, J. F.
1972. Seed Storage and Longevity. In: *Seed Biology,* edited by T.T. Kozlowski, Volume III, pp. 145 - 245. Academic Press, New York.

Hather, Jon G.
2000 *Archaeological Parenchyma*. Archetype Publications, London.

Hedrick, U. P. (editor)
1972 *Sturtevant's Edible Plants of the World*. Dover Publications, New York.

Heiser, C. B., Jr.
1990 *Seed to Civilization: The Story of Food*. Harvard University Press, Cambridge.

Hoese H. D., and R. H. Moore
1977 *Fishes of the Gulf of Mexico. Texas, Louisiana, and Adjacent Waters*. Texas A&M University Press, College Station.

Justice, O. L., and L. N. Bass
1978 Principles and Practices of Seed Storage. *Agriculture Handbook* No. 219. United States Department of Agriculture, Agricultural Marketing Service, Washington, D.C.

Kearney, T. A., and R. H. Peebles
1960 *Arizona Flora*. University of California Press, Berkeley.

Kindscher, K.
1987 *Edible Wild Plants of the Prairie*. University Press of Kansas, Lawrence.

Kirk, D. R.
1975 *Wild Edible Plants of Western North America*. Naturegraph Publishers, Happy Camp, California.

Krochmal, A., and C. Krochmal
1973 *A Guide to the Medicinal Plants of the United States*. Quadrangle, The New York Times Book Company, New York.

Loughmiller, C., and L. Loughmiller
1994. *Texas Wildflowers*. University of Texas Press, Austin.

McCormick, O. F, III
1973 *The Archaeological Resources in the Lake Monticello Area of Titus County, Texas*. Department of Anthropology, Southern Methodist University, Dallas.

McGee, H.
1984 *On Food and Cooking*. Charles Scribner's Sons, New York.

Mails, T. E.
1991 *The Mystic Warriors of the Plains*. Mallard Press, New York.

Martin, A. C.
1972 *Weeds*. Golden Press, Western Publishing Company, New York.

Martin, A. C., and W. D. Barkley
1973 *Seed Identification Manual*. University of California Press, Berkeley.

Medsger, O. P.
1966 *Edible Wild Plants*. MacMillan Publishing Company, Racine, Wisconsin.

Meuninck, J.
1988 *The Basic Essentials of Edible Wild Plants and Useful Herbs*. ICS Books, Merrillville, Indiana.

Millspaugh, C. F.
1974 *American Medicinal Plants: An Illustrated and Descriptive Guide to Plants Indigenous to and Naturalized in the Unites States Which are Used in Medicine*. Dover Publications, New York.

Minnis, P. E.
1981 Seeds in Archaeological Sites: Sources and Some Interpretive Problems. *American Antiquity* 46:143–152.

Moerman, D. E.
1998 *Native American Ethnobotany*. Timber Press, Portland, Oregon.

Moore, Michael
1990 *Los Remedios: Traditional Herbal Remedies of the Southwest*. Red Crane Books, Santa Fe, New Mexico.

Musil, A. F.
1978 Identification of Crop and Weed Seeds. *Agriculture Handbook* No. 219. United States Department of Agriculture, Agricultural Marketing Service, Washington, D.C.

Newcomb, W. W., Jr.
1983 Karankawa. In *Southwest*, edited by A. Ortiz, pp. 359-367. Handbook of North American Indians. Vol. 10. Smithsonian Institution, Washington, D.C.

Newman, M., and P. Julig
1989 The Identification of Protein Residues on Lithic Artifacts from a Stratified Boreal Forest Site. *Canadian Journal of Archaeology* 13:119-132.

Newman, M. E., R. M. Yohe, H. Ceri, and M. Q. Sutton
1993 Immunological Protein Residue Analysis of Non-lithic Archaeological Materials. *Journal of Archeological Science* 20:93-100.

Niering, W. A.
1985 *Wetlands*. The Audubon Society Nature Guides. Alfred A. Knopf, New York.

Palacios-Fest, M. R., A. S. Cohen, and P. Anadón
1994 Use of Ostracodes as Paleoenvironmental Tools in the Interpretation of Ancient Lacustrine Records. *Revista Española de Paleontologia* 9(2):145-164.

Peattie, D. C.
1953 *A Natural History of Western Trees*. University of Nebraska Press, Lincoln.

Peterson, L. A.
1977 *Edible Wild Plants*. Collier Books, New York.

Peterson, R. T.
1961 *A Field Guide to Western Birds*. 2nd ed. The Peterson Field Guide Series. Houghton Mifflin Company, Boston.

Peterson, R. T.
1980 *A Field Guide to the Birds: A Completely New Guide to All the Birds of Eastern and Central North Americ*a. 4th ed. The Peterson Field Guide Series. Houghton Mifflin Company, New York.

Petrides, G. A., and O. Petrides
1992 *A Field Guide to Western Trees*. The Peterson Field Guide Series. Houghton Mifflin Company, Boston.

Pough, R. H.
1951 *Audubon Water Bird Guide: Water, Game, and Large Land Birds—Eastern and Central North America from Southern Texas to Central Greenland*. Audubon Guides. Doubleday and Company, Garden City, New York.

Quick, C. R.
1961 How Long can Seed Remain Alive? *Seeds: The Yearbook of Agriculture*. U.S. Department of Agriculture, Washington, D.C.

Ricklis, R. A.
1996 *The Karankawa Indians of the Texas Coast: An Ecological Study of Cultural Tradition and Change*. University of Texas Press. Austin.

________
2002 *Archaeological Investigations at the Buckeye Knoll Site (41VT98), Victoria County, Texas*. Coastal Environments, Inc. Draft report submitted to the U.S. Army Corps of Engineers, Galveston District.

Schopmeyer C. S.
1974 Seeds of Woody Plants in the United States. United States Department of Agriculture, Agricultural Marketing Service, *Agriculture Handbook* No. 450, Washington, D.C.

Stenholm, N. A.
1993 Fort Rock Basin Botanical Analysis. In *Archaeological Researches in the Northern Great Basin: Fort Rock Archaeology Since Cressman*, edited by C. M. Aikens and D. L. Jenkins. University of Oregon Anthropological Papers, University of Oregon, Eugene, Oregon.

Swanton, J. R.
1942 *Source Material on the History and Ethnology of the Caddo Indians*. Bulletin No. 132. Bureau of American Ethnology, Smithsonian Institution, Washington, D.C.

Sweet, M.
1976 *Common and Useful Plants of the West*. Naturegraph Company, Healdsburg, California.

Tilford, G. L.
1997 *Edible and Medicinal Plants of the West*. Mountain Press Publishing, Missoula.

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

Vines, R. A.
1960 *Trees, Shrubs, and Woody Vines of the Southwest*. University of Texas Press, Austin.

Watt, B. K., and A. L. Merrill
1963 *Composition of Foods*. Agricultural Handbook No. 8. United States Department of Agriculture, Washington D.C.

Appendix D

# Lithic Use-Wear Analysis

**Jason Wallace Barrett**

### *Introduction*

This report details the analysis of use wear on stone tools recovered in excavations at the Buckeye Knoll site (41VT98). The assemblage includes various formal and informal tool types recovered in Early Archaic and Middle Archaic contexts. Twenty-two of the tools analyzed were recovered in mortuary contexts. The 53 non-mortuary specimens were selected to provide a representative sampling of the various kinds of tools present among the artifact assemblage as a whole. Specific tool specimens were selected based on their morphologically inferred functions. The focus of this report is on analysis of use-wear evidence. This includes the microscopic observation of edge attrition, polish, and striations. Environmental scanning electron microscopy (ESEM) was also used to detect plant residues. Metric traits and raw material properties were systematically recorded for each tool.

### *Equipment*

A Leica $MZ12_5$ (12.8 – 160.0 X) light microscope was used to obtain microscopic use-wear images at the Center for the Study of the First Americans microscopy laboratory at Texas A&M University. Images were captured using *Image-Pro Plus* (version 4.5.1), and *In-Focus* (V.1-60) was used to create final images with an extended depth of field. Scanning electron microscopy (SEM) was performed at the Microscopy and Imaging Center at Texas A&M University using an Environmental Scanning Electron Microscope (ESEM-E3).

### *Procedures*

Assessing the way in which a stone tool was used is an aspect of analysis that is often plagued by ambiguity. Morphologically-based analyses often provide a proclamatory assessment of function based on inference and cross-cultural analogy. Such efforts are often inadequate, failing to identify actual activities with any specificity, let alone the range of tasks for which any one tool may have been used. Analyses based wholly on tool morphology are prone to inaccuracies as form does not readily correlate to function, and because the multifunctional nature of many tool forms presents a significant obstacle to direct analogical approaches. Careful examination of use-wear has shown that specific tool forms were utilized for multiple tasks, with wear patterns showing marked variability among tools with nearly identical form. Function cannot be easily assumed based simply on tool morphology, but must be assessed through detailed microscopic observation of wear patterns left on tools.

Analysts perform microscopic use-wear analysis using both high-power (400 or greater) and low-power (40-100) approaches (Andrefsky 1998; Keeley and Newcomer 1977; Odell and Odell-Vereecken 1980). There is often a higher level of analytical certainty attained using high-power approaches, although low-power approaches have also proven quite accurate. Low-powered approaches are often more expedient and much less costly than high-power approaches, and the accuracy of each approach has been shown to benefit through the use of an extensive reference collection generated through controlled use experiments.

As a light microscope with a power range of 12.8 to 160.0 was used in this study, the method of analysis followed can be characterized as a low-power approach. High-powered SEM images were taken, but these were generally used for identifying use-derived residues rather than for observing wear. The approach used in this study has focused on describing the nature of edge modification and the patterns of its occurrence. Using these data, tool use is assessed with respect to the probable motion of use and the relative hardness of the contact material.

### *Analysis of Use-Wear*

#### *Patterns of Edge Modification*

Four separate qualities of edge modification and their associated pattern of distribution were recorded for tool forms within the Buckeye Knoll assemblage. These included flaking, crushing or smoothing, polish, and etching or pitting. A co-occurrence of these use-wear types is not uncommon, and the coding system used in this study has been designed to record all observable traces of wear.

The class of wear patterning labeled "flaking" includes instances of flake detachment along the tool's margin that relates to direction and form of use, type and relative strength of contact material, and desired edge of contact. Using a similar approach, Odell and Odell-Vereecken (1980:98-100) classified marginal attrition according to the form of flake terminations and their placement on the tool in their analysis of an experimental assemblage using low-power magnification (40-100). These data were then correlated to the activity performed with the tool that was responsible for generating the particular pattern of wear.

Edge modification is not always the product of material use. Other taphonomic processes, such as tramping, have been shown to produce edge modification similar to that developed through actual use (McBrearty et al. 1998; Shea and Klenck 1993; Tringham et al. 1974). Such taphonomic processes obviously affect the recognition of some patterns of wear more than others. Distinguishing use-derived feather terminations along the lateral margins of tools from attrition unrelated to use is perhaps the most equivocal functional assessment. However, the patternlessness of such incidental attrition is generally detectable, and thus one is able to be distinguished from actual use-wear with a high level of accuracy (Odell and Odell-Vereecken 1980).

The use-wear category "crushing or smoothing" was used to describe the form of wear attained through battering, grinding, or burnishing. A tool's edge may become blunted through battering or abrasion against a hard contact material in the process of use, and this is generally detectable even at very low magnification. Crushed working surfaces may be a desired and cultivated trait, such as with hammerstones, or they may be an undesired consequence of use and material attrition necessitating edge resharpening. Hafted bifaces are more likely to exhibit crushing distally or along one lateral margin. Smoothing is typically the result of intensive abrasion and is commonly observed on tools used for grinding, polishing, or burnishing. When observed, crushing or smoothing was recorded as distal, distal-lateral, unilateral, bilateral, facial-focused, facet-focused, circumferential, primary proximal, or secondary proximal.

The use-wear category "polish" was used to describe lustrous areas on the tool, typically located at distal or lateral margins, but occasionally noted on proximal and medial surfaces. When observed, polish was recorded as shallow distal, deep distal, shallow lateral, deep lateral, unifacial medial, bifacial medial, distal-medial, hafting, bipolar, or proximal. Polishes were recorded as shallow when restricted to within 5 mm of an edge. Polishes were defined as deep when they extending up to 20 mm from their edge of origin, while those extending beyond 20 mm were defined as distal-medial. Polishes that were detected on medial surfaces, often wrapping transversely around the artifact, and associated with worn, ground, or otherwise blunted lateral margins, were defined as hafting polishes. The presence or absence of a use-derived polish could not be determined in a limited number of cases due to the effects of fire alteration. In extreme cases, lithic material can become vitrified through an overexposure to heat, producing a lustrous sheen that covers the surface of the artifact.

The origin of polish is not well understood despite being the subject of generous scholarly attention (Odell 2001). Research into the nature of use-polish is generally focused either on the patterns of polish formed on stone tools as the result of a specific set of activities (cf. Aoyama 1999; Keeley 1977, 1980; Semenov 1964), or on the genesis and composition of polish itself (Fullagar 1991; Grace 1996; Odell 2001). In controlled studies, where tool forms were utilized in a defined set of prescribed behaviors, researchers have had notable success in correlating patterns of use-polish with the specific activities that generated them (Aoyama 1999; Clark 1988; Lewenstein 1987).

However, studies have also shown that a diverse set of activities may produce virtually identical patterns of use-polish (Lewenstein and Walker 1984). Researchers have also found that multifunctional tools generally preclude correlating specific tasks to patterns of polish (Clark 1988). It is perhaps best to consider that the form of the tool, the raw material used in its manufacture, and the patterns of wear (in any form) observable on the tool will provide a range of functional possibilities and limitations with regard to how it was used in a particular cultural and techno-environmental setting.

The use-wear category "etching or pitting" is used to describe striations produced through abrasive contact (see Semenov 1964). As with polish, such striations may occasionally derive from production techniques, though this is generally only a concern for tool forms featuring ground bits. Striations typically emanate from the distal or lateral margins, and the extent to which they cover the face of a tool form often provides some indication of how far the tool has penetrated the contact material. Striations may be created through activities such as quarrying, soil working, planing, polishing, or grinding.

### *Motion of Use*

Following the work of Odell and Odell-Vereecken (1980), categories used to classify motion of use included motions longitudinal to the working edge, motions transverse to the working edge, graving, boring, chopping, projectile, abrading, or pounding. Each of these categories coincides with a particular suite of use-wear traits, thus generally being quite discernable from one another. Subcategories also exist within several of the main categories. Motions longitudinal to the working edge include cutting, sawing, slicing, and carving. Motions transverse to the working edge include scraping, planing, and whittling. Boring may describe the work of either a drill or awl. Finally, chopping includes adzing, axing, and wedging.

Motions longitudinal to the working edge typically result in a bifacial attrition pattern, with flake removals occurring along either surface of the edge. A one-way cutting motion can be differentiated from a two-way sawing motion by the unidirectional scarring in the first instance and the multidirectional scarring in the latter case. Slicing and carving produce a pattern of flake detachment that remains bifacial, but noticeably favors one face over the other. Slicing and carving produce a scarring pattern that is typically unidirectional and diagonal to the working edge (Odell and Odell-Vereecken 1980:98). The presence of striations and formation of polish depends on a great deal on the nature of the contact material.

Motions transverse to the working edge typically involve pulling (scraping) or pushing (whittling and planing). Scarring is characteristically unifacial and distributed over a broad area (Odell and Odell-Vereecken 1980:99). Polish development also notably favors one face. Significant edge rounding or dulling may be observed. The working edge of tools used for scraping or planing will be particularly flat and even.

Graving may produce wear patterns similar to either transverse or longitudinal motions, depending on the method of use, but it is concentrated on a tip or projection. Spalling may be present on the tip emanating from the contact edge. Polish is concentrated on the contact edge of the projection.

Boring generally results in a distinctive, bilateral-unifacial pattern of flake removal. Scarring is caused by the unidirectional twisting of the tool in use and will occur only on opposing lateral margins of the tool. Spiral fractures may emanate from the tip. Flake removals may be bilateral-bifacial where the tool is used as an awl because the twisting motion of use may not be exclusively unidirectional. Awls may also exhibit a bifacial attrition pattern along their distal margin from thrusting and puncturing. The edge angle of drills is notably steeper than that of awls, and edge rounding is more pronounced.

Chopping typically produces a bifacial pattern of flake removal. The distribution of flake scars will be similar on either side of the utilized margin when the edge is symmetrical. When edges are not symmetrical, such as on adzes, flaking will favor one face over the other—although it is likely to be present on either face to some degree. Heavy impact generally results in step and hinge terminations along the used margin. Striations may be produced along the working edge of the tool. Such striations are typically at an angle to the edge when produced from a chopping motion, transverse to the edge when produced by an adzing motion, and perpendicular to the edge when produced through wedging (Odell and Odell-Vereecken 1980:99-100).

Projectile wear can be identified by the presence of a snap or spiral fracture at the distal margin. Striations perpendicular to the tip (parallel to the long axis of the tool) may also be present. Polish is expected to be heaviest at the tip, but may also be observed along the lateral margins. Proximal polish, often associated with a hafting element, is also common on projectiles.

**Table D-1.** Reliability Assessment of Low-Powered Microscopic Techniques Using an Experimental Study Sample (from Odell and Odell-Vereecken 1980).

| Measure | Low-Power Accuracy | High-Power Accuracy |
|---|---|---|
| Location of Use | 79% | 88% |
| Tool Movement | 69% | 75% |
| Determining Specific Contact Material | 39% | 63% |
| Contact Material Hardness | 61-68%* | NA |

* Accuracy improved when medium-soft and medium-hard categories were combined into a single grouping.

Hafting may also produce proximal-edge attrition in the form of abrasion or marginal rounding.

The use-wear on a tool used for abrading is typically located on the surface rather than on a flaked edge. Abrading may result in surfaces that are rounded and polished, or surfaces that are coarse and grooved with little or no polish. Striations are commonly present, whether or not clear directionality is determinable. The wear produced by abrasion depends on the nature of use (grinding vs. polishing) and the relative hardness of the contact material compared to that of the abrader.

Pounding wear is typical of hammerstones. Pounding wear may be present along the edge or on the surface of a tool. The point of contact is generally heavily worn, fractured and pitted. Use may be concentrated at one point on the tool or displayed circumferentially.

***Contact Material Hardness***

Odell and Odell-Vereecken (1980:116) conclude that identification of the specific material worked by stone tools is not generally possible. Several studies have achieved a measure of success in identifying details of use through plant residue analysis (e.g. Shafer and Holloway 1979), and encouraging results have been achieved through experimental studies with the production of reference collections (e.g. Aoyama 1999; Keeley 1977, 1980; Keeley and Newcomer 1980). Odell and Odell-Vereecken state that a higher level of accuracy can be attained through assessing the general hardness of the contact material (Table D-1) rather than attempting to determine its specific identity. Furthermore, the authors found that the accuracy of low-power techniques of assessing use-wear (magnification up to 100) were comparable to the accuracy attained through using high-power techniques (400 or higher). A complicating (and little studied) variable affecting the accuracy of assessing the specific identity - or even relative hardness - of the contact material on which a tool was used is the influence of lithic raw material composition on the patterns of wear produced. However, addressing this issue is beyond the scope of the present study.

The determination of contact material hardness in the present study was accomplished using criteria established by Odell and Odell-Vereecken (1980:101). These authors classified contact materials as being soft, soft-medium, hard-medium, or hard. Further, they state that significantly greater accuracy can be achieved using the low-power approach in identifying the relative hardness of the contact material than can be achieved in attempting to identify the specific material worked.

Soft contact materials do not produce significant flake removals. Any scarring is shallow and lacking clear directionality. Polish may be very well developed depending on the nature of the contact material and the duration of use. Striations do not typically form. Soft materials include muscle tissue, fats, hides, tubers, leaves, and some stalks.

Medium-soft contact materials produce large but poorly defined flake removals. Polish can be deep due to the depth the tool can penetrate into the material being worked. Shallow, often broad, striations may be present. Medium-soft contact materials include soft woods, nuts, and coarser vegetal substances.

Medium-hard contact materials produce defined flake scars that generally terminate in hinge fractures. Polish and striations are common, though they are typically shallow as it is uncommon for tools to penetrate deeply into medium-hard contact materials. Medium-hard contact materials include hardwoods, fresh bone, and soaked antler.

Hard contact materials typically produce stepped flake terminations that are medium to large in size. Flakes may remove considerable material mass. Shallow striations and polish may occur, though there is a tendency for them to be removed fairly quickly by attrition. Edges often become rounded from continuous friction.

### *Artifact Analysis*

The following analysis presents use-wear data for 23 mortuary artifacts and 54 non-mortuary artifacts (Table D-2). Artifacts from non-mortuary contexts are described first, followed by mortuary artifacts. Each tool is identified by its catalogue number ("Artifact ID"). A photograph or drawing of each artifact follows the metric description showing the areas where microscope images were taken. These areas are numbered from 01 on the images and correspond to the microscope images in the pictures that follow the description of the artifact and its use-wear patterns. For instance, if the Figure D-12 shows a dart point with three areas of interest, the magnified images that follow are labeled D-12.01, D-12.02, and D-12.03. Areas of interest taken on the portion of the artifact facing the viewer are circled in red, while photographs taken of the opposite side of the artifact are indicated in black. Some redundant microscope images are not shown, although the areas from which all images were taken are depicted in the artifact illustrations. In addition, under the terms of the study agreement negotiated between INVISTA and the U.S. Army Corps of Engineers, photographs of mortuary artifacts cannot be displayed. However, all microscope images for both mortuary and non-mortuary artifacts are on file at the Texas Archeological Research Laboratory (TARL).

### *Artifact Taxonomy*

The artifact taxonomy presented here has been designed as a means to record various levels of analytical data for each specimen, and to move beyond a strict reliance on static artifact names and types. This taxonomy is consistent with the Chipped Stone Analytical Protocol developed by the Texas Department of Transportation, and it is hoped that this taxonomy will help identify technological traditions and preferences of technique within and between groups, landscapes, regions, and periods. Taxonomic classification of stone tools will also provide the eventual database with greater analytical potential.

#### *Class*

A tool class identifies the general form of the tool with implicit information relevant to understanding the techniques of manufacture. For simple detachment-based tools, classes include flakes and blades. For both complex detachment-based tools and core-based tools, classes include bifaces and non-bifaces.

#### *Subclass*

The subclass of a tool provides additional information with respect to its class, often related to the degree to which the producer adhered to a predetermined manufacturing template. A subclass also encodes implicit information relevant to understanding the degree of expediency with which the tool was crafted. Tools classified as either flakes and blades are sub-classified as either modified or unmodified. Such tools are sub-classified as modified when additional stages of manufacture are required following their initial detachment prior to their use. Sequent flake unifaces, end scrapers, drills, and backed blades are a few examples of modified simple detachment-based tools.

Tools classified as either bifaces or non-bifaces are sub-classified as either formal or informal. If tools fit within a standardized, pervasive, recognizable morphology, they are considered formal as the producer is presumed to have been following a traditional manufacturing template. Unique tool forms that (typically) appear more expedient in design are considered informal.

#### *Type*

A tool's type identifies aspects of its use. Complex detachment-based and core-based tools should be typed according to their function. Function should be determined through use-wear analysis using the methods and observations outlined below. Some examples of biface tool types include projectiles, adzes, choppers, and knives. Examples of non-biface tool types include scrapers, adzes, and gouges.

**Table D-2.** Provenience Data for Stone Tools Analyzed for Use-Wear.

| Cat No. | Unit/Burial No. | Depth | Feature | FS # |
|---|---|---|---|---|
| 474 | S5W4 | Level 11 (108 cm) | - | 51 |
| 478 | S6W12 | Level 8 (76 cm) | - | 58 |
| 549 | N6W22 | Level 4 (30-40 cm) | - | 63 |
| 556 | N6W22 | Level 6 (50-60 cm) | - | 69 |
| 740 | BHT 47 | Backdirt | - | 43 |
| 743 | S33W118 | Level 10 (93-103 cm) | - | 136 |
| 748 | S33W118 | Level 11 (112 cm) | - | 141 |
| 752 | S33W118 | Level 12 (116 cm) | - | 145 |
| 753 | S33W118 | Level 12 (117 cm) | - | 146 |
| 822 | S12W60 | Level 9 (81 cm) | - | 153 |
| 832 | S12W60 | Level 11 (105 cm) | - | 163 |
| 880 | S12W82 | Level 10 (100 cm) | - | 211 |
| 886 | ST #5 | Level 4 (100 cm) | - | 217 |
| 944 | S31W116 | Level 11 (106 cm) | - | 245 |
| 961 | S31W118 | Level 13 (120-130 cm) | - | - |
| 1005 | S16W88 | Level 9 (86 cm) | - | 273 |
| 1039 | S16W88 | Level 10 (100 cm) | - | 292 |
| 1046 | S16W88 | Level 8 (70-80 cm) | - | - |
| 1115 | S14W86 | Level 10 (97 cm) | - | 341 |
| 1122 | S14W86 | Level 11 (113 cm) | - | 349 |
| 1145 | S31W118 | Level 12 (120 cm) | - | 389 |
| 1158 | S12W88 | Level 12 (110-120 cm) | - | 412 |
| 1249 | S20W90 | Level 9 (89 cm) | - | 536 |
| 1292 | S33W116 | Level 10 (100 cm) | - | 585 |
| 1298 | S16W84 | Level 10 (95 cm) | - | 591 |
| 1378 | S6W84 | Level 23 (230 cm) | - | 664 |
| 1385 | S32W117 | Level 2 (10-20 cm) | - | 671 |
| 1580 | S12W90 | Level 16 (154 cm) | - | 749 |
| 1581 | S12W90 | Level 16 (161 cm) | - | 750 |
| 1642 | S12W90 | Level 17 (164 cm) | - | 766 |
| 1716 | S12W86 | Level 11 (107) cm | - | 828 |
| 1723 | S12W86 | Level 12 (117 cm) | - | 835 |
| 1830 | S12W74 | Level 16 (150-160 cm) | - | - |
| 1844 | S18W18 | Level 11 (109 cm) | - | 889 |
| 1853 | S29W118 | Level 15 (148 cm) | - | 897 |
| 1867 | S18W18 | Level 12 (120 cm) | - | 911 |
| 1891 | S29W118 | Level 18 (178 cm) | - | 934 |
| 1919 | S4W12 | Level 14 (130-140 cm) | - | - |
| 1940 | S14W84 | West Wall Fall | - | 966 |

continued.

**Table D-2.** (concluded)

| Cat No. | Unit/Burial No. | Depth | Feature | FS # |
|---|---|---|---|---|
| 1943 | S14W86 | Level 8 (78 cm) | - | 969 |
| 1995 | S12W88 | North Wall Fall | - | 996 |
| 2022 | S9.61W87.60 | Level 13 (132 cm) | - | 1008 |
| 2031 | S10W90 | Level 15 (146 cm) | - | 1017 |
| 2237 | S12W86 | Level 17 (170 cm) | - | 1229 |
| 3015 | S29W116 | Level 14 (135 cm) | - | 1301 |
| 3326 | S14W86 | Level 2 (10-20 cm) | - | - |
| 3350 | S14W86 | Level 10 (90-100 cm) | - | - |
| 3351 | S14W86 | Level 10 (90-100 cm) | - | - |
| 3769 | S12W90 | Level 12 (110-120 cm) | - | - |
| 3981 | S6W84 | Level 16 (150-160 cm) | - | - |
| 4178 | S16W86 | Level 7 (60-70 cm) | - | - |
| 4374A | S10W90 | Level 12 (110-120 cm) | - | - |
| 4375 | S10W90 | Level 13 (120-130 cm) | - | - |
| 1038 | Burial 1B | Level 14 (132 cm) | - | 291 |
| 1151 | Burial 1B | Level 14 (136 cm) | 6 | 402 |
| 1152 | Burial 58 | Level 14 (139 cm) | - | 403 |
| 1671 | Burial 21 | Level 18 (183 cm) | - | 771 |
| 1685 | Burial 6 | Level 18 (181 cm) | 18 | 796 |
| 2035 | Burial 6 | Level 16 (159 cm) | 18 | 1021 |
| 2036 | Burial 6 | Level 16 (160 cm) | 18 | 1022 |
| 2037 | Burial 6 | Level 16 (159 cm) | 18 | 1023 |
| 2038 | Burial 6 | Level 16 (161 cm) | 18 | 1024 |
| 2039 | Burial 6 | Level 17 (169 cm) | 18 | 1025 |
| 2042 | Burial 6 | Level 17 (161 cm) | 18 | 1028 |
| 2045 | Burial 23 | Level 13 (120-130 cm) | - | 1031 |
| 2046 | Burial 23 | Level 13 (120-130 cm) | - | 1032 |
| 2047 | Burial 23 | Level 13 (120-130 cm) | - | 1033 |
| 2048 | Burial 23 | Level 13 (120-130 cm) | - | 1034 |
| 2049 | Burial 23 | Level 13 (120-130 cm) | - | 1035 |
| 2050 | Burial 23 | Level 13 (120-130 cm) | - | 1036 |
| 2219 | Burial 58 | Level 15 (150 cm) | - | 1189 |
| 2227 | Burial 26 | Level 15 (148 cm) | - | 1208 |
| 2298A | Burial 52 | Level 14 (130 cm) | - | 1283 |
| 3049 | Burial 74 | Level 12 (115 cm) | - | 1335 |

Simple detachment-based tools sub-classified as modified flakes should also be typed according to their function (ex. burin, drill, graver, etc.). Simple detachment-based tools sub-classified as unmodified flakes should only be typed as expedient. Simple detachment-based tools sub-classified as unmodified blades should be typed according to their morphology. Common unmodified blade types include dihedral and polyhedral varieties. Simple detachment-based tools sub-classified as modified blades should be typed according to modification form (ex. backed, stemmed, etc.).

***Artifact ID: 0474***

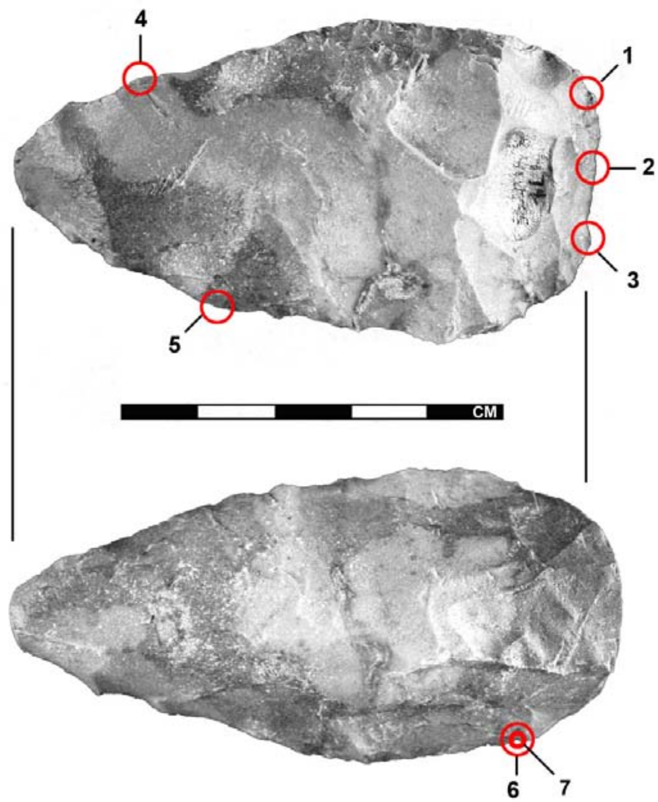



**Figure D-1.** Dalton adze (Catalog/ID# 474) from Unit S5W4, Level 11.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Adze.

***Characteristics***

**Length:** 75 mm; **Width:** 39 mm; **Thickness:** 20 mm; **Weight:** 57.0 g; **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** very coarse chert; **Alteration:** black patina (50 percent coverage).

***Use-Wear Pattern***

**Edge Attrition:** distal-bifacial; **Polish:** shallow distal; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-hard.

***Comments:***

Specimen matches description of Dalton adze given by Morse (1997:23).

Distal polish is very shallow and lightly developed. The distal edge shows a very light feather attrition pattern. The working edge is only slightly dull (mostly sharp), but displays some rounding under higher magnification.

Polish observed along the lower lateral margins is a medium gloss and is not clearly associated with attrition. This polish is very likely the result of hafting.

The extraordinary shallowness of the polish observed along the distal margin suggests a lack of penetration into contact material. Based on the pattern of wear

continued.

***Artifact ID: 0474***
(continued)

recorded, the contact material is most likely of medium-hard hardness. The lack of observable attrition may be due to light use, but the development of a hafting polish suggests otherwise. The durability of the tool's working edge in this instance may possibly be due to the hardness of the raw material from which the tool was crafted.

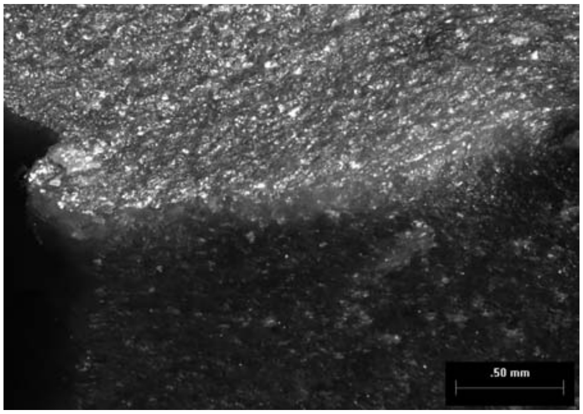



**Figure D-1.01.** Shallow polish and slight rounding at distal margin. Shallowness of polish suggests that contact material was medium-hard.

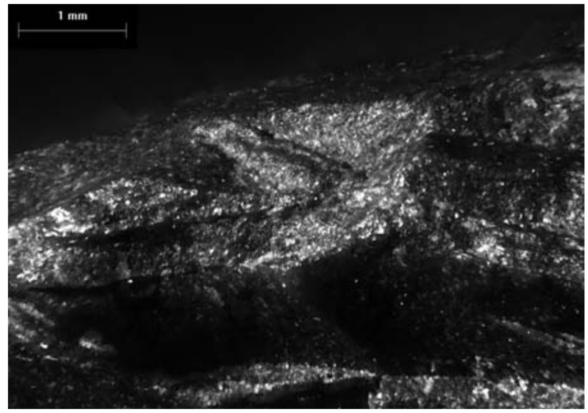



**Figure D-1.02.** Shallow polish, slight rounding, and micro-step fractures at center of distal margin. Shallowness of polish suggests that contact material was medium-hard.

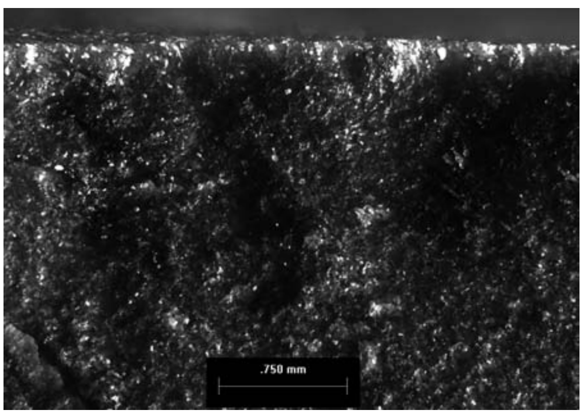



**Figure D-1.03.** Shallow polish and modest abrasion noted at distal margin.

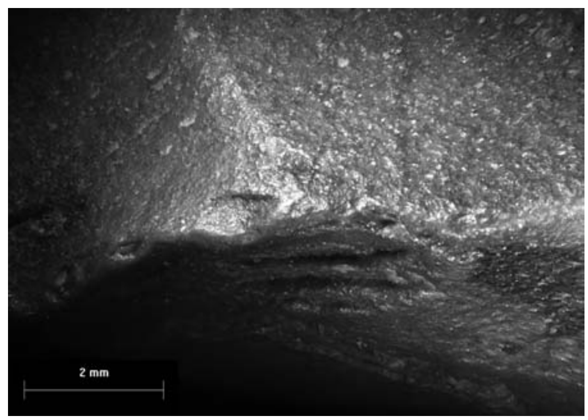



**Figure D-1.04.** Slight polish on proximal lateral margin suggests hafting.

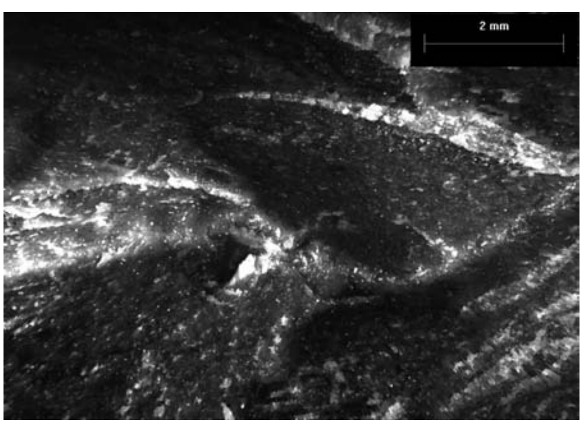



**Figure D-1.05.** Edge rounding on proximal lateral margin suggests hafting.

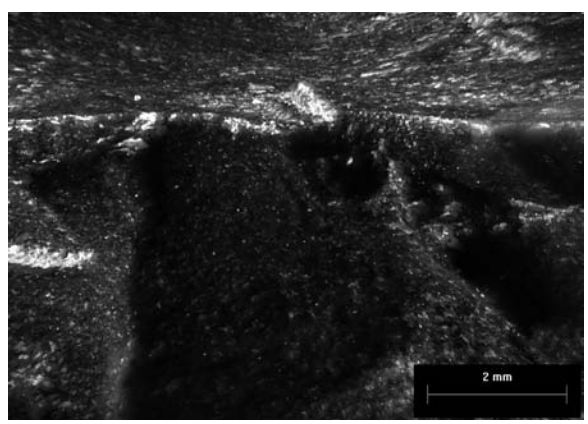



**Figure D-1.06.** Shallow polish observed at distal corner.

continued.

***Artifact ID: 0474***
(concluded)

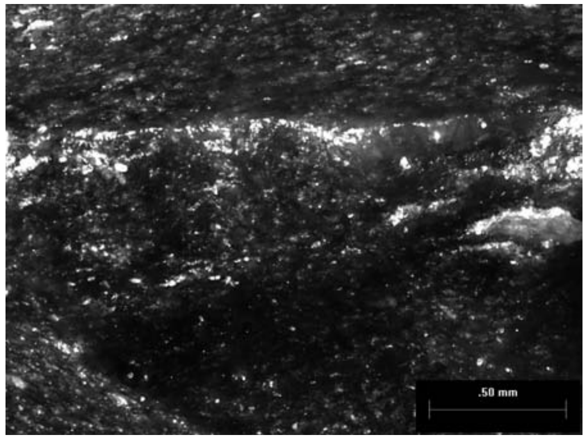



**Figure D-1.07.** Close-up view of shallow polish observed at distal corner.

## *Artifact ID: 0478*

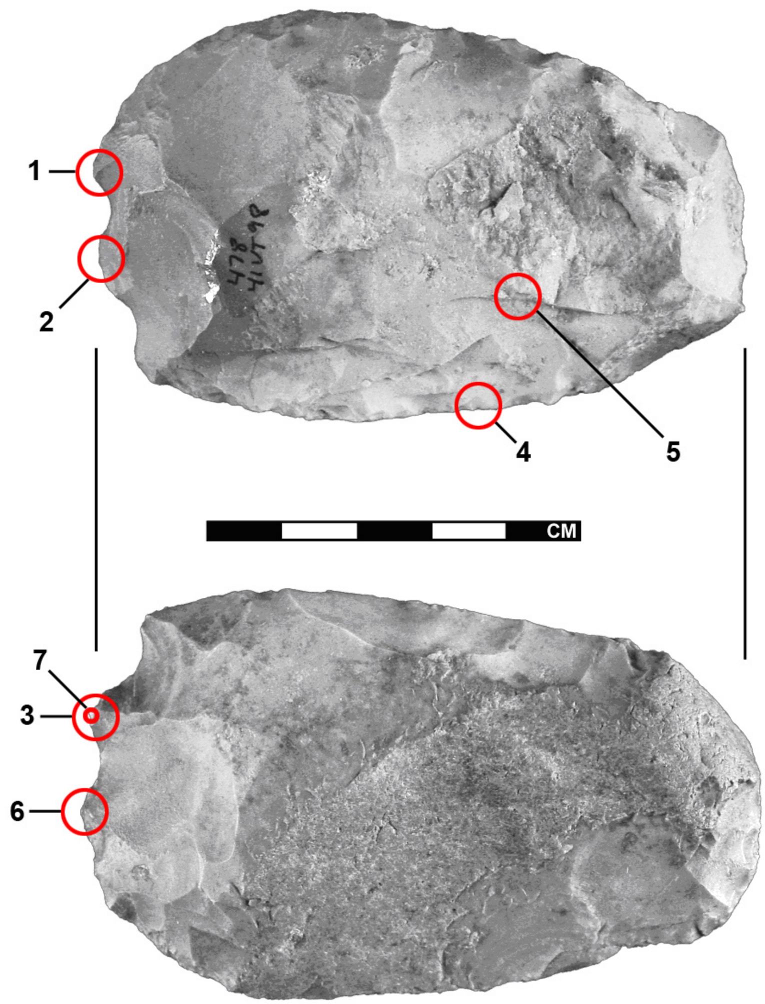



**Figure D-2.** Chopper (Catalog/ID# 478) from Unit S6W12, Level 8.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Informal; **Artifact Type:** Chopper.

### *Characteristics*

**Length:** 90 mm; **Width:** 56 mm; **Thickness:** 28 mm; **Weight:** 141.3 g; **Edge Angle:** 70-75°; **Portion:** complete; **Raw Material Type:** coarse chert; **Alteration:** oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** distal-bifacial; **Polish:** deep distal; **Battering:** none observed; **Etching:** none observed; Hafting Polish Observed: yes; Contact Material Hardness: medium-soft.

### *Comments*

Artifact is a biface constructed from a river cobble. This assessment is based on cortex char

continued.

***Artifact ID: 0478***
(continued)

acteristics. The cortex is hard, smooth, and worn to a polish.

The artifact appears to have been recycled. The distal margin exhibits flake removals apparently intended to resharpen the working bit. Flake detachments have removed polish in most areas, but some polish remains on remnant ridges, facets and faces.

Polish depth suggests a medium-soft contact material. The distal-bifacial attrition pattern and hafting polish are consistent with expectations for an implement that performed a chopping function.

The step and hinge fractures observed along the distal margin may have impeded resharpening efforts.

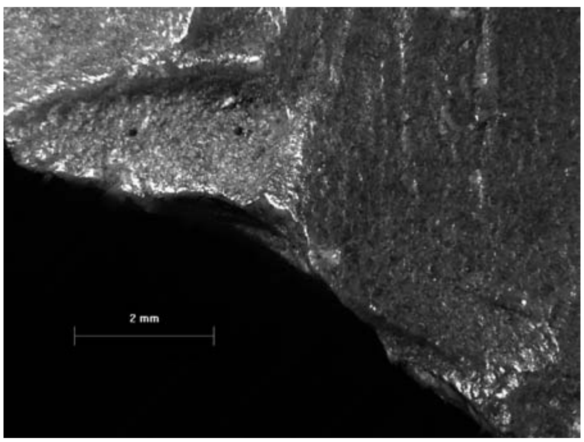



**Figure D-2.01.** Somewhat shallow polish observed at distal margin. Polish has rounded facets and step fractures.

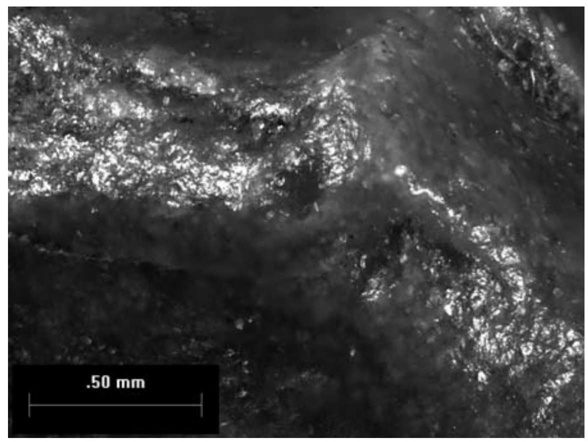



**Figure D-2.02.** View of distal edge showing rounding and polish.

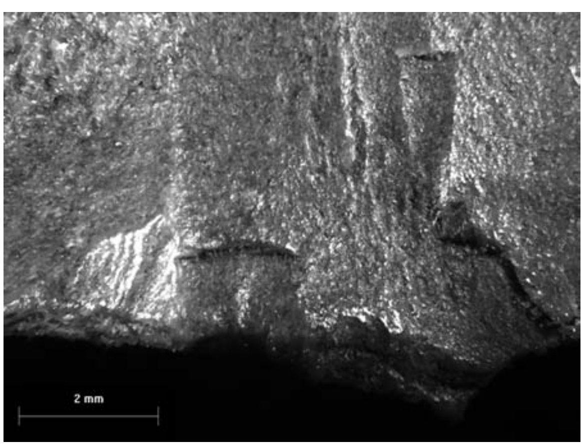



**Figure D-2.03.** Shallow polish and slight rounding at distal margin. Shallowness of polish suggests that contact material was medium-hard and siliceous.

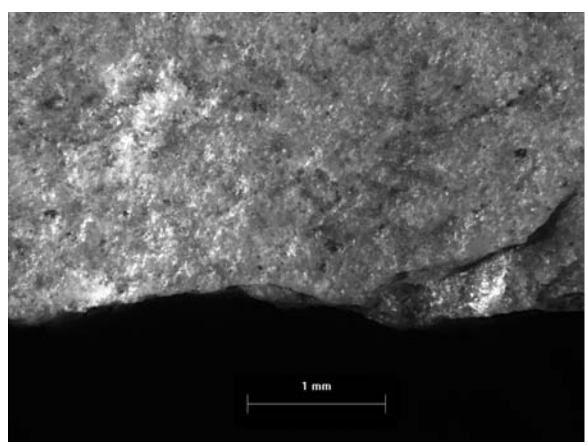



**Figure D-2.04.** Possible slight polish observed along lateral margin. Polish in this area would provide evidence of hafting.

continued.

***Artifact ID: 0478***
(concluded)

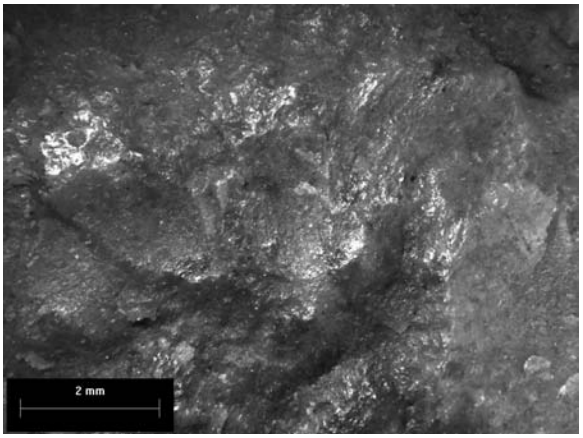



**Figure D-2.05.** Polished interior facets observed within proximal half of tool form. Similar polish was not observed on interior facets within the distal halt of the object. Polish in this area suggests either hafting or prehensile wear.

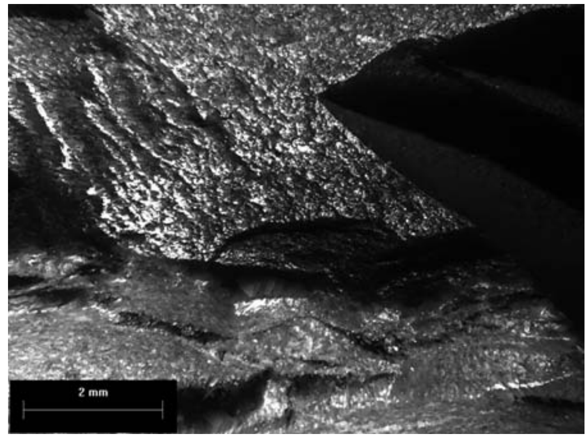



**Figure D-2.06.** View of distal bit showing shallow polish. Facets appear to have been caused by production of the bifacial bit rather than through use, suggesting a medium to medium-hard contact material.

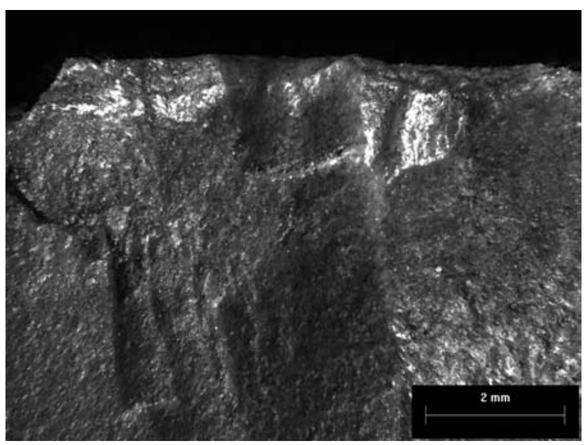



**Figure D-2.07.** View of distal margin showing shallow polish.

***Artifact ID: 0549***

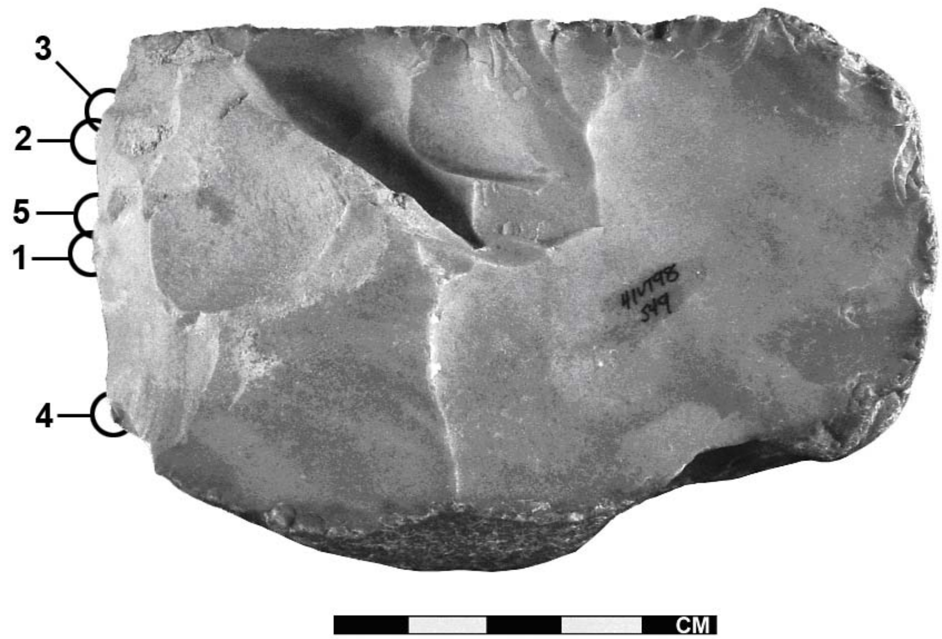



**Figure D-3.** Preform (Catalog/ID# 549) from Unit N6W22, Level 4.

***Classification***

**Artifact Class:** Modified cobble; **Artifact Subclass:** Informal; **Artifact Type:** Preform (scraper/shaver – low probability).

***Characteristics***

**Length:** 108 mm; **Width:** 69 mm; **Thickness:** 39 mm; **Weight:** 393.2 g; **Edge Angle:** 70-75°; **Portion:** complete; **Raw Material Type:** coarse chert; **Alteration:** none observed,

***Use-Wear Pattern***

**Edge Attrition:** distal (unifacial)–likely resulting from edge preparation; **Polish:** very shallow distal–may not have derived from use; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed**: no; **Contact Material Hardness**: not applicable (artifact was unused).

***Comments***

Original raw-material package appears to have been a river cobble based on smooth, hard, polished cortex.

An indeterminate faint gloss is present on several facets (ridges) dispersed sporadically across distal margin. This gloss is very shallow and barely developed, and it cannot be classified as a polish with any certainty. The faint gloss noted may have resulted from prehensile manipulation during the manufacturing process, but even this is speculative. The artifact appears to have received light attrition along its margins, and this is almost certainly due to edge preparation during manufacturing. Supporting the assertion that the tool was unused, there is no recorded rounding at the margins and the edges remain sharp.

There remains a slight probability that the artifact was, in fact, used for a very short duration. The

continued.

***Artifact ID: 0549***
(continued)

longevity of any use was not sufficient to produce unequivocal evidence of such activity. If such was the case, the fact that the edge attrition noted and gloss/polish observed were only recorded on the dorsal face suggests that the artifact would have functioned as a scraper or shaver rather than a chopping tool.

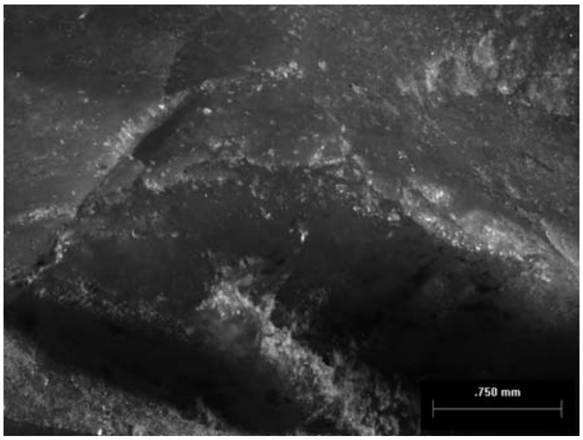



**Figure D-3.01.** View of distal bit showing crushing along the margin.

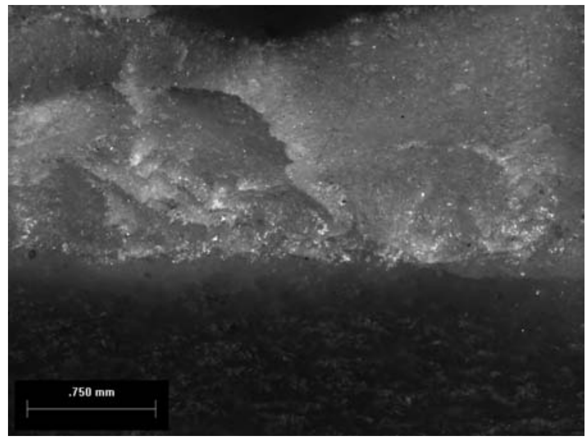



**Figure D-3.02.** View of distal bit. No polish is observed.

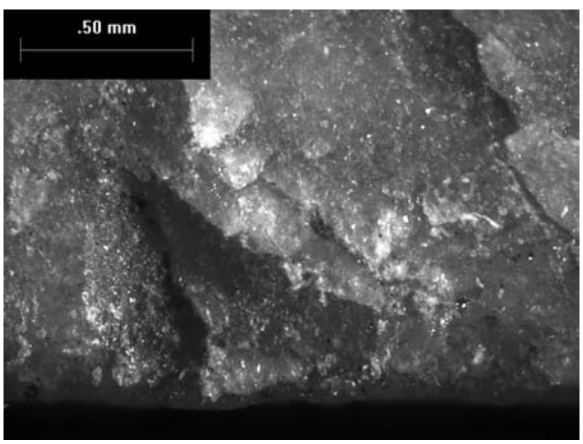



**Figure D-3.03.** View of distal bit. Edge shows slight abrasion. Lack of polish suggests that abrasion was caused by manufacturing activities rather than use.

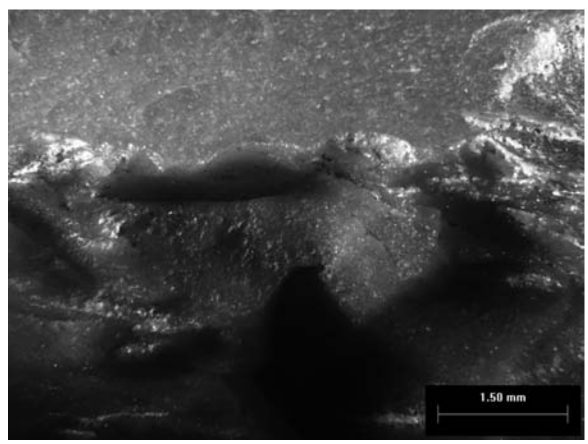



**Figure D-3.04.** View at edge of distal margin. No evidence of use is observed.

continued.

***Artifact ID: 0549***
(concluded)

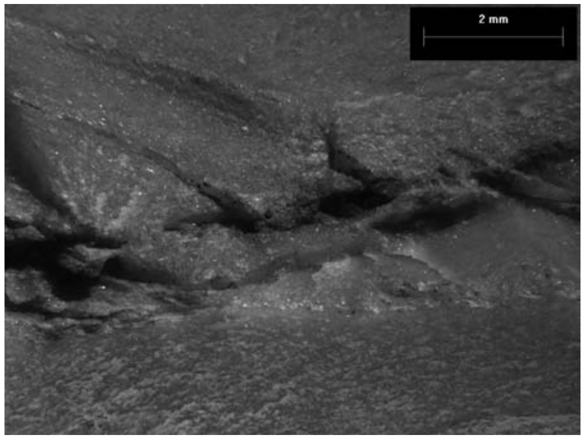



**Figure D-3.05.** View at middle of distal margin. Multiple step fractures appear to be the result of manufacture. No polish is observed. All flaking observed along the distal margin is consistent with manufacturing-derived features.

### Artifact ID: 0556

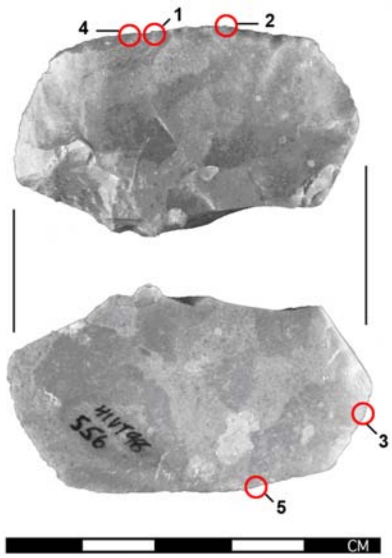



**Figure D-4.** Scraper (Catalog/ID# 556) from Unit N6W22, Level 6.

*Classification*

**Artifact Class:** Flake (edge-modified); **Artifact Subclass**: Altered; **Artifact Type:** Scraper.

*Characteristics*

**Length:** 42 mm; **Width:** 31 mm; **Thickness:** 7 mm; **Weight:** 9.3 g; **Edge Angle:** 50-60°; **Portion:** complete; **Raw Material Type:** mottled chert; **Alteration:** minor oxide yellowing.

*Use-Wear Pattern*

**Edge Attrition:** unilateral-unifacial; **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

*Comments*

Unifacial edge attrition is observed along the distal margin of the flake. This suggests a unidirectional motion of use, characteristic of a scraper.

The tool is an altered form manufactured on a flake. The use edge has been purposefully modified to create a uniform edge. The duration of use would have been relatively short.

A soft contact material is most likely, based on polish development and scarring characteristics. Use association with a soft contact material is also likely based on the thinness of the working edge and the delicate nature of the edge attrition recorded.

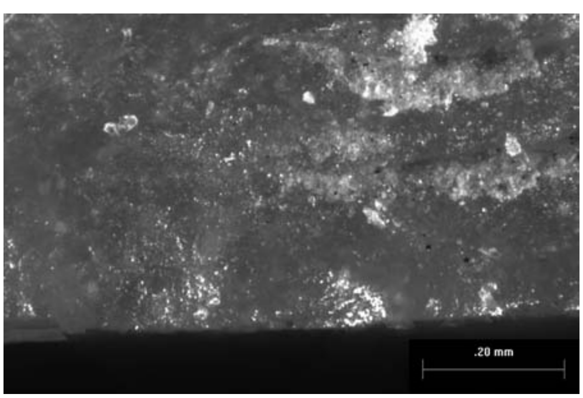



**Figure D-4.01.** Relatively deep polish observed along margin of flake.

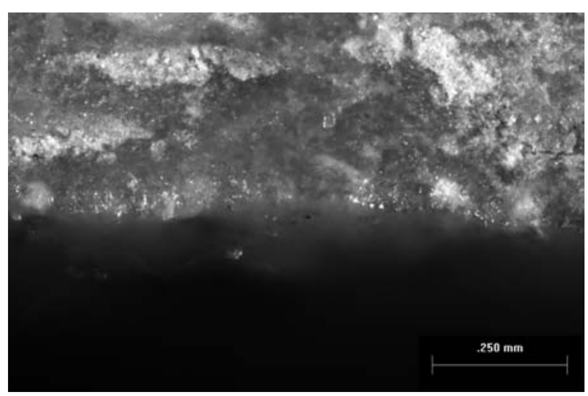



**Figure D-4.02.** Margin of flake has been rounded and dulled through use.

continued.

***Artifact ID: 0556***
(concluded)

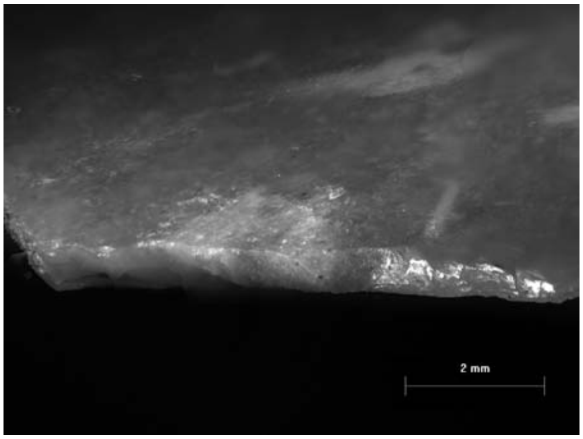



**Figure D-4.03.** Use-derived feather terminations observed along margin. Polish has covered flake facets. Given the well-developed polish, the thinness of bit edge, and the delicate nature of the edge attrition, the contact material would have been soft.

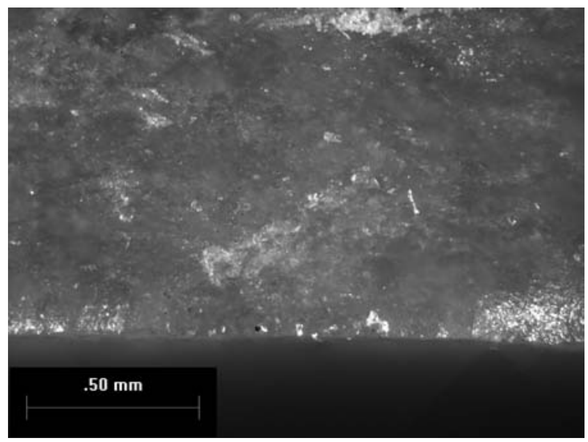



**Figure D-4.04.** Polish and edge rounding observed along flake margin.

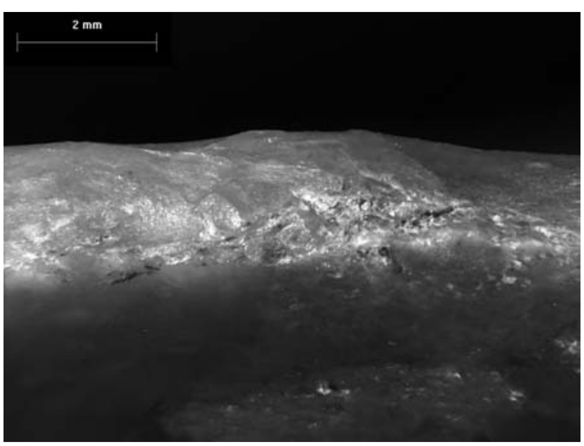



**Figure D-4.05.** Polish and delicate attrition observed along flake margin.

***Artifact ID: 0740***

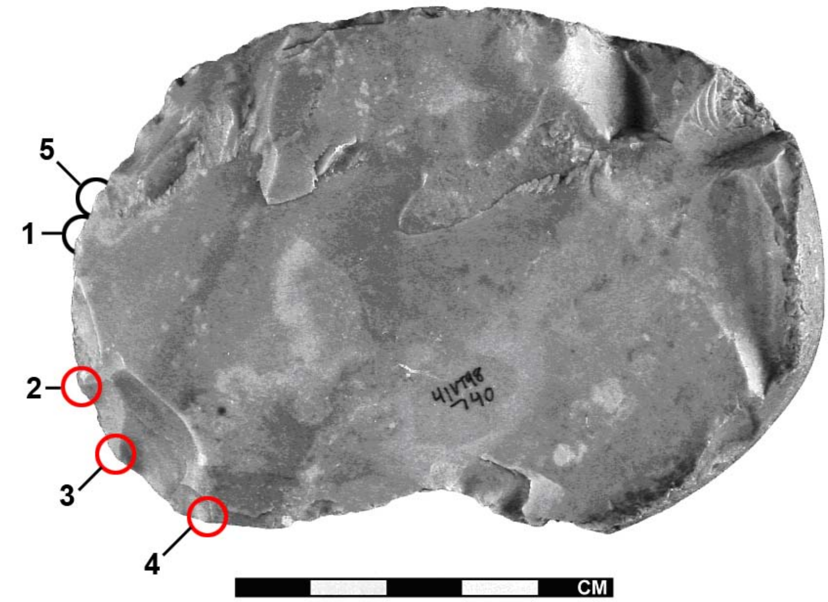



**Figure D-5.** Unifacial Chopper (Catalog/ID# 740) from the Backdirt of BHT 47.

***Classification***

**Artifact Class:** Non-Biface/Uniface (minor bifacial retouch to distal bit); **Artifact Subclass:** Informal; **Artifact Type:** Chopper.

***Characteristics***

**Length**: 102 mm; **Width:** 67 mm; **Thickness:** 38 mm; **Weight:** 280.3 g; **Edge Angle:** 70-75°; **Portion:** complete; **Raw Material Type:** chert (medium grade); **Alteration:** oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal (bifacial); **Polish:** deep distal; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-hard.

***Comments***

Original raw-material package was likely a river cobble, based on size and cortex characteristics (smooth, hard, and polished). The artifact is a cobble fragment roughly modified into what appears to be a chopper. Most modification is hard-hammer with a unifacial focus.

Some bifacial attrition was noted along the distal margin, though this has most likely developed from use rather than deliberate bifacial edge preparation. Although speculative, this assertion is based on the discontinuous distribution of polish along the distal margin.

The polish observed had penetrated the contact material up to 6 mm based on the development of polish along the distal margin. There is a lack of heavy edge attrition along this margin, suggesting that the tool was used in association with a medium-hard contact material such as hardwood or green bone.

Attrition observed at the distal corners and interior facets along the dorsal margin suggest that the tool was resharpened following use.

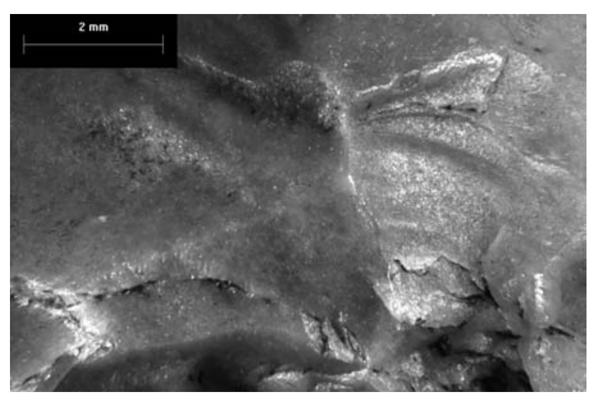



**Figure D-5.01.** Battering and slight polish observed at distal margin. Battering may be remnant of edge production.

continued.

***Artifact ID: 0740***
(concluded)

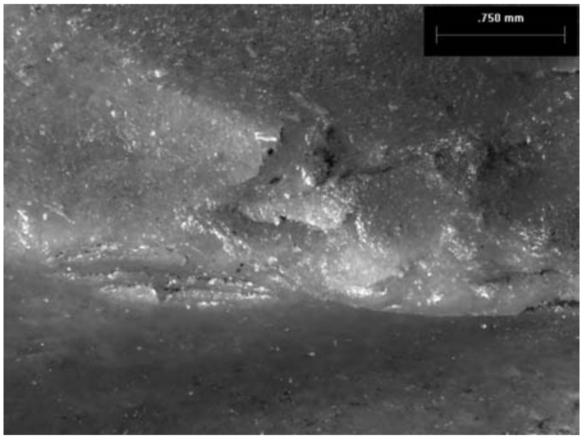



**Figure D-5.02.** Rounding and polish observed along distal margin.

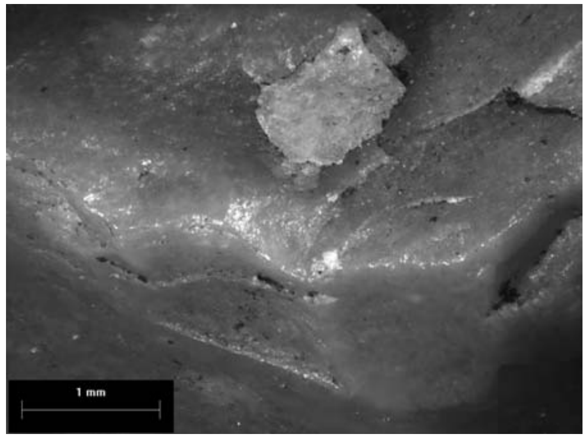



**Figure D-5.03**. Rounding and polish observed along distal margin. Slight rounding also evident on flake facets proximal to margin.

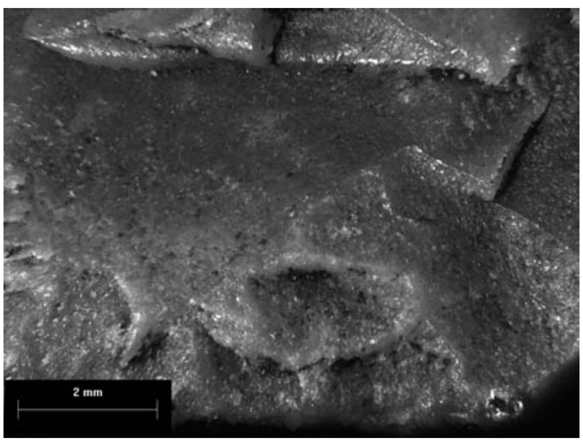



**Figure D-5.04.** Polish observed at up to 6 mm from edge at corner of distal margin. Depth of polish and lack of clear use-derived attrition suggests a contact material of medium hardness.

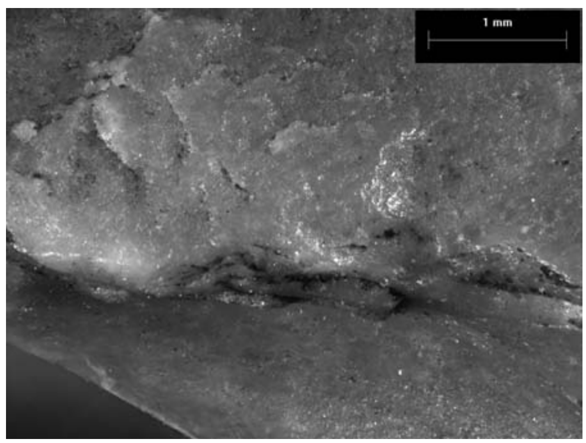



**Figure D-5.05.** Polish and rounding observed along distal margin.

***Artifact ID: 0743***

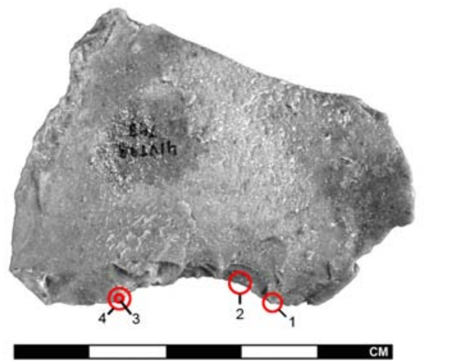



**Figure D-6.** Spokeshave (Catalog/ID# 743) from Unit S33W118, Level 10.

***Classification***

Artifact Class: Flake (edge-modified); Artifact Subclass: Unaltered; Artifact Type: Spokeshave.

***Characteristics***

**Length:** 40 mm; **Width:** 51 mm; **Thickness:** 12 mm; **Weight:** 19.9 g; **Edge Angle:** 80°; **Portion:** complete; **Raw Material Type:** quartzite; **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** none observed (poorly preserved on hard, granular quartzite); **Polish:** shallow lateral; **Battering:** lateral dulling at notch; **Etching:** none observed; **Hafting Polish Observed**: no; **Contact Material Hardness:** medium-soft/medium-hard.

***Comments***

A very slight polish and edge rounding/dulling are observed around the lateral margin of the notch. Attrition in the form of unifacial removals is also recorded along the lateral margin of the notch. No other areas of the artifact appear modified.

It should be noted that all evidence of wear is poorly developed. While the evidence examined suggests that the tool was expedient and used over a short duration, no unequivocal evidence of use attrition or polish was observed.

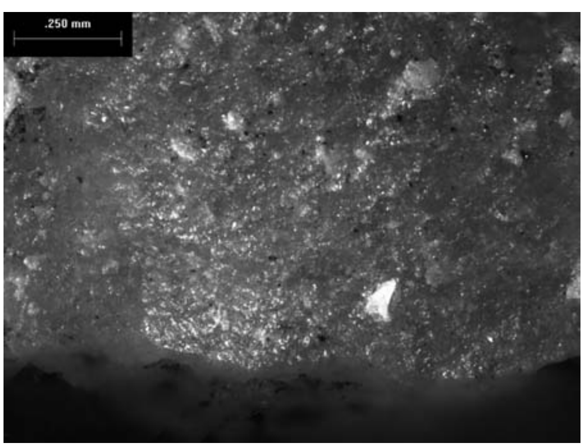



**Figure D-6.01.** Shallow polish and edge dulling observed at lateral margin of notch.

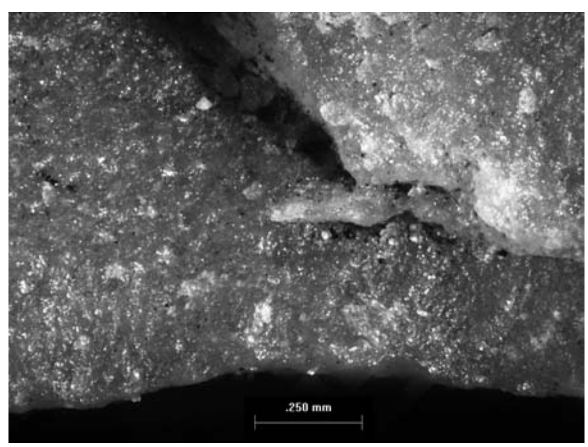



**Figure D-6.02.** Edge dulling observed at notch.

continued.

***Artifact ID: 0743***
(concluded)

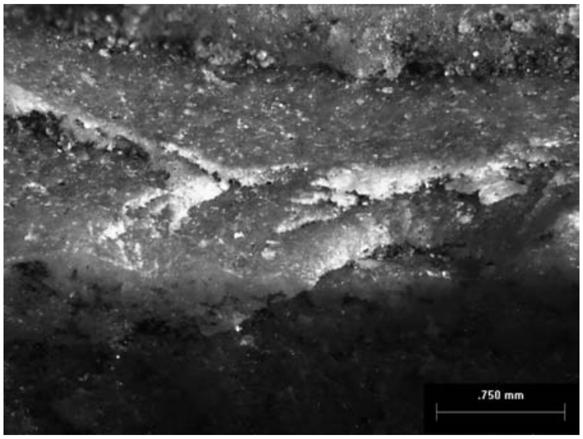



**Figure D-6.03.** Edge dulling and faint polish observed at corner of notch.

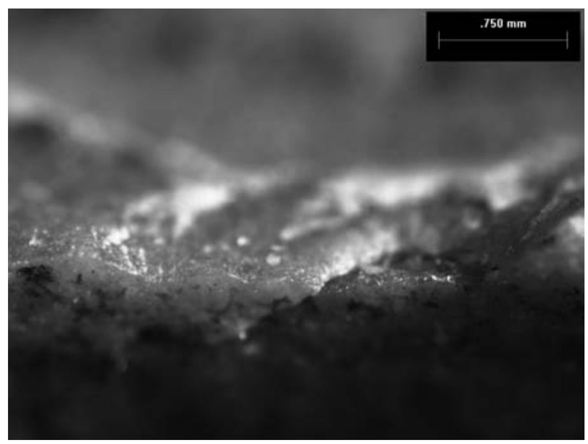



**Figure D-6.04.** Edge dulling and faint polish observed at corner of notch.

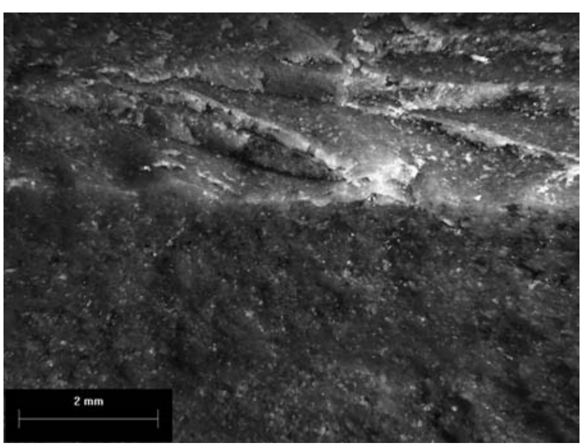



**Figure D-6.05.** Unifacial terminations recorded along lateral margin. No definitive evidence of use attrition or polish observed.

***Artifact ID: 0748***

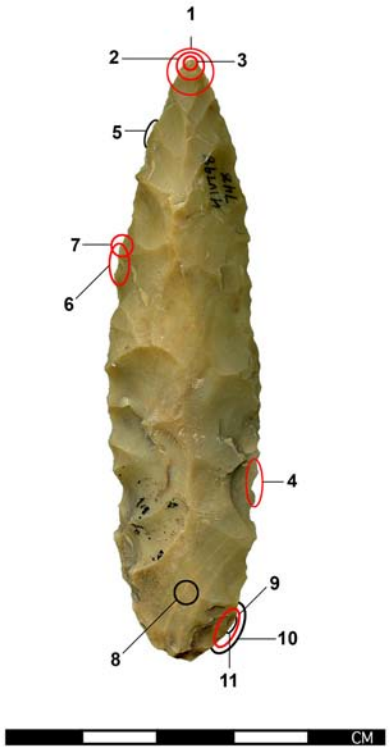



**Figure D-7.** Projectile Point (Catalog/ID# 748) from Unit S33W118, Level 11.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

***Characteristics***

**Length:** 79 mm; **Width:** 20 mm; **Thickness:** 10 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grade); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** primary proximal; **Battering:** none; **Etching:** proximal (possible); **Hafting Polish Observed:** yes (faint on ridges, but edges not abraded); **Contact Material Hardness:** medium-soft

***Comments***

The distal tip of the tool exhibits step fracturing and edge rounding indicative of use-wear. Lateral margins near the tip appear likewise rounded, exhibiting shallow polish. Lateral margins along medial extent of tool exhibit only faint evidence of modification in the form of very faint, poorly developed polish and modest rounding. This wear is observed at the tool edges and on interior facets near the edges. In general, the wear observed at the distal tip is significantly more developed than that recorded along the lateral margins. This indicates that the distal tip was the primary area of contact during use.

The polish and edge-rounding observed along the proximal margin is not inconsistent with the form of modification expected from contact with hafting material.

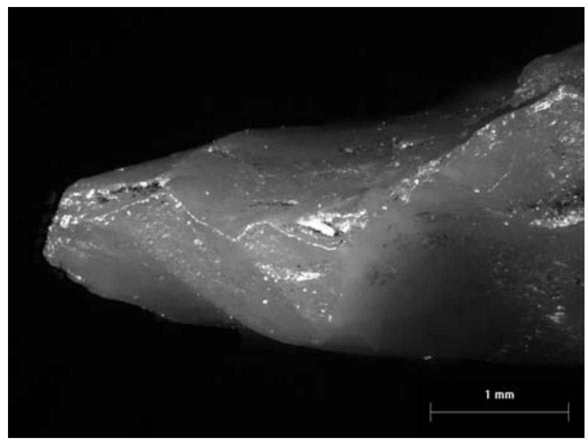



**Figure D-7.01.** Distal tip showing attrition consistent with use-derived wear.

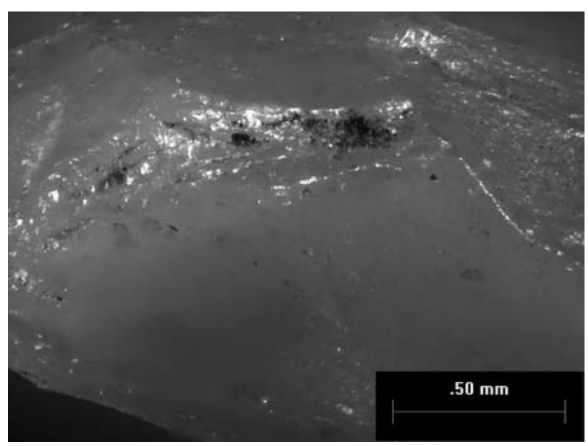



**Figure D-7.02.** Close-up of distal attrition showing edge rounding and polish. Attrition pattern and distribution of polish consistent with use on relatively soft contact material.

continued.

***Artifact ID: 0748***
(continued)

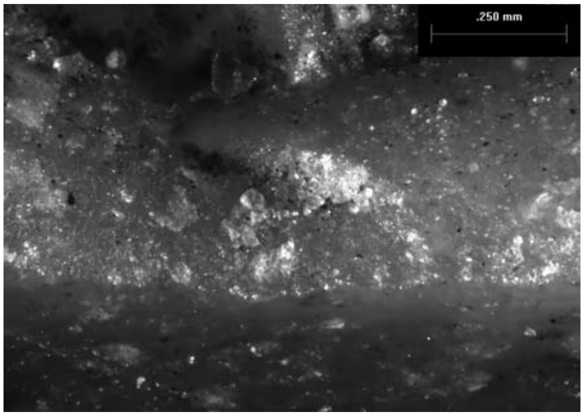



**Figure D-7.03.** Polish visible on rounded distal margin.

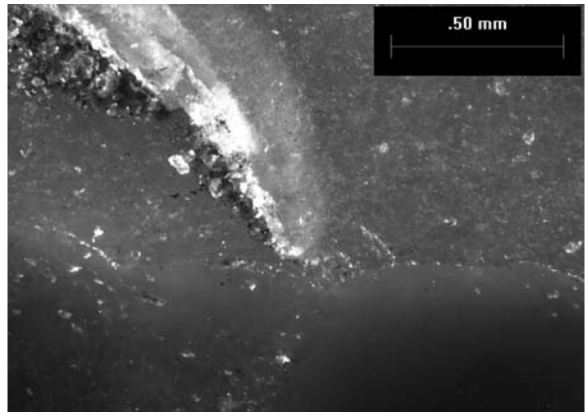



**Figure D-7.04.** Lateral margin displays faint rounding but little polish near proximal end of object. Subtle rounding may be due to hafting.

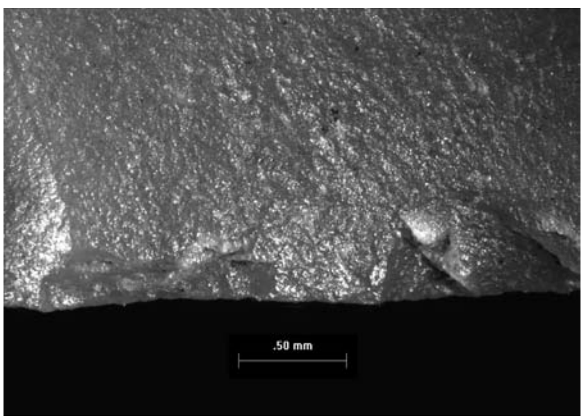



**Figure D-7.05.** Polish observed along lateral margin near distal tip.

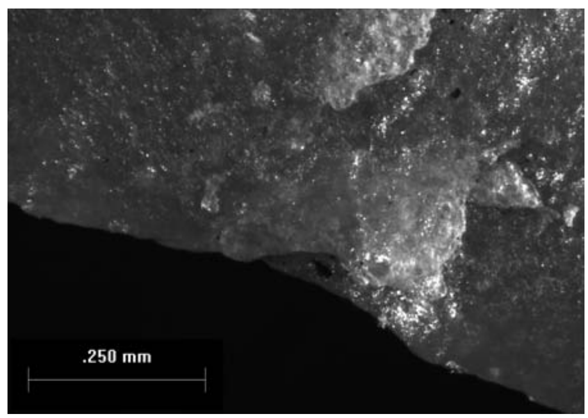



**Figure D-7.06.** Lateral edge near midsection of tool showing modest rounding at the margin and shallow polish.

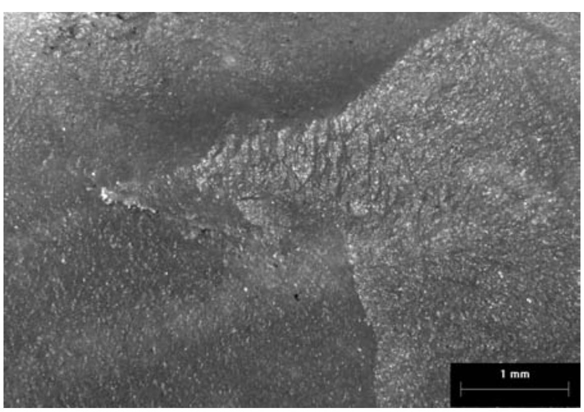



**Figure D-7.07.** Close-up of lateral edge at midsection of tool showing rounding and polish development.

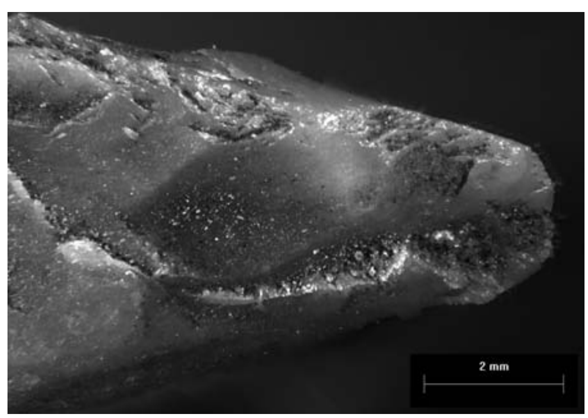



**Figure D-7.08.** Medial facet at proximal end of object does not exhibit clear signs of hafting such as polish or abrasion.

continued.

***Artifact ID: 0748***
(concluded)

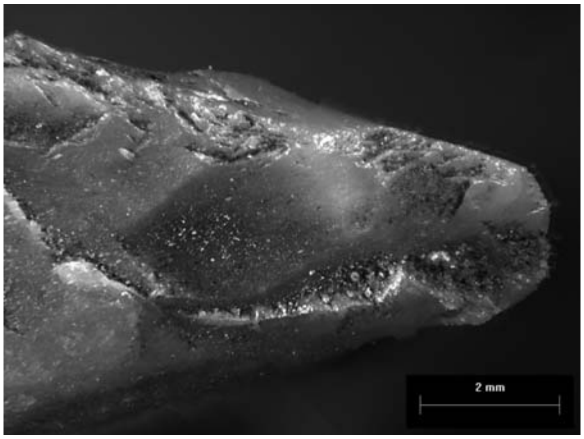



**Figure D-7.09.** Edge rounding and polish observed at proximal margin of object.

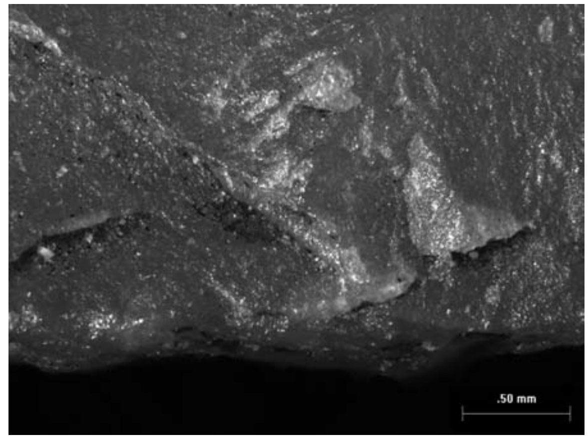



**Figure D-7.10.** Close-up of edge rounding and polish observed at proximal margin. Pattern of edge modification may be derived from hafting, but pattern is not inconsistent with use-derived wear from contact with a material of medium hardness.

*Artifact ID: 0752*

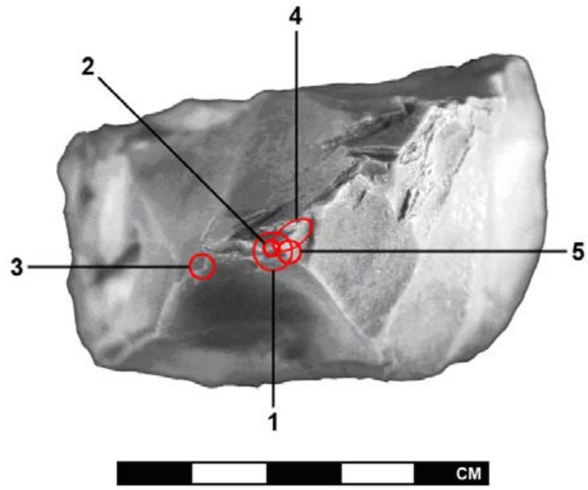



**Figure D-8.** Chopper (Catalog/ID# 752) from Unit S33W118, Level 12.

### *Classification*

**Artifact Class:** Biface (core-based tool); **Artifact Subclass:** Informal; **Artifact Type:** Chopper.

### *Characteristics*

**Length:** 108 mm; **Width:** 91 mm; **Thickness:** 54 mm; **Weight:** 636.3 g; **Edge Angle:** 80°; **Portion:** complete; **Raw Material Type:** chert (medium grade); **Alteration:** minor oxide yellowing (mainly near cortex).

### *Use-Wear Pattern*

**Edge Attrition:** distal-bifacial; **Polish:** shallow distal; **Battering:** margins worn smooth and polished; **Etching:** shallow distal; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft (hide working?)/medium-hard.

### *Comments*

Original raw-material package appears to have been a river cobble, based on cortex characteristics (smooth, hard, polished). The artifact is roughly constructed, employing only hard hammer-percussion techniques—mimics a core. Edge manufacture has only been performed on one end of the artifact while the other has been left unmodified with cortex still present.

Flake facets along the distal margin exhibit rounding and shallow, yet well-developed, polish. Broad, shallow striations can be observed in polished areas of the distal margin. The striations run perpendicular to the working edge.

The use-wear pattern observed is consistent with expectations for choppers (Turner and Hester 1985:204). This artifact may have been used on bone in the process of butchering or, alternatively, it may have been used as a hide-breaking tool in the tanning process. Either use is consistent with the observed wear pattern.

Areas of high polish are observed on the proximal cortical surface. These almost certainly derive from prehensile wear.

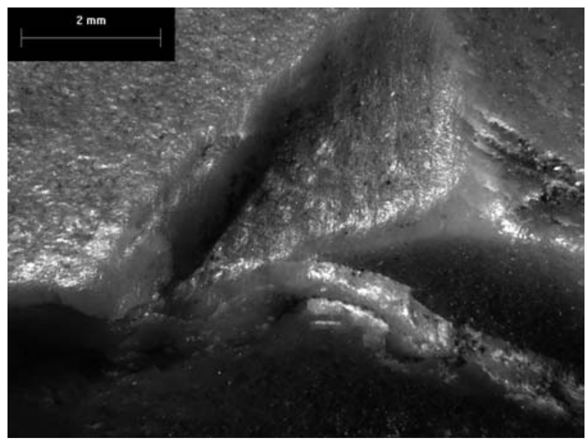



**Figure D-8.01.** Shallow, well-developed polish observed at distal tip.

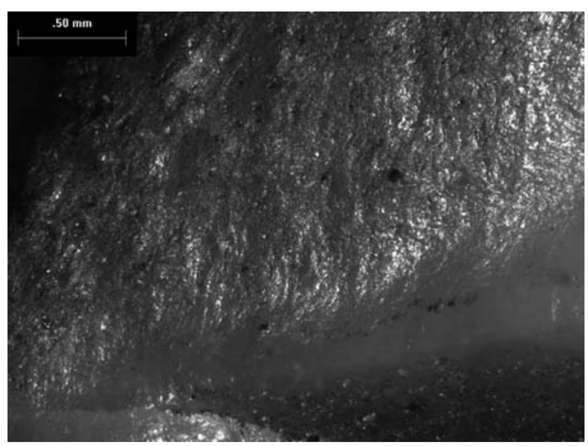



**Figure D-8.02.** Close-up of distal tip showing broad, shallow stria derived from abrasion during use. Contact material was likely siliceous and of medium-hard hardness.

continued.

***Artifact ID: 0752***
(concluded)

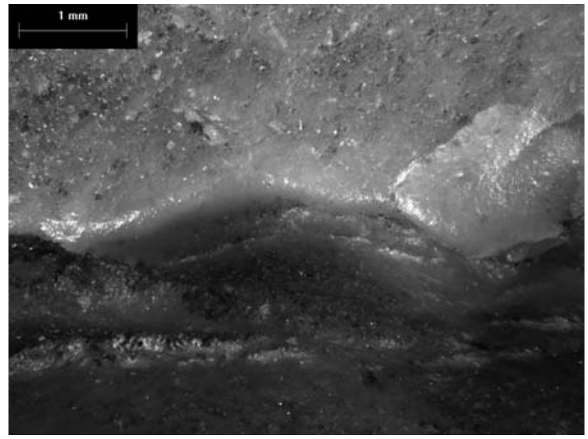



**Figure D-8.03.** Distal margin exhibits well-developed polish and rounding.

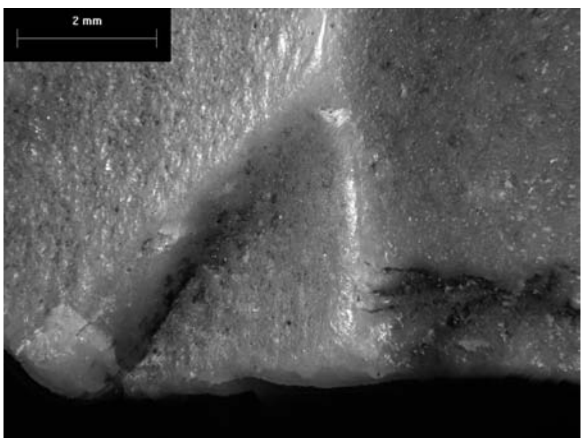



**Figure D-8.04.** Polish observed along distal margin.

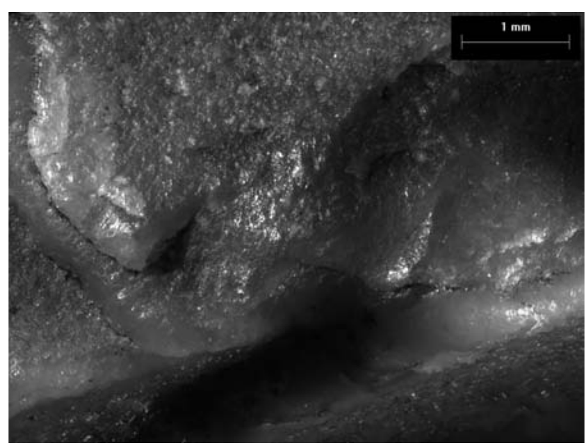



**Figure D-8.05.** Polish observed along distal margin.

***Artifact ID: 0753***

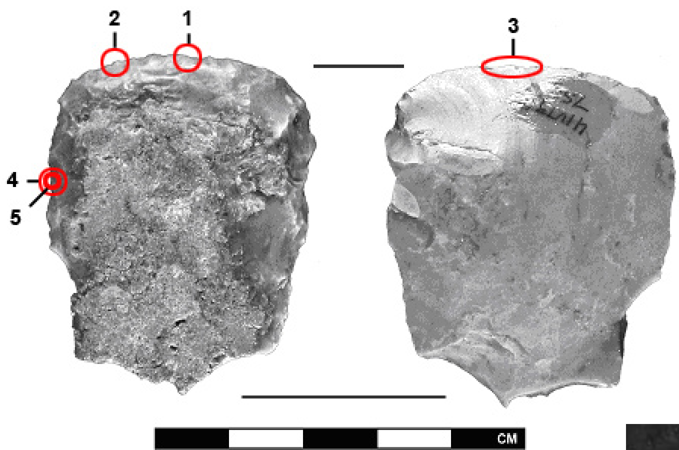



**Figure D-9.** (Left) End Scraper (Catalog/ID# 753) from Unit S33W118, Level 12.

### *Classification*

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Unaltered; **Artifact Type:** End scraper.

### *Characteristics*

**Length:** 38 mm; **Width:** 45 mm; **Thickness:** 12 mm; **Weight:** 20.9 g; **Edge Angle:** 60-65°; **Portion:** complete; **Raw Material Type:** chert; **Alteration:** oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** distal-lateral (unifacial); **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

### *Comments*

Raw material package appears to have been a river cobble, based on cortex characteristics (smooth, hard, and polished).

Attrition pattern observed matches the characteristics expected of a tool used in performing a scraping function on relatively soft contact material.

Unifacial edge attrition in the form of feather terminations, edge rounding, and polish are observable along the modified margin. Edge rounding, attrition and polish favor the ventral surface of the modified flake.

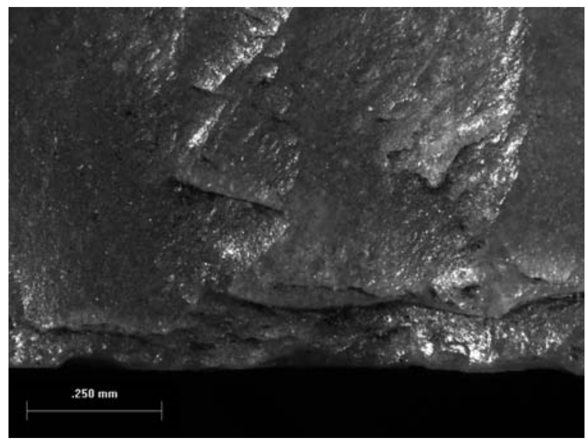



**Figure D-9.01**. Unifacial edge attrition, edge rounding, and polish observed along modified margin. Wear is consistent with a scraping function against a relatively soft to medium-soft contact material.

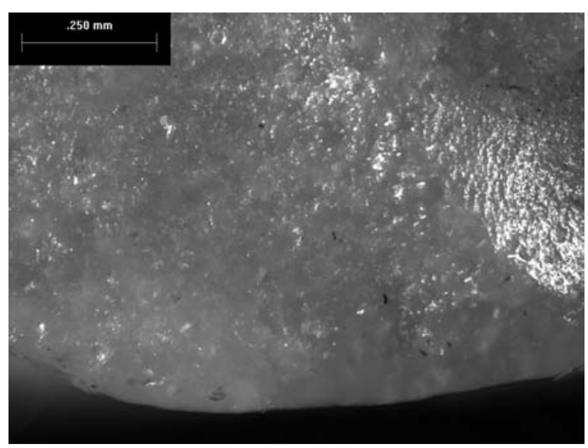



**Figure D-9.02.** Close-up of polish developed along modified edge.

continued.

***Artifact ID: 0753***
(concluded)

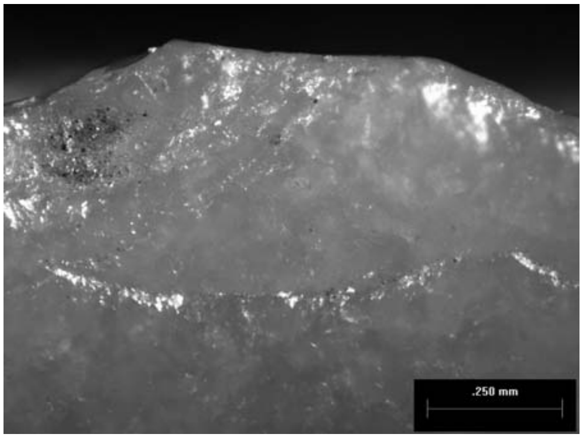



**Figure D-9.03.** Rounded and polished edge observed from ventral surface.

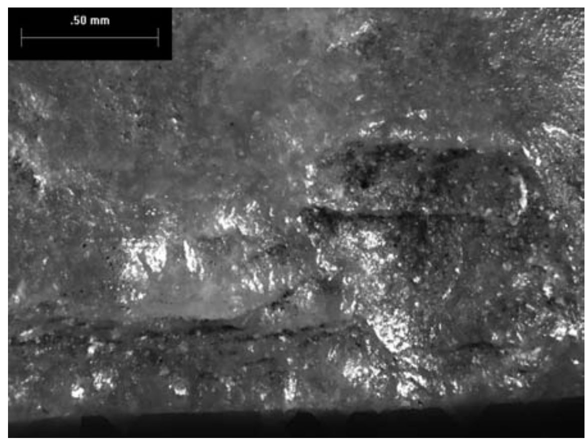



**Figure D-9.04.** Rounded and polished edge observed from ventral surface.

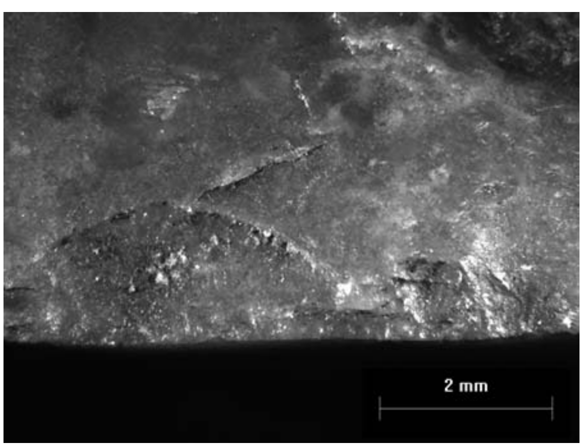



**Figure D-9.05.** Lateral margin showing polish development, but few of the step fractures observed along the distal margin.

**Artifact ID: 0822**

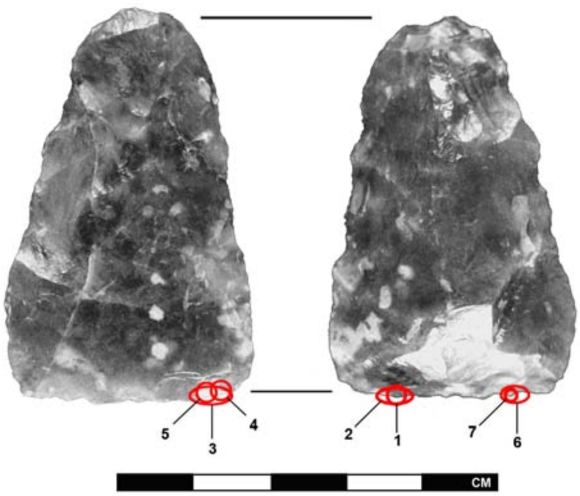



**Figure D-10.** Clear Fork Tool (Catalog/ID# 822) from Unit S12W60, Level 9.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Clear Fork Tool.

***Characteristics***

**Length:** 52 mm; **Width:** 32 mm; **Thickness:** 13 mm; **Weight:** 21.4 g; **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chalcedony; **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** shallow distal; **Battering:** none observed; **Etching:** distal; **Hafting Polish Observed**: yes; **Contact Material Hardness:** medium-soft

***Comments***

The distal bit is well polished and appears dulled with an almost flattened appearance. Striations emanate from the distal margin and can be observed on the dorsal face of the bit under higher magnification. Siliceous deposits can also be observed along the dorsal surface at the distal margin under higher magnification.

Light attrition is noted on the dorsal and ventral faces of the distal bit, but this attrition pattern is expressed more heavily on the ventral face. The lateral margins on proximal one-third exhibit light attrition (almost certainly from hafting or wrapping), but polish development is indeterminate. It should be noted that the artifact's translucency hampers ability to consistently detect polish.

As a general observation, the material is too brittle to be used for heavy gouging or adzing. The flaking pattern and polish development recorded suggest that the tool was used as a scraper (although not on hides as the corners are too sharp and would have either become rounded or damaged the skin).

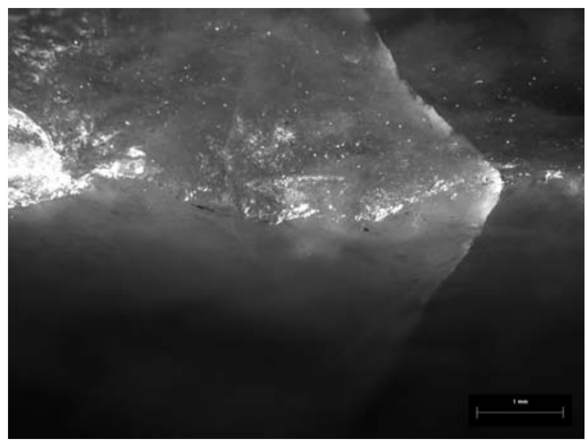


**Figure D-10.01.** Close-up, straight-on view of distal margin showing rounded bit and polish.

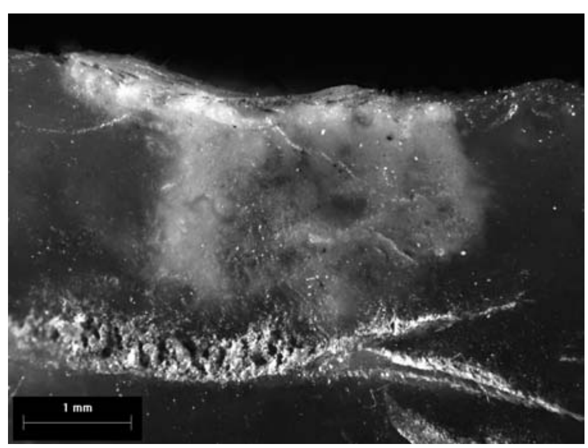



**Figure D-10.02.** Dorsal view of distal margin showing edge attrition.

continued.

**Artifact ID: 0822**
*(concluded)*


**Figure D-10.03.** Edge rounding and modest attrition observed along distal margin.

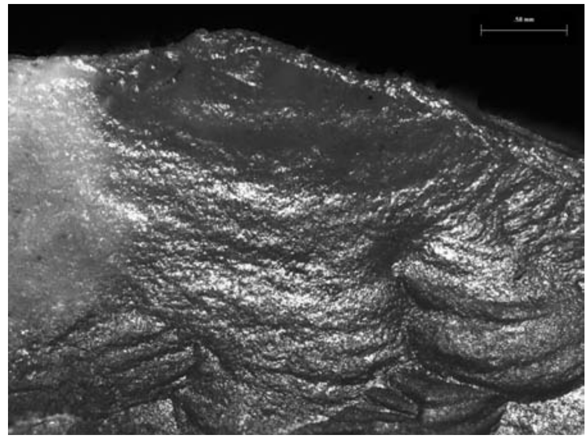


**Figure D-10.04.** Edge rounding and polish observed along bit edge along ventral face.

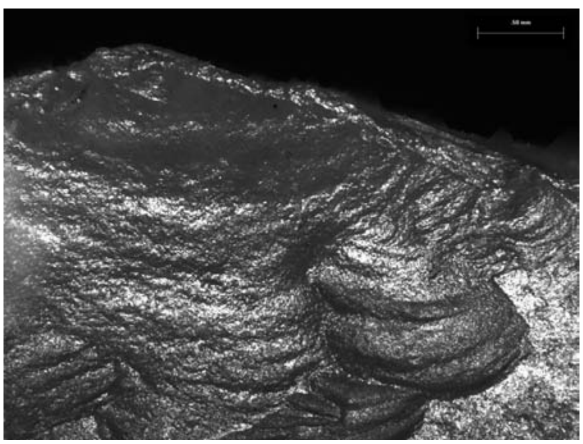


**Figure D-10.05.** Edge rounding observed along bit edge along ventral face.

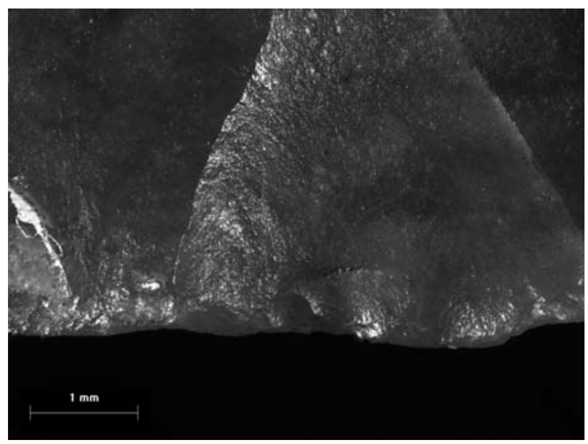



**Figure D-10.06.** Attrition along bit edge observed here on dorsal surface. More attrition is observed on ventral face.

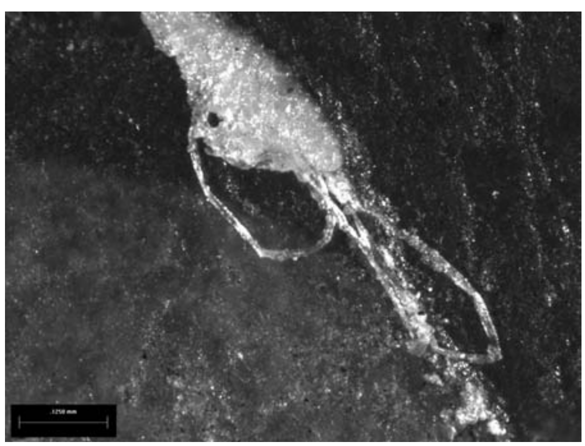


**Figure D-10.07.** Close-up siliceous deposit observed on dorsal surface.

## *Artifact ID: 0832*

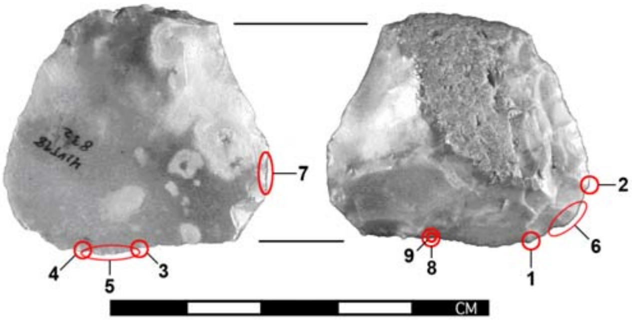



**Figure D-11.** Multifunctional Tool (Catalog/ID# 832) from Unit S12W60, Level 11.

### *Classification*

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Unaltered; **Artifact Type:** Multifunctional (primarily scraper).

### *Characteristics*

**Length:** 34 mm; **Width:** 38 mm; **Thickness:** 11 mm; **Weight:** 13.1 g; **Edge Angle:** 35-40°; **Portion:** complete; **Raw Material Type:** mottled chert; **Alteration:** minor oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** lateral (sub-bifacial); **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** none; **Contact Material Hardness:** soft.

### *Comments*

Raw material package appears to have been a river cobble or gravel, based on cortex characteristics (smooth, hard, and polished).

The tool has been constructed from a modified flake. Edge attrition and modestly developed polish are observable on all lateral margins. The attrition pattern is primarily unifacial, although a bifacial pattern is observer at one corner.

Primary use of the tool appears to have been an expedient scraper used for a relatively short duration. However, the attrition pattern suggests that the tool may also have been used for cutting. It appears likely that the tool was multifunctional in nature.

The recorded pattern of flake termination and the distribution of polish suggest that the tool was used in association with a soft contact material.

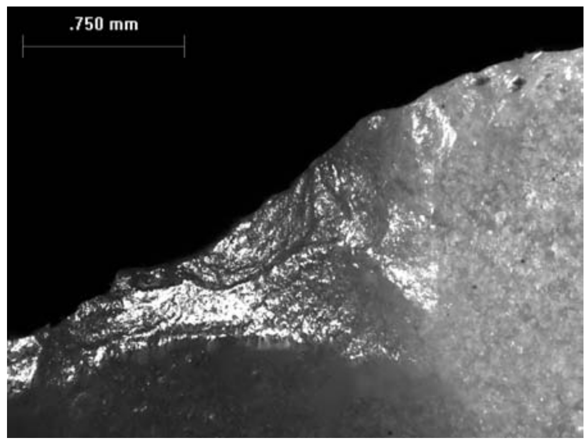



**Figure D-11.01** Polish noted along distal margin of tool. Polish is shallow where observed.

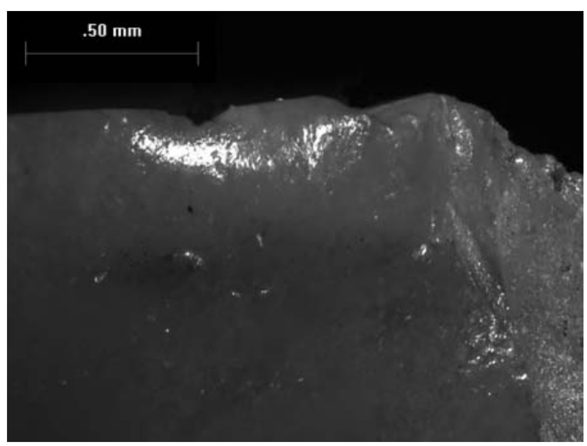



**Figure D-11.02** Polish and edge rounding observed along lateral margin of tool.

continued.

***Artifact ID: 0832***
(continued)

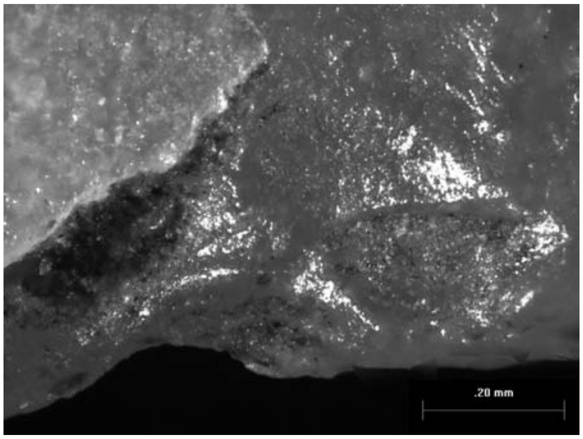



**Figure D-11.03**. Polish and attrition noted along distal margin.

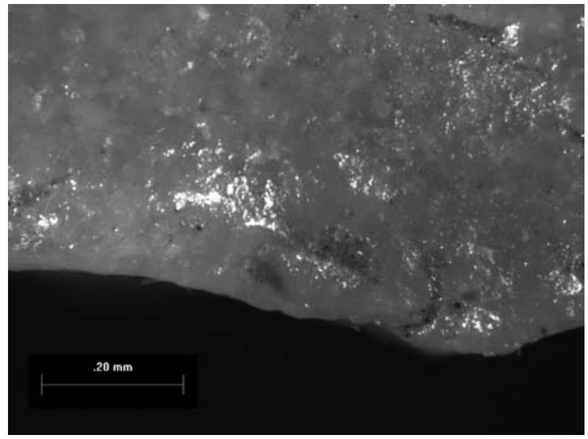



**Figure D-11.04.** Close-up of polish developed along rounded distal margin.

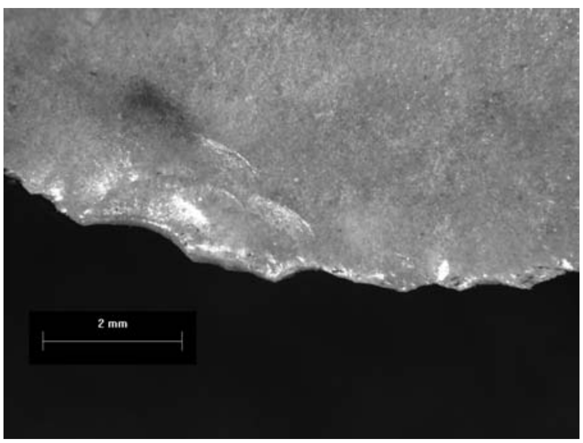



**Figure D-11.05.** Polish and attrition observed along distal margin

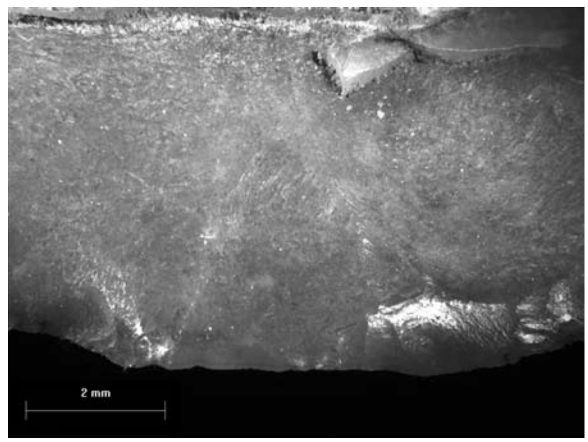



**Figure D-11.06.** Polish noted at corner of tool.

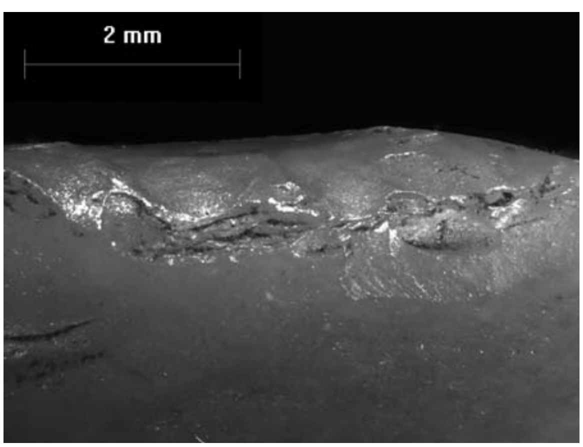



**Figure D-11.07.** Bifacial attrition noted at corner consistent with a cutting function.

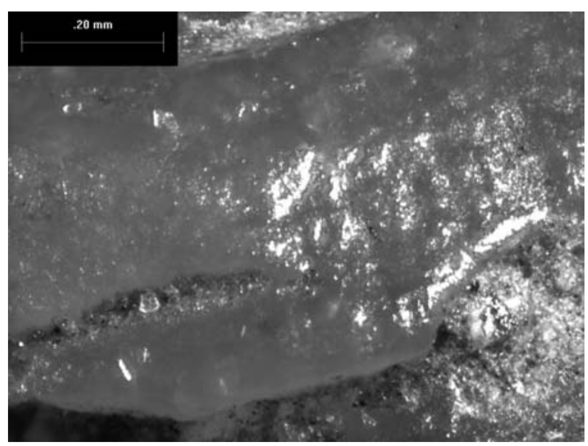



**Figure D-11.08.** Close-up of polish developed along distal margin.

continued.

***Artifact ID: 0832***
(concluded)

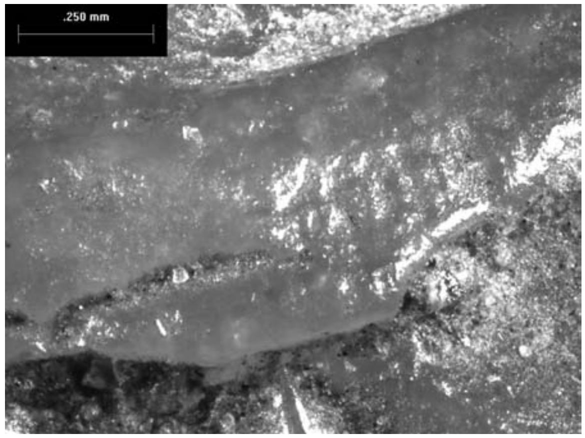



**Figure D-11.09.** Polish developed along distal margin.

*Artifact ID: 0880*

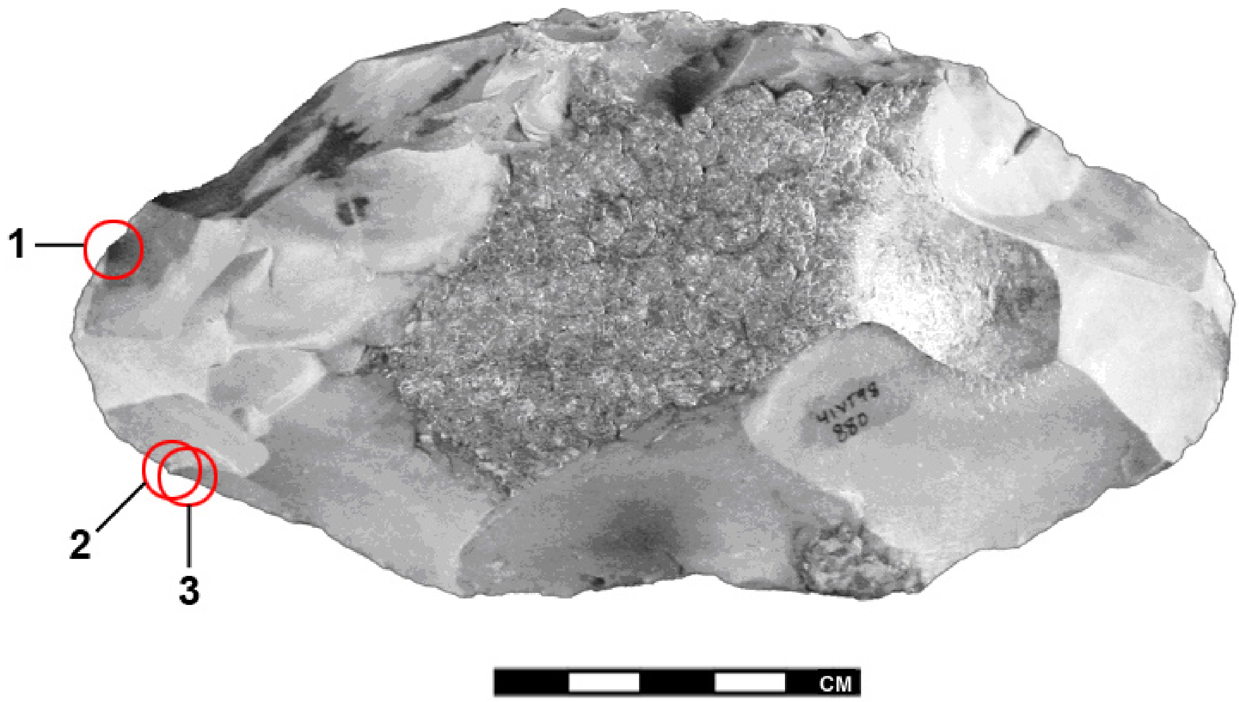



**Figure D-12.** Early Stage Preform (Catalog/ID# 880) from Unit S12W82, Level 10.

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Early-stage preform.

*Characteristics*

**Length:** 168 mm; **Width:** 85 mm; **Thickness:** 53 mm; **Weight:** 650.5 g; **Edge Angle:** 0° (bit unfinished); **Portion:** complete; **Raw Material Type:** mottled chert; **Alteration:** oxide yellowing (possibly thermal).

*Use-Wear Pattern*

**Edge Attrition:** none observed; **Polish:** none observed; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

*Comments*

Raw-material package was likely a moderately sized river cobble, based on cortex characteristics.

The artifact is an early-stage preform. Substantial effort was expended to remove medial cortical mass, terminating with multiple step and hinge fractures and critical platform loss. A formal tool was never completed due to these multiple failures.

The attrition noted along the distal margin is almost certainly the result of edge preparation rather than use. Some faint gloss and marginal dulling (rounding) are present sporadically on fracture ridges, but this modification may easily have resulted from the manufacturing process. There is no evidence to suggest that the tool was ever used.

continued.

***Artifact ID: 0880***
(concluded)

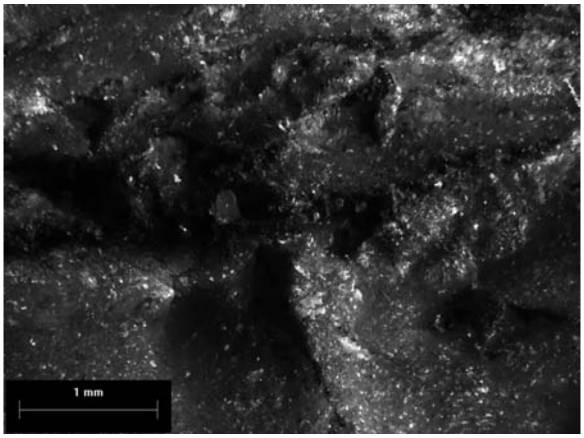



**Figure D-12.01.** Edge damaged observed at probable distal end of preform. Damage is consistent with manufacturing-caused fracturing. No use-derived modification is observed.

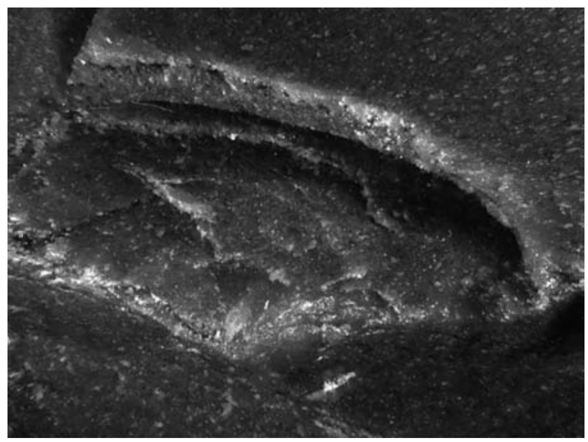


**Figure D-12.02.** Edge damage consistent with manufacturing-caused fracturing along margin.

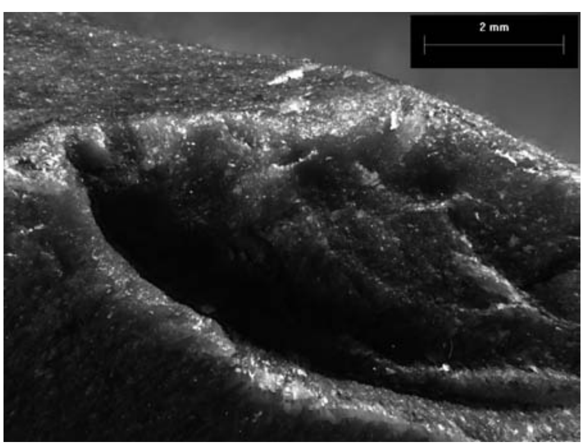



**Figure D-12.03.** Close-up view of edge fracturing. No evidence of use-derived modification is observed.

***Artifact ID: 0886***

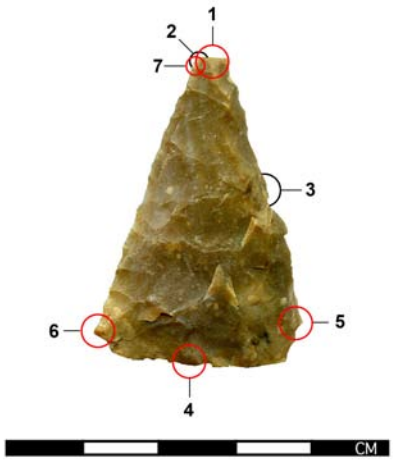



**Figure D-13.** Projectile Point (Catalog/ID# 886) from ST #5, Level 4.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

### *Characteristics*

**Length:** 41 mm; **Width:** 29 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 65°-70°; **Portion:** complete; **Raw Material Type:** chert (medium to fine grained); **Alteration:** very faint white patina.

### *Use-Wear Pattern*

**Edge Attrition:** distal; **Polish:** circumferential; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** possible (likely); **Contact Material Hardness:** medium-soft.

### *Comments*

Point is burinated at the distal tip—a wear pattern consistent with impact fracturing. Polish is present at the distal tip and along the lateral margins, but it is not well developed. Interestingly, the fracture at the distal tip has been rounded and polished, suggesting that tool remained in use following the fracture.

The lateral margins exhibit very faint edge rounding and shallow polish. Edge rounding and polish are much better developed at the tip and along the basal margin. Polish and rounding are particularly evident at corner tangs. This, together with the edge rounding and polish observed along the basal margin suggest that the artifact was hafted.

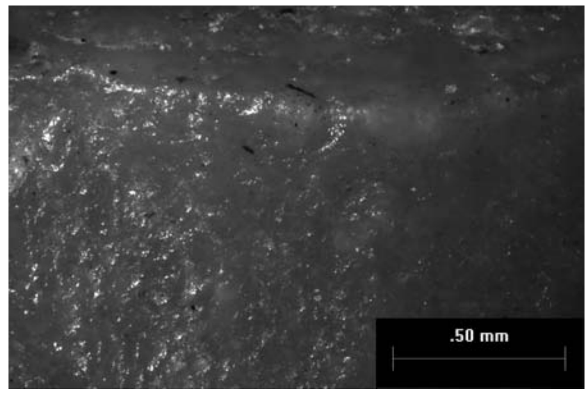



**Figure D-13.01**. Fracture at tip has been rounded and polished suggesting that tool was used following fracture.

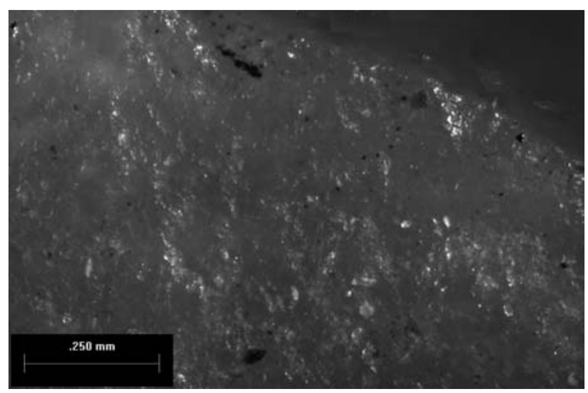



**Figure D-13.02.** Shallow polish development observed at distal margin.

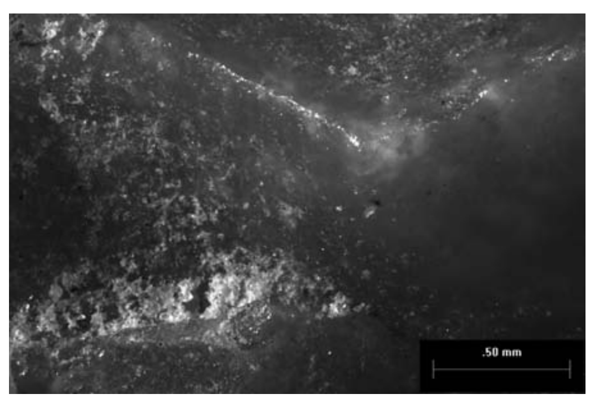



**Figure D-13.03.** Shallow polish noted along lateral margin.

continued.

***Artifact ID: 0886***
(concluded)

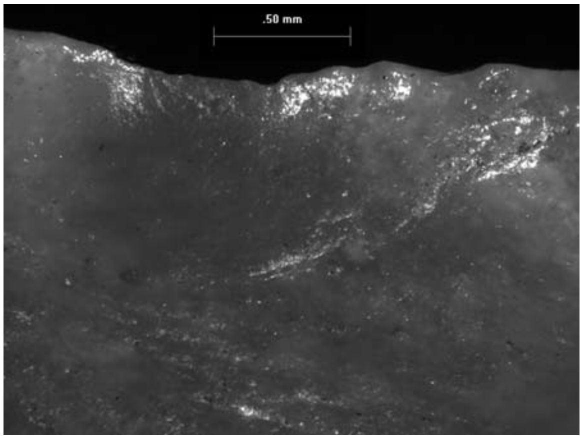



**Figure D-13.04.** Edge rounding and polish noted along basal margin. This wear may have been caused by hafting, but it is not inconsistent with wear derived from use.

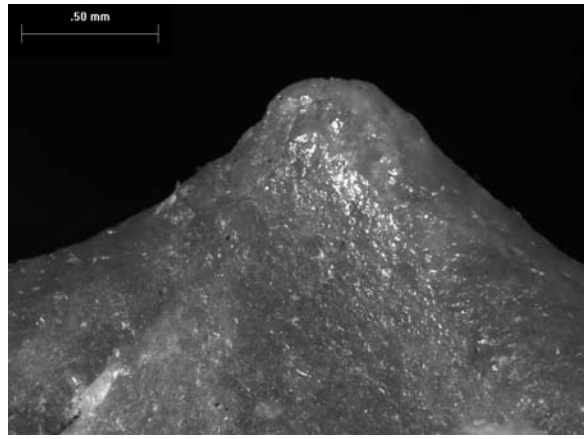



**Figure D-13.05.** Polish and rounding observed near left basal corner.

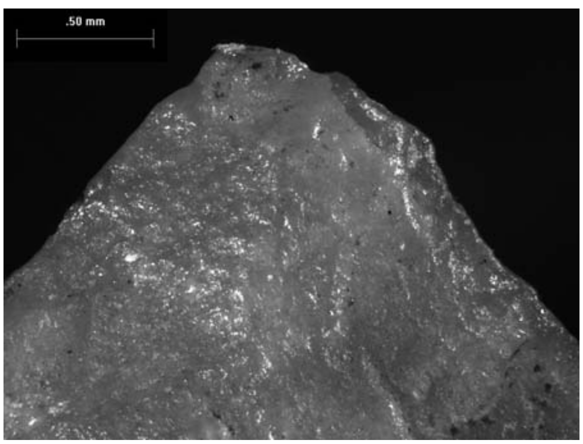



**Figure D-13.06.** Polish and attrition noted near right basal corner.

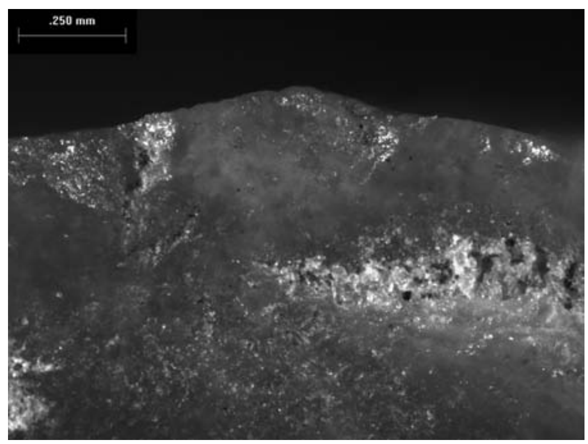



**Figure D-13.07.** Attrition and polish recorded near distal margin.

***Artifact ID: 0944***


**Figure D-14.** Biface (Catalog/ID# 944) from Unit S31W116, Level 11.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate (likely informal); **Artifact Type:** Indeterminate (multifunctional).

***Characteristics***

**Length:** 89 mm; **Width:** 26 mm; **Thickness:** 11 mm; **Weight:** (unrecorded); **Edge Angle:** 55°; **Portion:** complete; **Raw Material Type:** chalcedony; **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** bipolar–unifacial (some lateral unifacial near distal margin); **Polish:** medial bipolar; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no (possible prehensile polish); **Contact Material Hardness:** soft.

***Comments***

Contrary to Ricklis' (see Chapter 7) identification, the author (Bateman) does not believe this artifact is a Refugio dart point. The predominate pattern of use-wear is bipolar and related to a scraping function. Further, there is no evidence to suggest that this artifact represents a modified (recycled) form.

Polish is medial-bifacial, suggesting that the tool was not hafted, but rather directly manipulated during use.

Some unilateral attrition is observed on lateral margins. Most of this attrition is located near the base of the tool, but a small amount is isolated along the medial margin. Medial attrition is not oppositional bilateral-unifacial as would be expected with a twisting motion.

The use-wear observed on this tool does not conform to the expectations of one specific formal tool type. It is reasonable to suggest that the artifact was multifunctional in design and use.

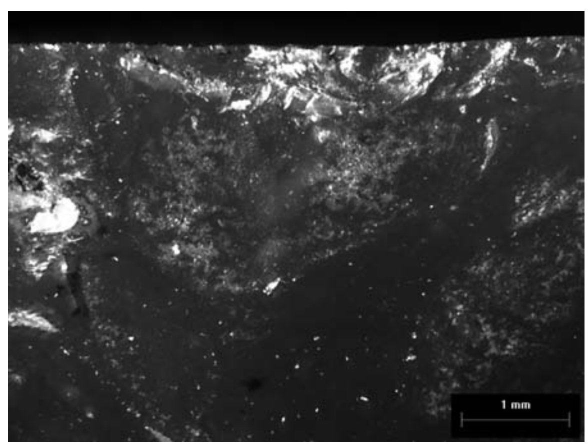



**Figure D-14.01.** Distal edge of tool form. Attrition is unilateral suggesting use in a scraping function.

continued.

***Artifact ID: 0944***
(continued)

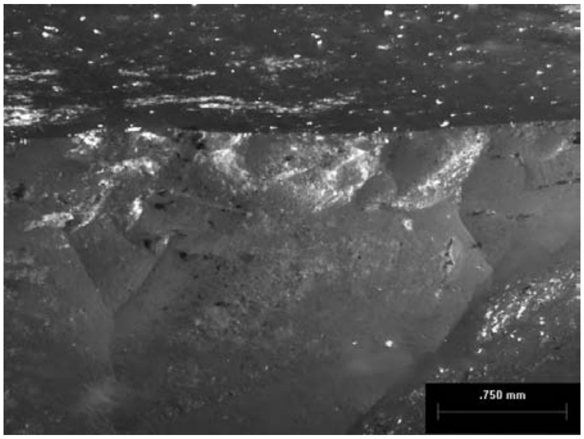



**Figure D-14.02.** Close-up of distal margin shows unilateral attrition pattern.

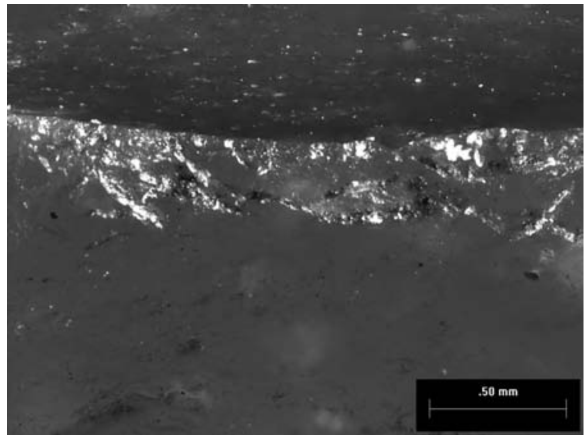



**Figure D-14.03.** Medial-lateral edge showing unilateral attrition.

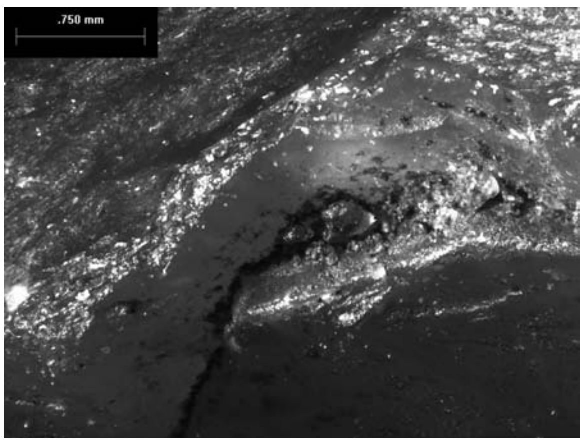



**Figure D-14.04.** Close-up of lateral edge near proximal end shows attrition.

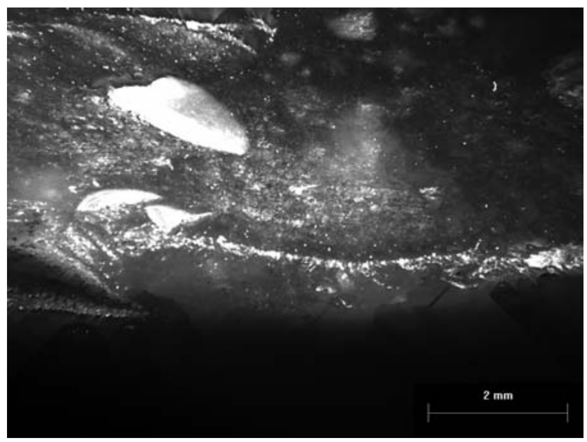



**Figure D-14.05.** Lateral edge near proximal end exhibits attrition and slight polish.

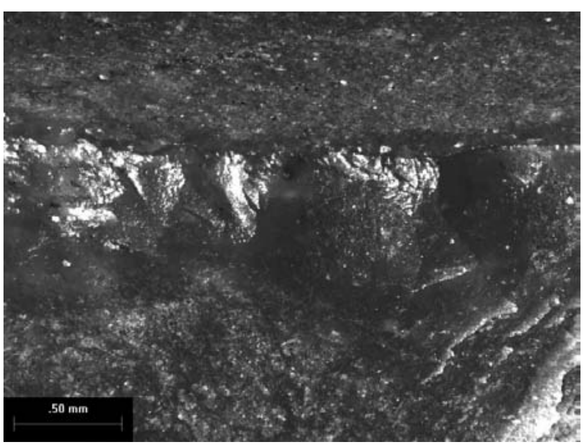



**Figure D-14.06.** Proximal margin exhibits unifacial-directed wear and shallow polish.

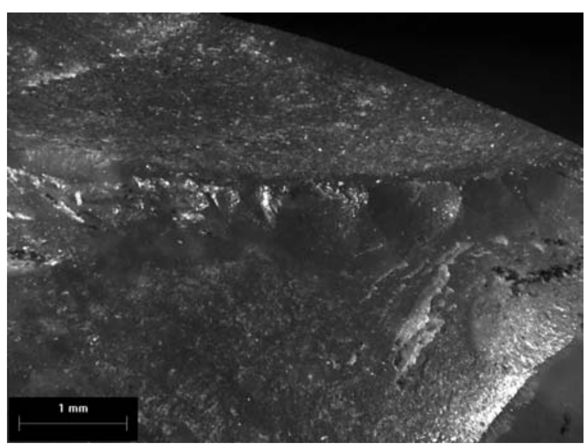



**Figure D-14.07.** View of proximal margin shows unifacial attrition.

continued.

***Artifact ID: 0944***
(concluded)

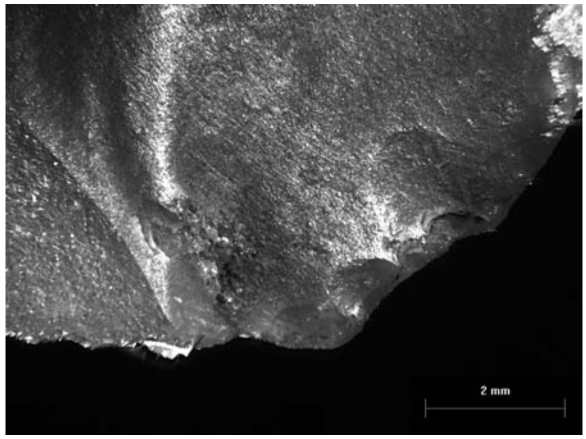



**Figure D-14.08.** Lateral edge near proximal end exhibiting minor attrition.

***Artifact ID: 0961***

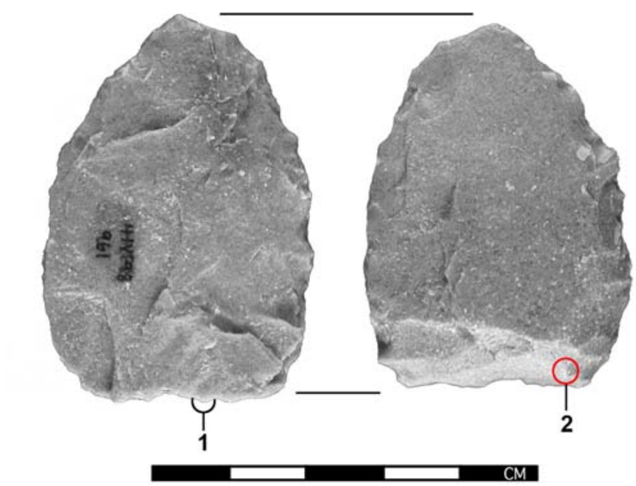



**Figure D-15.** Gouge (Clear Fork Tool) (Catalog/ID# 961) from Unit S31W118, Level 13.

***Classification***

**Artifact Class:** Biface (altered flake); **Artifact Subclass:** Formal; **Artifact Type:** Gouge (Clear Fork Tool).

***Characteristics***

**Length:** 48 mm; **Width:** 35 mm; **Thickness:** 13 mm; **Weight:** 20.7 g; **Edge Angle:** 70°; **Portion:** complete; **Raw Material Type:** quartzite; **Alteration:** oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** deep distal; **Battering:** none observed; **Etching:** shallow distal; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-hard.

***Comments***

The artifact fits the published description of a Middle Archaic period Clear Fork "gouge" (Turner and Hester 1985:205).

Edge attrition recorded along the distal bit is unifacial in character. Retouch observed along the lateral margins is roughly bifacial (edges are not finely finished).

A shallow polish is located along the medial margins. Given its placement, this polish may have resulted from hafting. Edge rounding is also observed along the distal margin. The pattern of polish and attrition observed on the dorsal face of the distal bit is relatively shallow, whereas polish observed on the ventral face of the distal bit is deep. Facets on the ventral surface exhibit polish and faint linear striations running perpendicular to the distal edge.

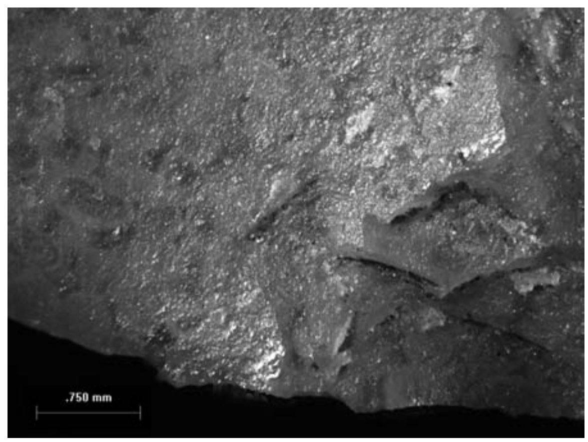



**Figure D-15.01.** Faint polish observed at edge and on facets at distal margin.

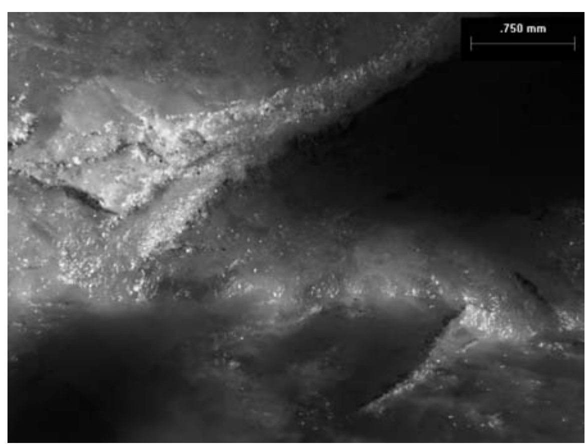



**Figure D-15.02.** Dorsal facets near distal margin exhibit rounding and polish. Wear is consistent with abrasion against a medium-hard contact material.

***Artifact ID: 1005***

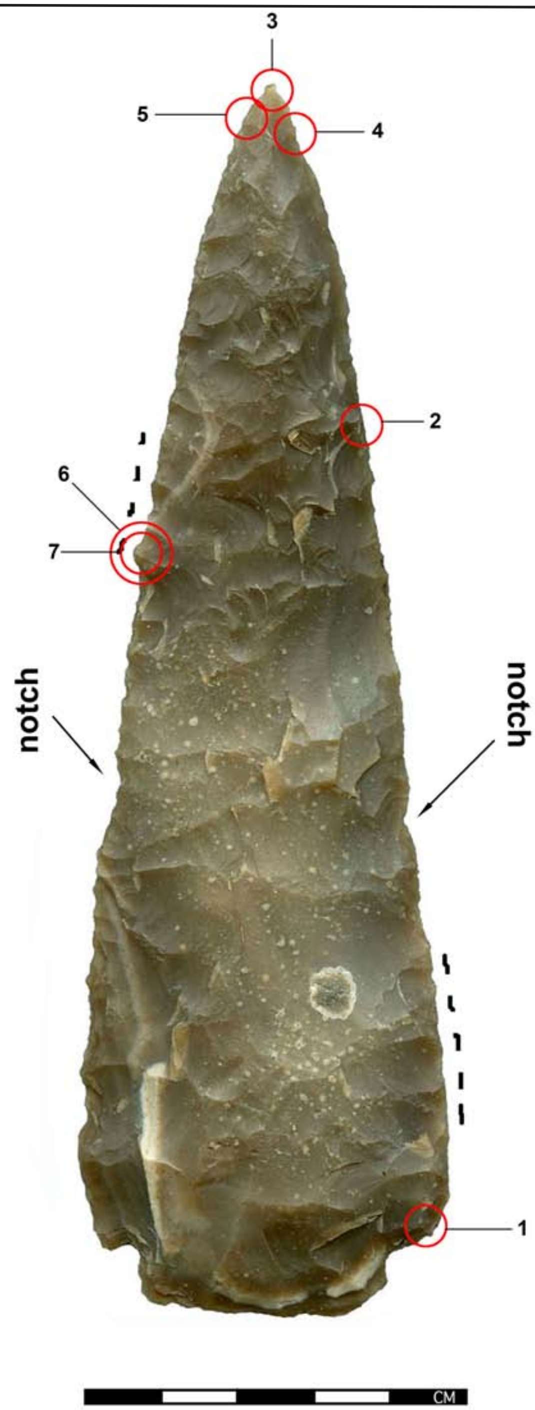



**Figure D-16.** Projectile Point (Catalog/ID# 1005) from Unit S16W88, Level 9.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

***Characteristics***

**Length:** 182 mm (base = 7 mm); **Width:** 50 mm (base=33 mm); **Thickness:** 12 mm; **Weight:** (unrecorded); **Edge Angle:** 55°-60°; **Portion:** complete; **Raw Material Type:** chert (medium to fine grained); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** distal-medial; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

***Comments***

Two minute notches are present on oppositional lateral margins at the midsection of the blade. Margins are rounded and dulled from base to notches, suggesting that this area was modified through contact with a hafting material. The basal margin is similarly rounded and dulled.

Some high points on facets and protrusions are rounded and polished forward of notches. The distal tip shows some attrition (spalling) and faint polish.

The recorded pattern of use-wear suggests that the tool was used in thrusting through a soft contact material, though on a very limited basis. This is consistent with use as a projectile or dagger.

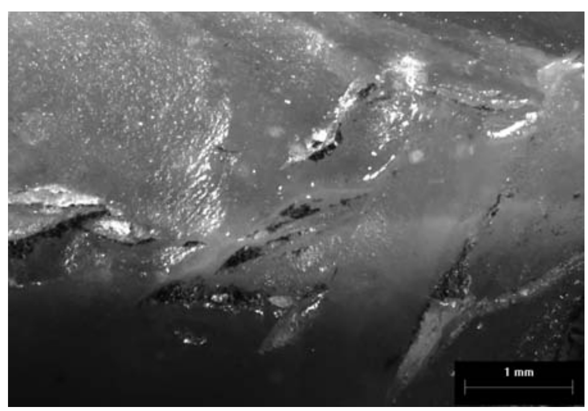



**Figure D-16.01.** View of edge rounding and shallow polish at basal corner of blade. Similar modification is observed along extent of margin below notches. This modification is likely derived from hafting.

continued.

***Artifact ID: 1005***
(concluded)

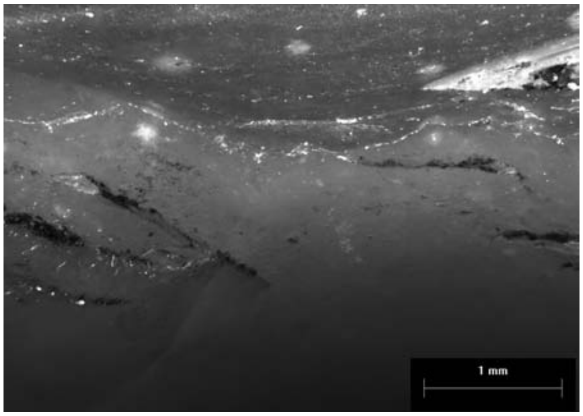



**Figure D-16.02.** View of lateral margin at upper midsection of tool. Edge remains sharp. No evidence of attrition or polish is observed.

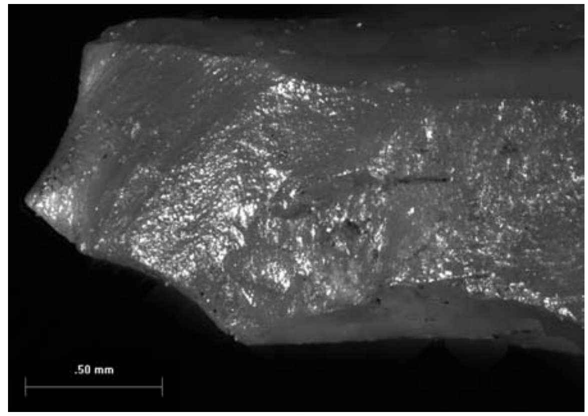



**Figure D-16.03.** Burination and faint polish noted at distal tip. Wear is consistent with an impact fracture.

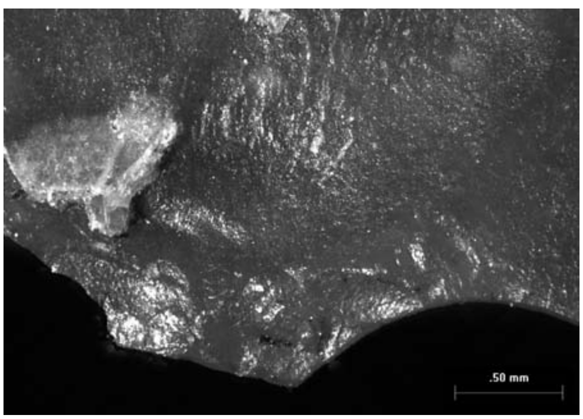



**Figure D-16.04.** Attrition and shallow polish observed near distal tip of tool.

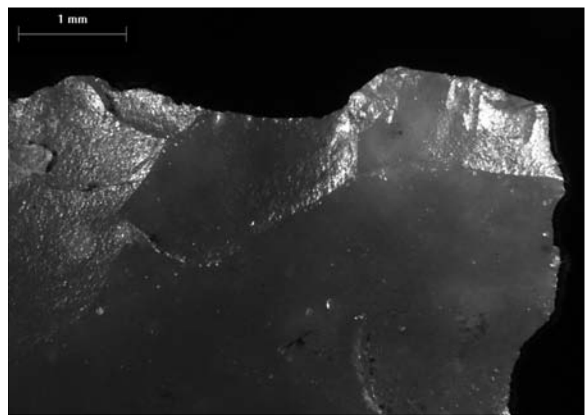



**Figure D-16.05.** Attrition recorded along distal tip.

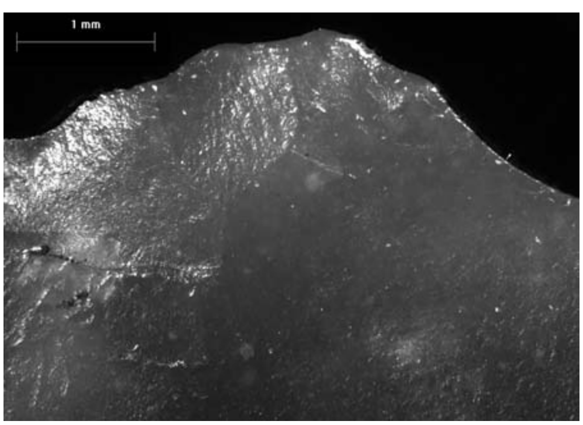



**Figure D-16.06.** Marginal rounding and very shallow polish recorded along lateral margin near midpoint of blade.

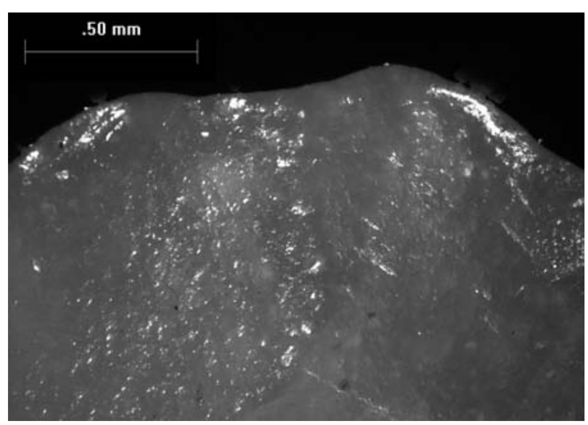



**Figure D-16.07.** Edge rounding and polish recorded at lateral margin illustrated at higher magnification.

***Artifact ID: 1039***

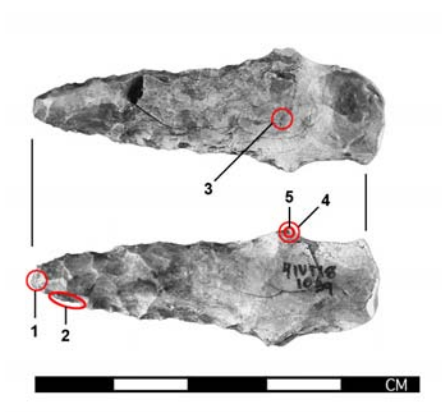



**Figure D-17.** Drill (Catalog/ID# 1039) from Unit S16W88, Level 10.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Drill.

### *Characteristics*

**Length:** 43 mm; **Width:** 15 mm; **Thickness:** 7 mm; **Weight:** 3.8 g: **Edge Angle:** 80°; **Portion:** near complete; **Raw Material Type:** indeterminate; **Alteration:** thermal (fire fractured).

### Use-Wear Pattern

**Edge Attrition:** distal (torque)/bifacial-unilateral; **Polish:** lateral margins worn smooth and polished on high points; **Battering:** edge abrasion; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

### *Comments*

Tool exhibits extensive fire damage. An indeterminate portion of the proximal element is missing. The artifact is cracked in several places and is light grey to black in color. The artifact exhibits a highly developed, ubiquitous gloss or "polish." However, the intensity of this sheen has certainly resulted from thermal vitrification rather than being derived from use.

The edge angle along the lateral margin is consistent with the expectations for a tool used as a drill. The bilateral-unifacial pattern of edge attrition and the distal perverse (torque) fracture is also consistent with the expectation for a drill.

The polish generally recorded on the high points and facets along the lateral margins cannot be unequivocally classified as use-derived due to the effects of thermal alteration. However, a few transverse striations are evident on several of the lateral edges, and these have almost certainly resulted from tool use.

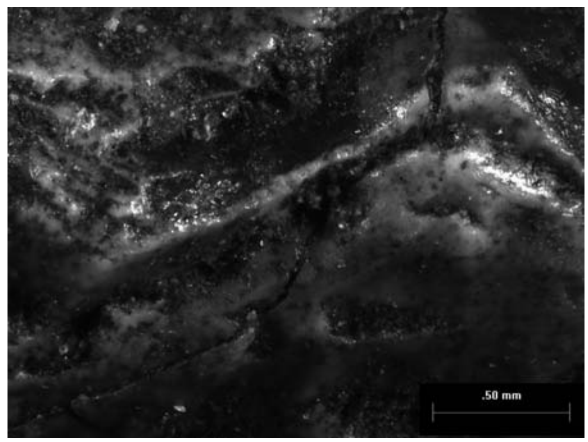



**Figure D-17.01.** Vitrification and crazing observed at distal tip caused from fire damage. Fracture at tip is perverse in form, resembling a torque break resulting from twisting.

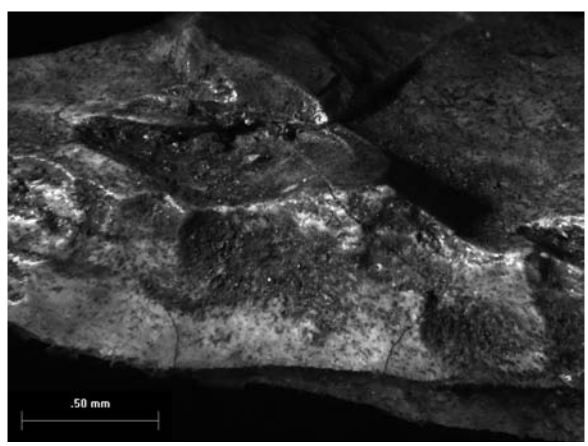



**Figure D-17.02.** Fracturing due to thermal damage recorded along lateral margin near distal tip. Edge attrition is bilateral-unifacial, consistent with the expected use pattern of a drill.

continued.

***Artifact ID: 1039***
(concluded)

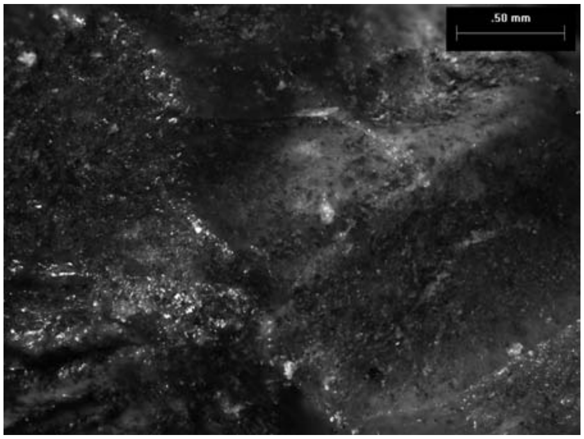



**Figure D-17.03.** Vitrification observed on internal facets at midsection of tool.

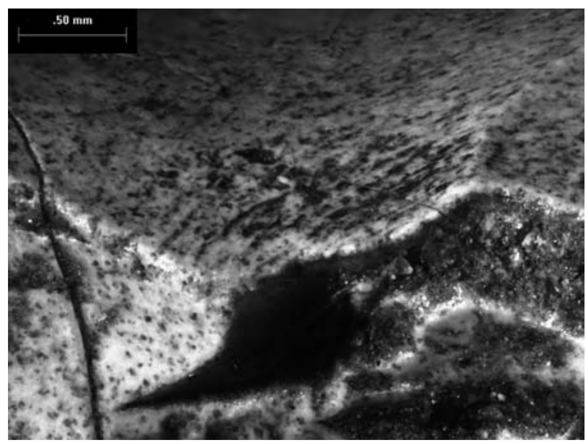



**Figure D-17.04.** Edge rounding observed on lateral tang.


**Figure D-17.05.** Edge rounding on lateral tang observed at higher magnification.

## *Artifact ID: 1046*


**Figure D-18.** Projectile Point (Catalog/ID# 1046) from Unit S16W88, Level 8.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate (likely formal); **Artifact Type:** Projectile (possibly an awl).

### *Characteristics*

**Length:** 35 mm; **Width:** 13 mm; **Thickness:** 4 mm; **Weight:** 1.8 g; **Edge Angle:** 50°; **Portion:** tip; **Raw Material Type:** coarse chert; **Alteration:** slight oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** distal; **Polish:** very light marginal (close to distal tip); **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

### *Comments*

Although resembling a distal drill fragment, the width-to-thickness ratio is incompatible with this function, being notably thin to function in this manner. Furthermore, the specimen lacks the oppositional bilateral-unifacial attrition pattern diagnostic of drill wear. No attrition along the lateral margins is observed.

The proximal fracture appears to be the result of a bending failure rather than a production failure. The tool does appear to have been used. The attrition pattern observed along the distal margin suggests that the fracture may have resulted from a torque snap. This form of break could have been produced through a motion similar to that made by an awl or drill. As the lateral margins lack transverse linear scarring typical of drill wear, and as the blade is too thin relative to its length to have been used as a drill, an awl function is better supported. Alternatively, the thinness of the blade may have caused such a snap at impact should the tool have been used as a projectile.

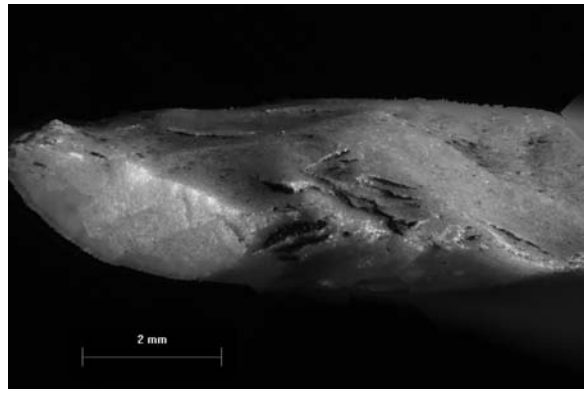



**Figure D-18.01.** Attrition observed along distal margin.

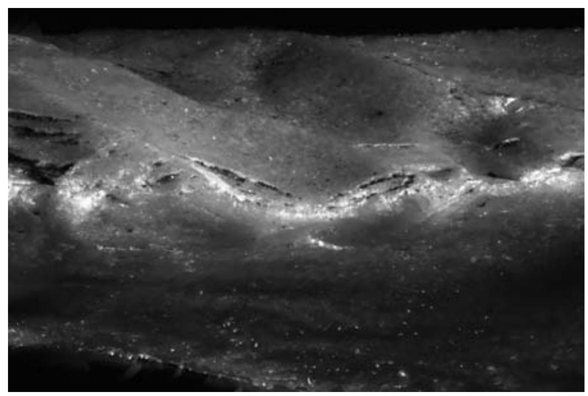


**Figure D-18.02.** Slight attrition and faint polish observed on lateral margin near distal tip.

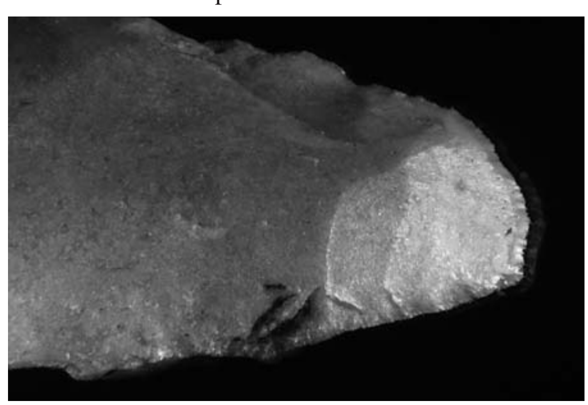


**Figure D-18.03.** Distal tip shows light attrition and faint polish along margin.

continued.

***Artifact ID: 1046***
(concluded)

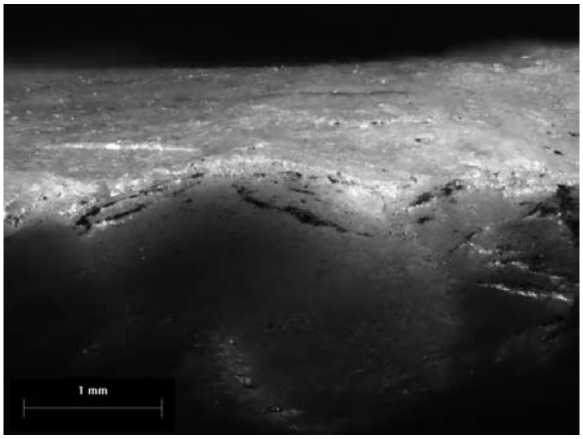



**Figure D-18.04.** Unifacial attrition noted on lateral margin near distal tip.

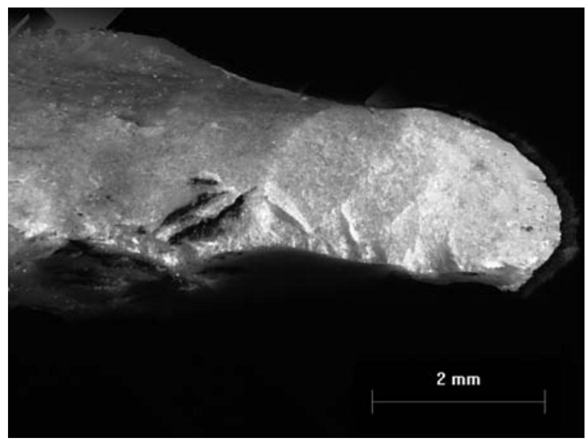



**Figure D-18.05.** Distal tip shows light attrition along margin.

*Artifact ID: 1115*

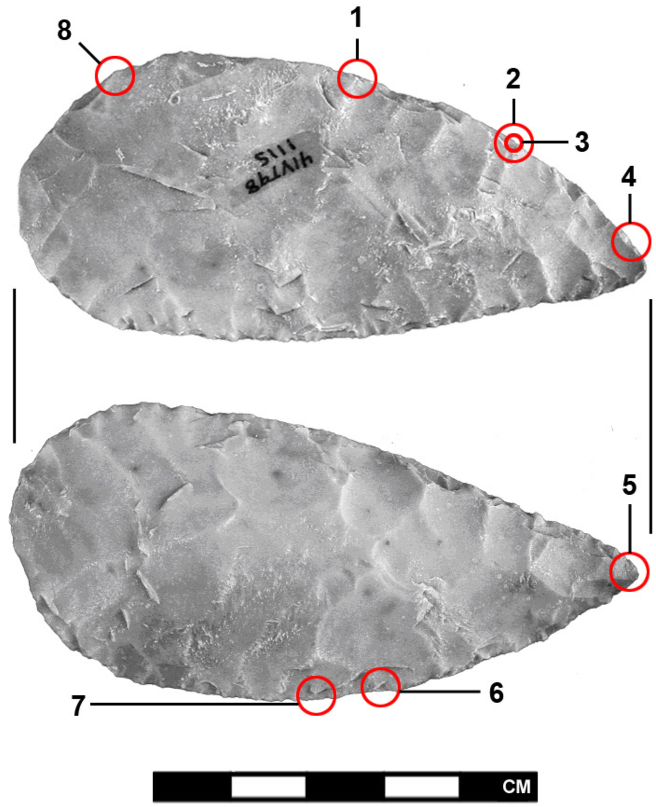



**Figure D-19.** Knife (Catalog/ID# 1115) from Unit S14W86, Level 10.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

***Characteristics***

**Length:** 85 mm; **Width:** 38 mm; **Thickness:** 10 mm; **Weight:** 29.6 g; **Edge Angle:** 35-40°; **Portion:** complete; **Raw Material Type:** chert (medium grade); **Alteration:** thermal (at tip only).

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** circumferential; (shallow); **Battering:** none observed; **Etching:** shallow lateral (perpendicular to margin); **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft (possibly soft).

***Comments***

The artifact is a bifacial knife with fine pressure flaking around its circumference.

No marginal edge attrition (flaking) is observed, even though polish and dulling (rounding) are present. Shallow, broad striations are also evident, running perpendicular to margin. This suggests a cutting (not slicing or whittling) action with a medium-soft contact material.

The edges along each lateral margin show wear in the form of rounding and the development of a shallow polish. However, the polish and striations observed along the convex margin are better defined and more strongly developed. There is an area of heavy backside polish along the straight margin that may have resulted from direct manipulation during use. The edge in this

continued.

***Artifact ID: 1115***
(continued)

area appears flatter and the polish is better developed than it is elsewhere along the margin. Modification along straight margin (backside) is not well developed in general, but polish and faint striations are present.

Wear observed at the distal tip resembles that derived from impact fracturing and/or thrusting. This is anomalous to expectations if the implement was hand held during use. However, if the tool was hafted at its base, a thrusting and cutting action could have occurred.

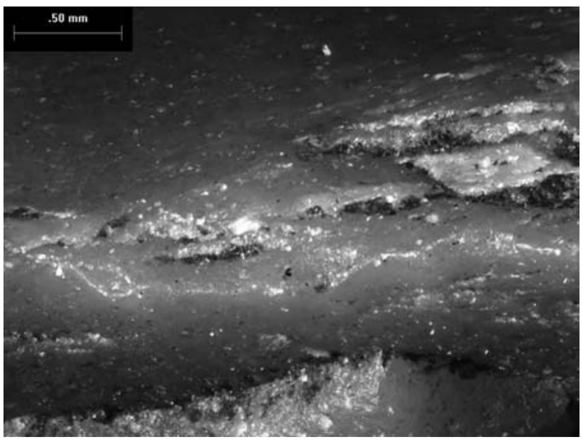



**Figure D-19.01.** Edge rounding and shallow polish observed along lateral margin.

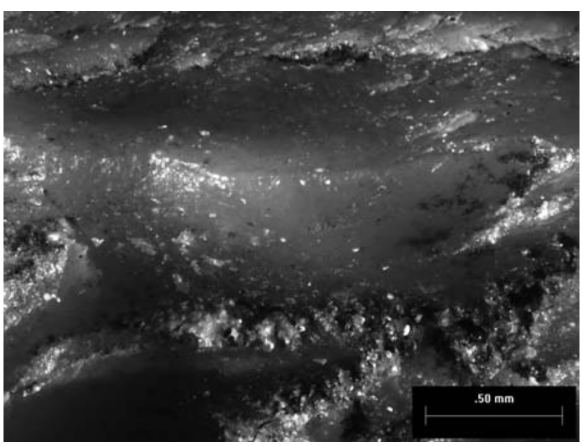



**Figure D-19.02.** Edge rounding and shallow polish observed along lateral margin near distal tip. Shallow, broad striations observed perpendicular to edge. Pattern of edge modification is consistent with that derived from cutting or whittling a material of medium-soft hardness.

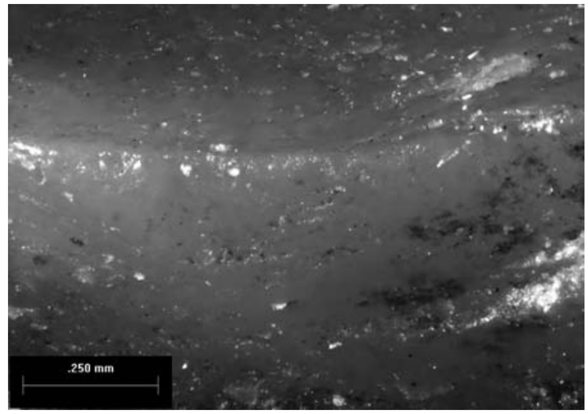



**Figure D-19.03.** Edge rounding and polish observed along lateral margin near tip at higher magnification.

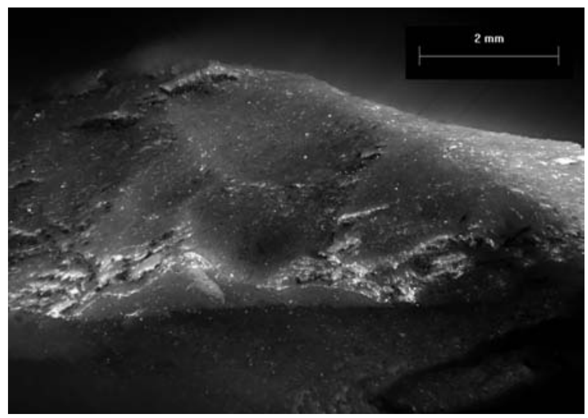



**Figure D-19.04.** Scaring at distal tip appears to be remnant abrasion from production of the tool form rather than use-derived attrition.

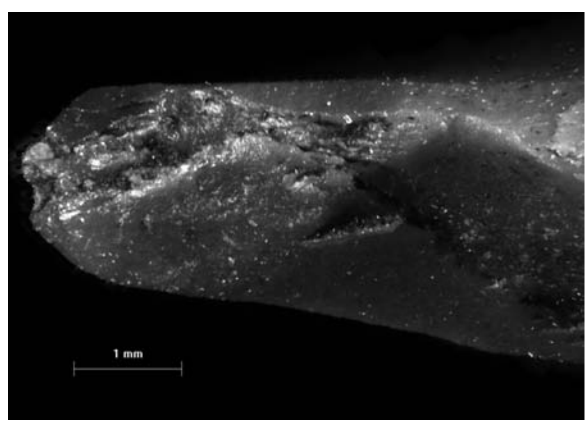



**Figure D-19.05.** Edge rounding observed at distal tip.

continued.

***Artifact ID: 1115***
(concluded)

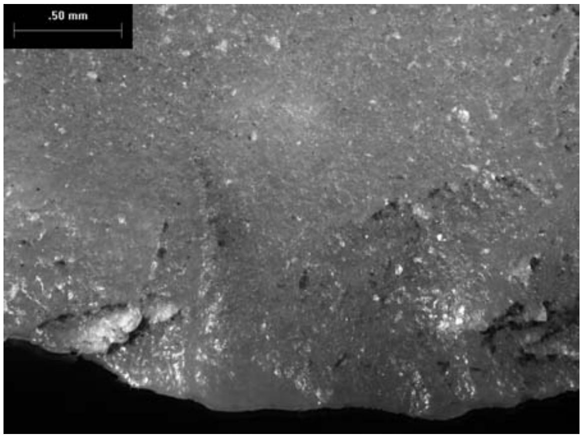



**Figure D-19.06.** Shallow polish observed along lateral margin.

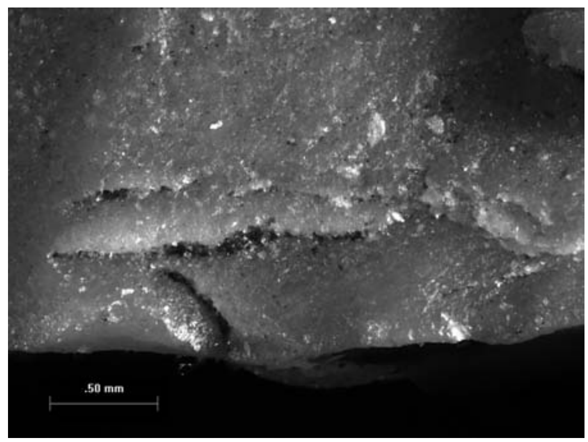



**Figure D-19.07.** Edge rounding and shallow polish observed along lateral margin.

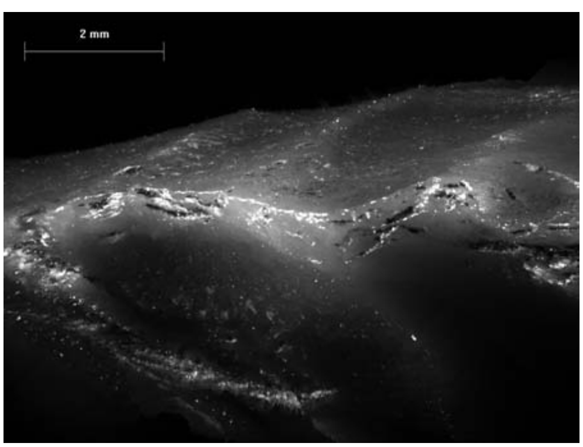



**Figure D-19.08.** Light edge rounding observed along distal margin.

***Artifact ID: 1122***

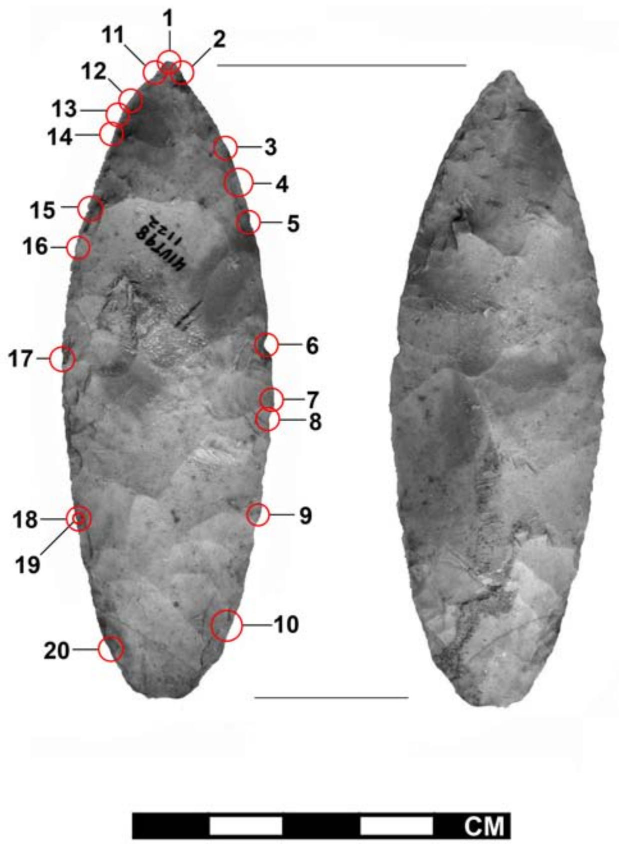



**Figure D-20.** Knife (Catalog/ID# 1122) from Unit S14W86, Level 11.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

### *Characteristics*

**Length:** 84 mm; **Width:** 29 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 55°; **Portion:** complete; **Raw Material Type:** chert (medium grain size; **Alteration:** none.

### *Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

### *Comments*

Modest rounding and very shallow polish are present along the lateral margins of the blade. The tool's distal tip exhibits a shallow polish and is dull and blunt from edge rounding. High points and facets along the lateral and distal margins exhibit the most strongly developed edge rounding and polish.

Edge attrition recorded along the blade margin is typically bilateral-bifacial in distribution, but flake removals are shallow. The attrition pattern is that of sequential step fractures running the length of the edge, terminating approximately three-quarters of the length of the blade from distal point. The proximal one-quarter of the blade exhibits only modest edge abrasion.

Deposits of silica are present in several places along the lateral margin. Fibrous material can be seen trapped below silica. This material is most likely plant fiber, but animal hair cannot be ruled out.

The assessment of a medium-soft contact material is based on the presence of the silica deposits along the blade margins, but the shallowness of the polish observed suggests that the contact material may have been medium-hard.

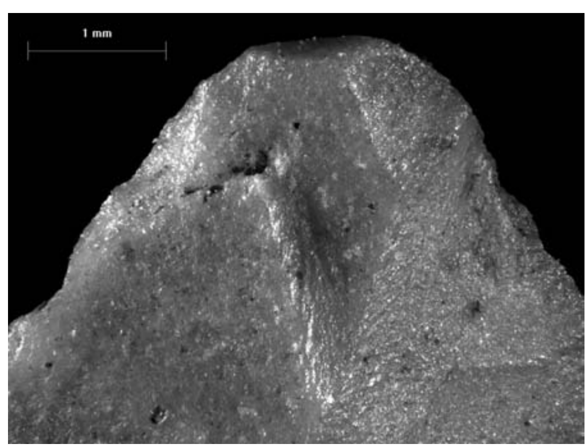



**Figure D-20.01.** Distal tip blunted with dull, rounder edges.

continued.

***Artifact ID: 1122***
(continued)

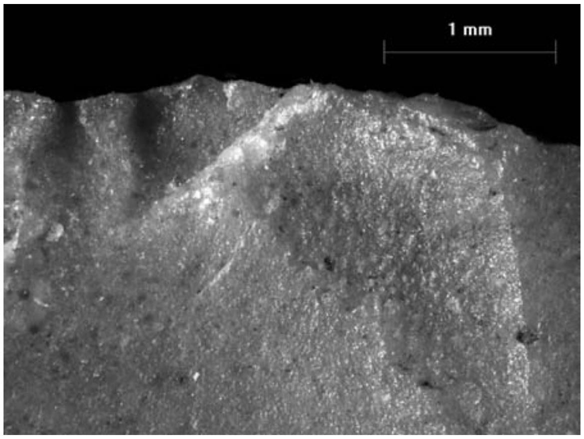



**Figure D-20.02.** Shallow polish developed on lateral margin near distal tip.

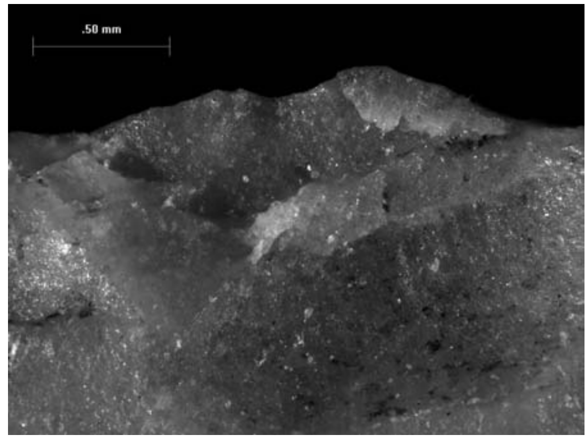



**Figure D-20.03.** Silica build up on lateral margin.

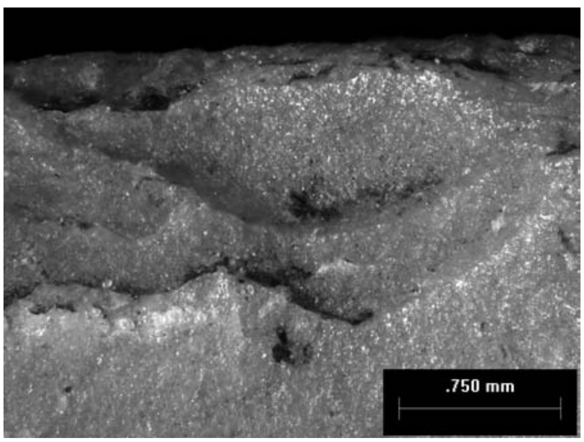



**Figure D-20.04.** Shallow polish and light attrition noted along lateral margin.

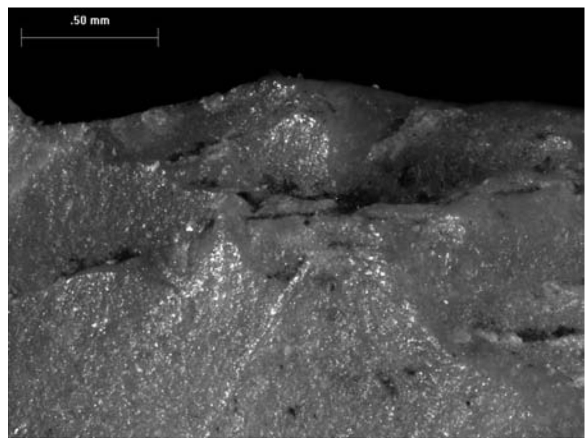



**Figure D-20.05.** Shallow polish and light attrition noted along lateral margin.

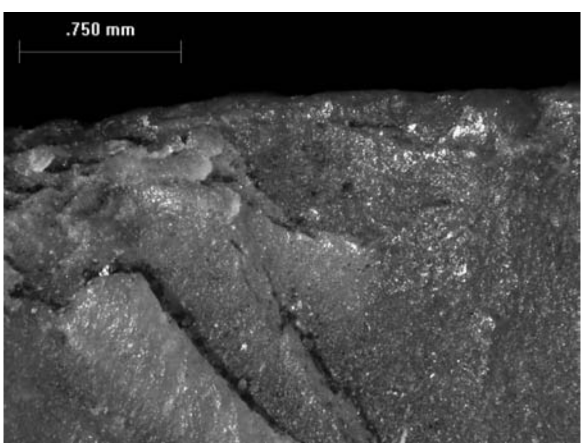



**Figure D-20.06.** Shallow polish, edge rounding and light attrition noted along lateral margin.

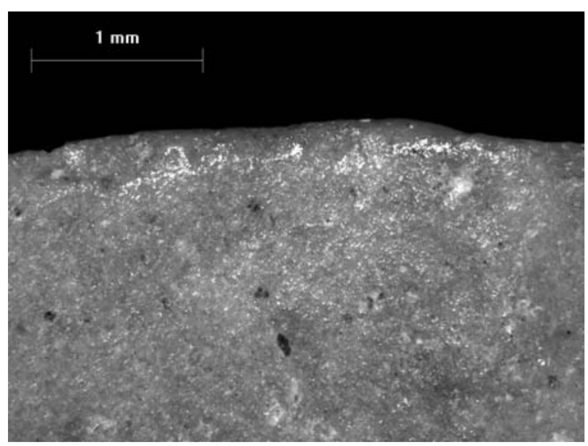



**Figure D-20.07.** Edge Rounding and shallow polish recorded along lateral margin near midsection of blade.

continued.

***Artifact ID: 1122***
(continued)

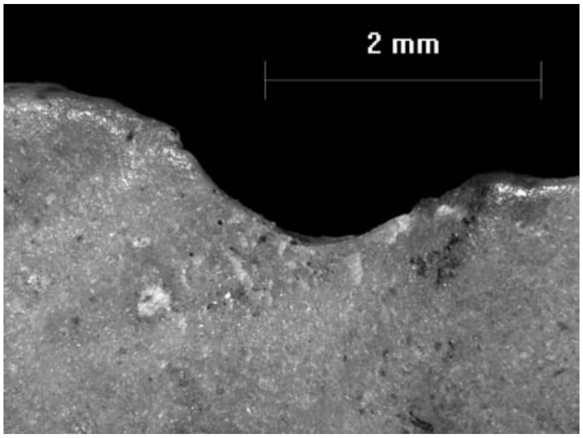



**Figure D-20.08.** Edge Rounding and shallow polish recorded along lateral margin near midsection of blade.

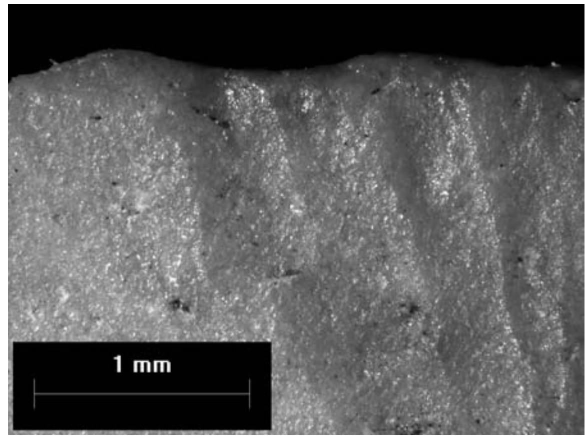



**Figure D-20.09.** Edge rounding and shallow polish recorded along lateral margin near proximal end of blade.

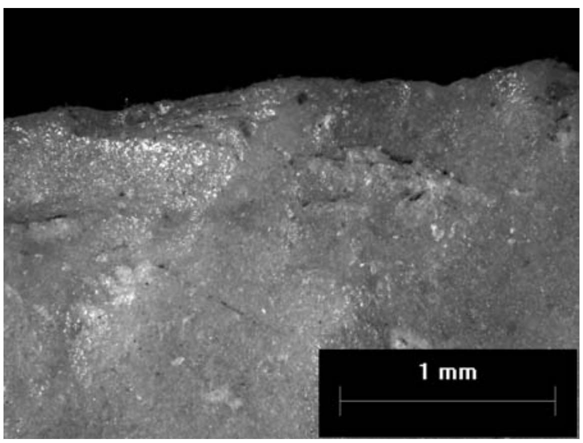



**Figure D-20.10.** Light attrition and shallow polish recorded near distal margin.

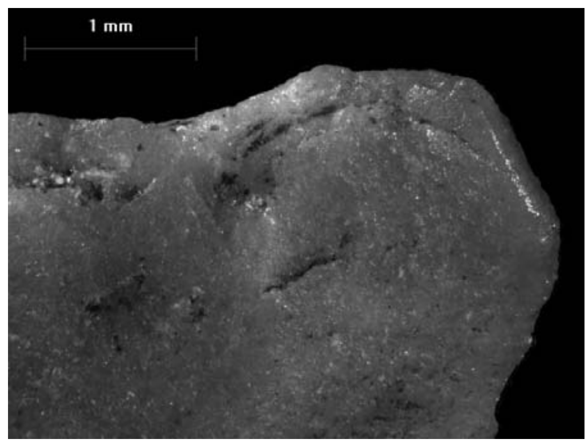



**Figure D-20.11.** Light attrition, edge rounding, and shallow polish observed at distal tip of blade.

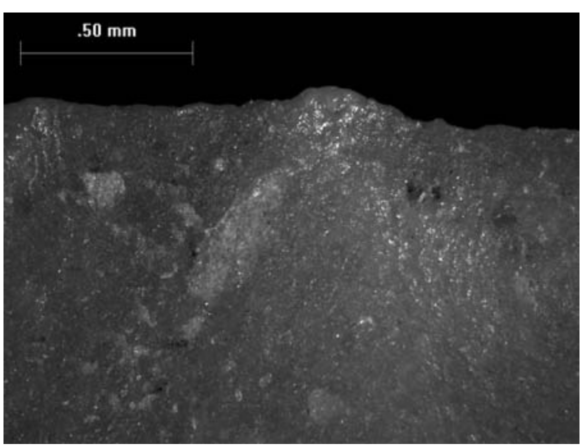



**Figure D-20.12.** Edge rounding and shallow polish observed along margin near distal tip.

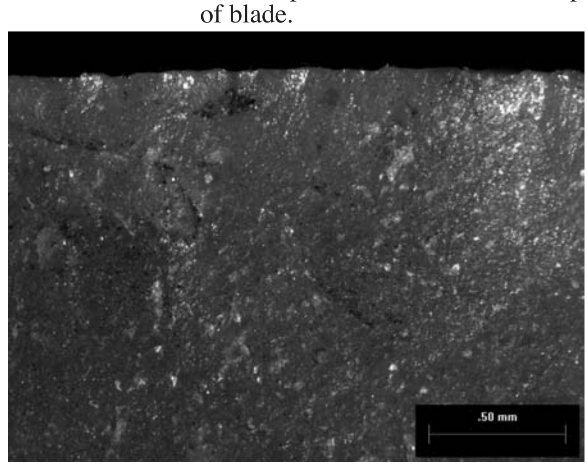



**Figure D-20.13.** Light attrition and shallow polish located on lateral margin near distal tip.

continued.

***Artifact ID: 1122***
(continued)

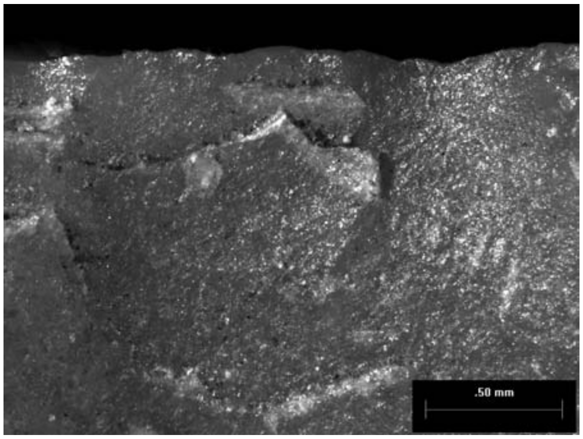



**Figure D-20.14.** Edge rounding and shallow polish located along lateral margin near distal tip.

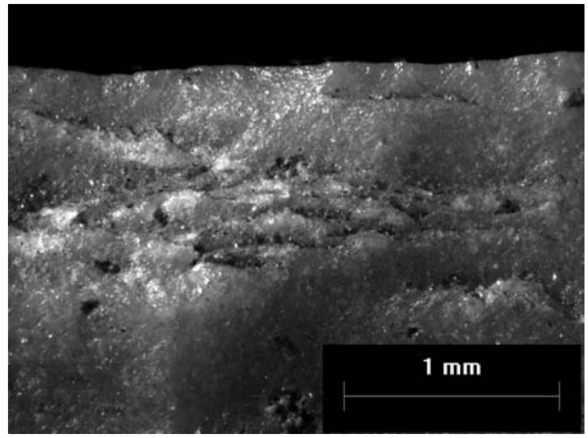



**Figure D-20.15.** Shallow polish and light attrition located along lateral margin.

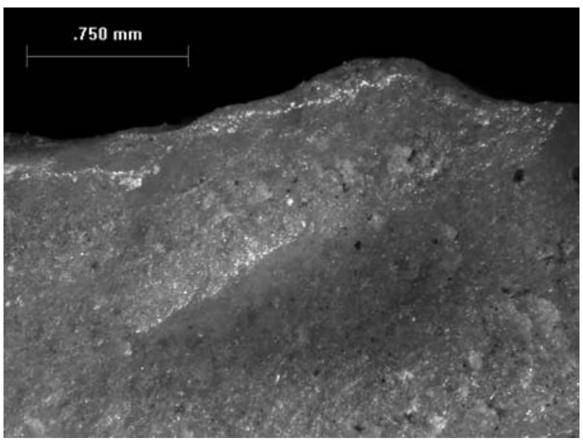



**Figure D-20.16.** Edge Rounding and shallow polish recorded along lateral margin near midsection of blade.

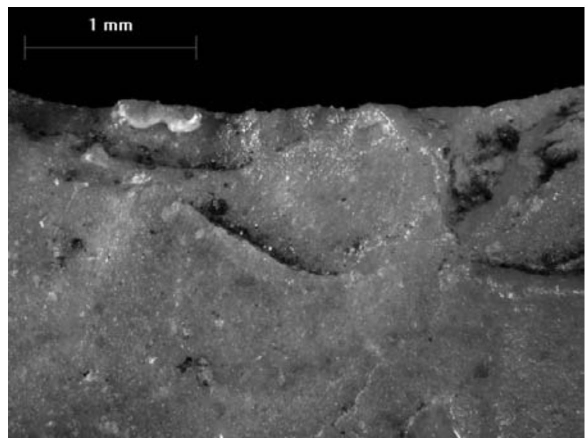



**Figure D-20.17.** Silica build up on lateral margin.

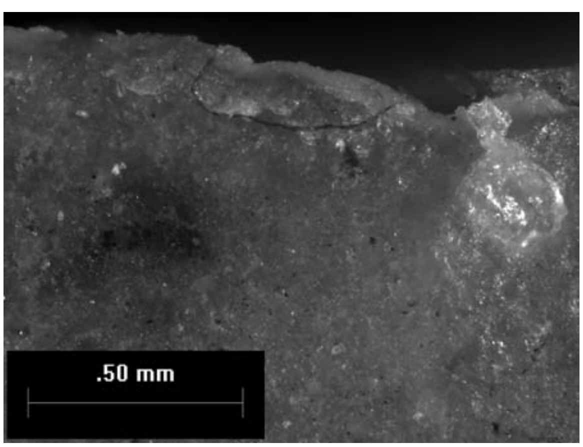



**Figure D-20.18.** Silica build up on lateral margin. Fibrous material can be seen trapped below silica.

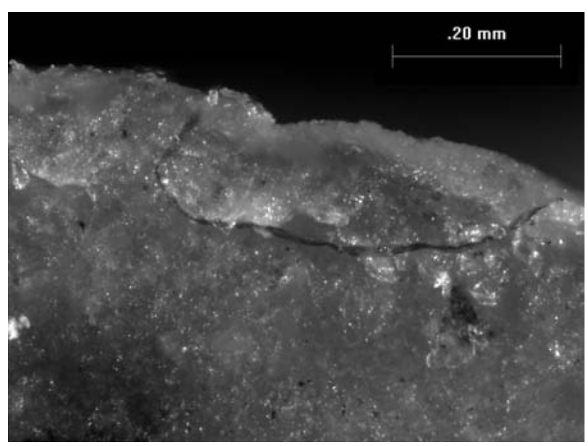



**Figure D-20.19.** Fibrous material trapped below silica deposit observed at higher magnification.

continued.

***Artifact ID: 1122***
(concluded)

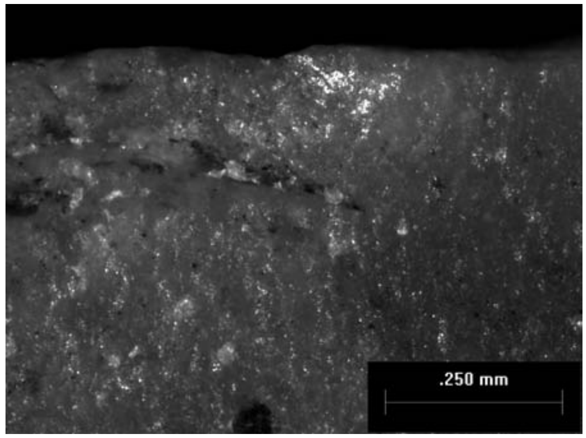



**Figure D-20.20.** Edge rounding and shallow polish observed along margin near proximal end of blade.

## *Artifact ID: 1145*

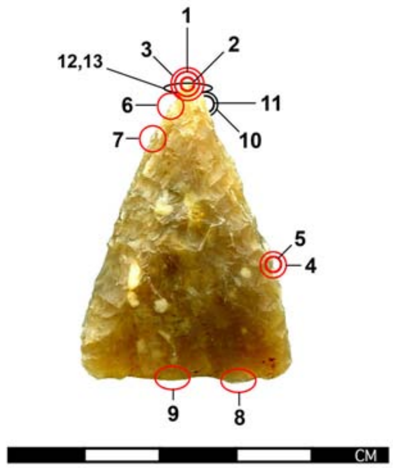



**Figure D-21.** Projectile Point (Catalog/ID# 1145) from Unit S31W118, Level 12.

### *Classification*

**Artifact Class:** Biface; Artifact Subclass: Formal; Artifact Type: Projectile.

### *Characteristics*

**Length:** 41 mm; **Width:** 29 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 50°; **Portion:** complete; **Raw Material Type:** chalcedony; **Alteration:** none.

### *Use-Wear Pattern*

**Edge Attrition:** distal (lateral?); **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

### *Comments*

The lateral margins at the basal corners and along the basal margin exhibit modest rounding. Most terminations observed are smooth-faceted, with only some displaying sharp steps. Most of the feather terminations observed along the lateral margin near the distal tip exhibit sharp step fractures, although many are worn smooth.

Marginal attrition recorded along the lateral margin near the distal tip favor an oppositional unilateral-bifacial pattern of flake removal. If this is not indicative of an edge preparation preference, it suggests the removals resulted from a twisting motion (counter-clockwise). A flake scar emanates from the distal tip. This pattern of removal is consistent with impact fracturing. Facets lining the flake scar have been rounded from wear.

There is greater emphasis on edge thinning along the basal margin. This was likely accomplished for hafting purposes.

Some staining is noticeable at the tip. This staining may be from organic residue or from contact with an iron deposit during burial.

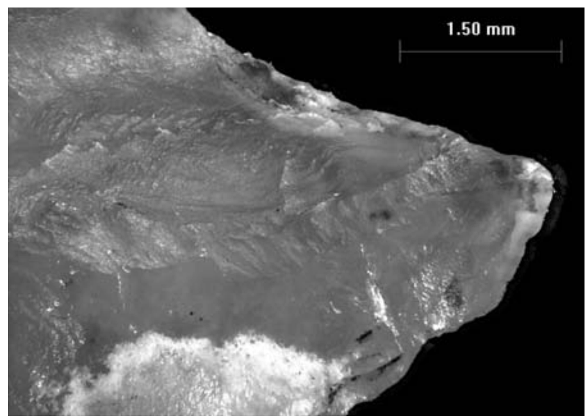



**Figure D-21.01.** Edge attrition observed at distal tip.

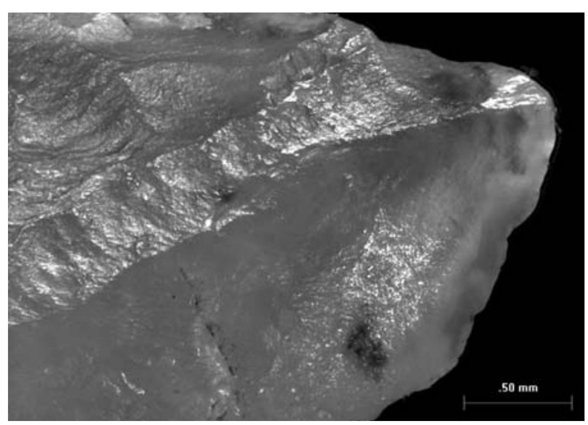



**Figure D-21.02.** A flake scar is shown with initiation of removal emanating from tip. This pattern of wear is consistent with impact fracturing. Facets of flake scar have been rounded from wear. A stain is observed near the tip.

continued.

***Artifact ID: 1145***
(continued)

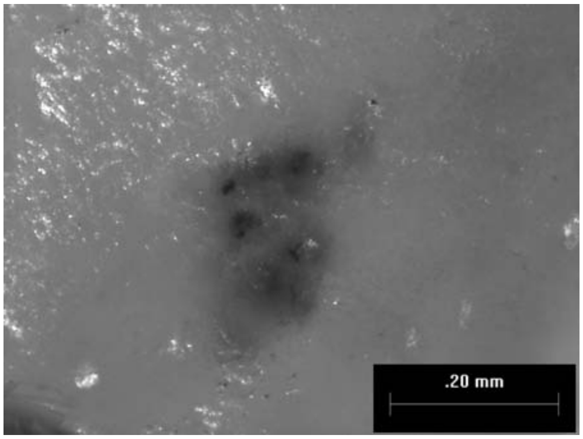



**Figure D-21.03.** Stain observed at higher magnification. The stain is believed to have been made either from an organic residue or an iron deposit.

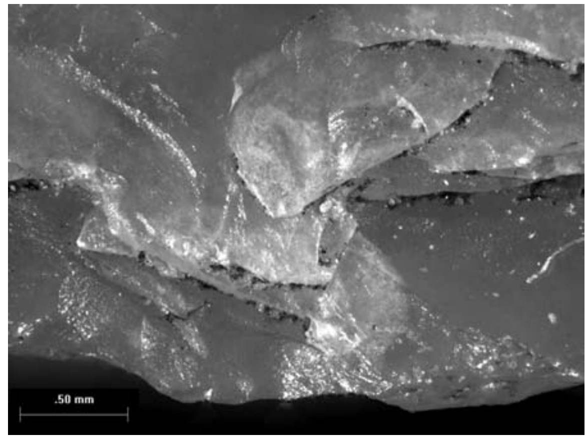



**Figure D-21.04.** Rounding of edge and interior facets along lateral margin at midsection of tool.

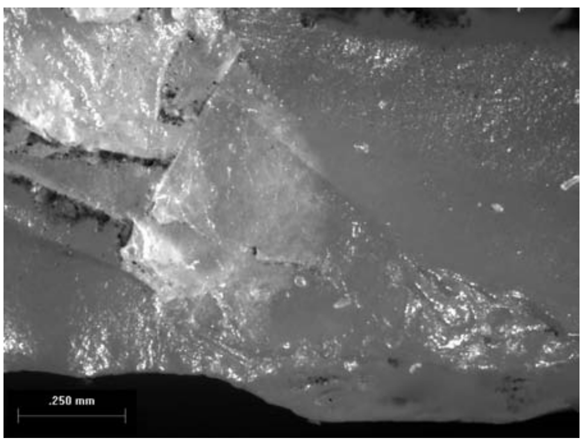



**Figure D-21.05.** Rounding of edge and interior facets along lateral margin at midsection of tool.

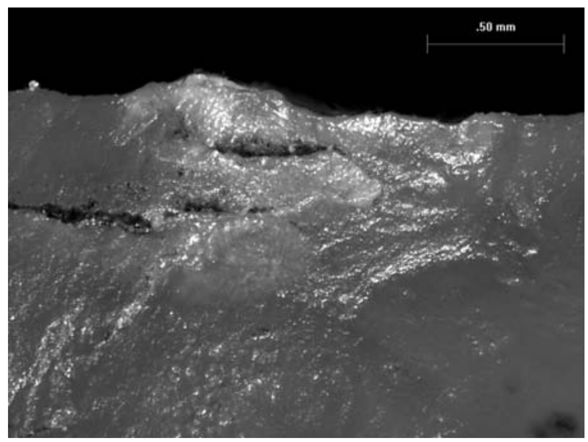



**Figure D-21.06.** Light attrition and shallow polish observed on lateral margin near distal tip.

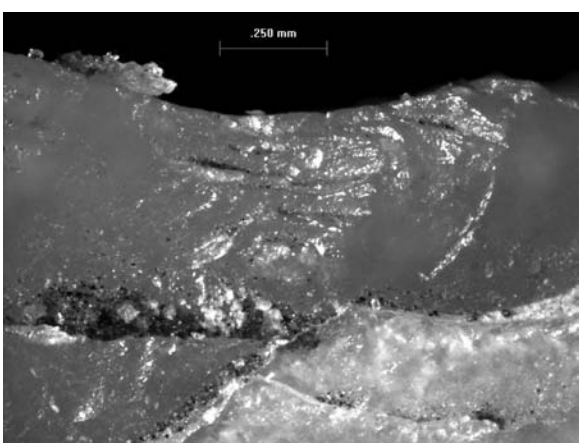



**Figure D-21.07.** Light attrition and silica deposits recorded on lateral margin.

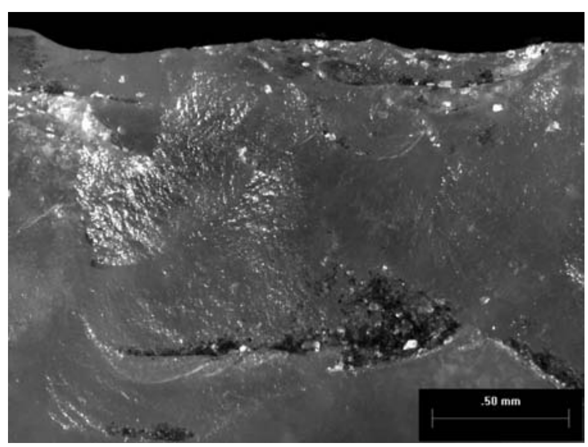



**Figure D-21.08.** Light attrition recorded along basal margin.

continued.

***Artifact ID: 1145***
(concluded)

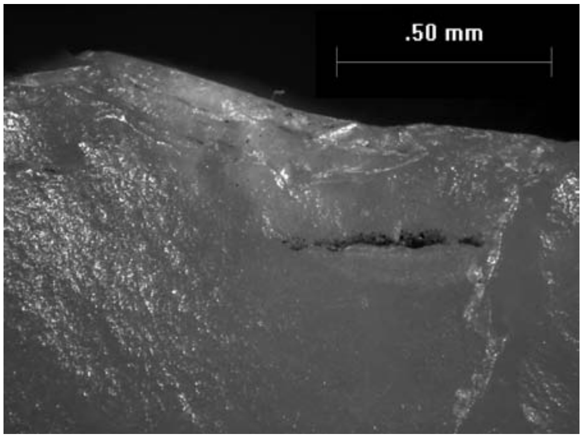



**Figure D-21.09.** Light attrition and shallow polish recorded along basal margin.

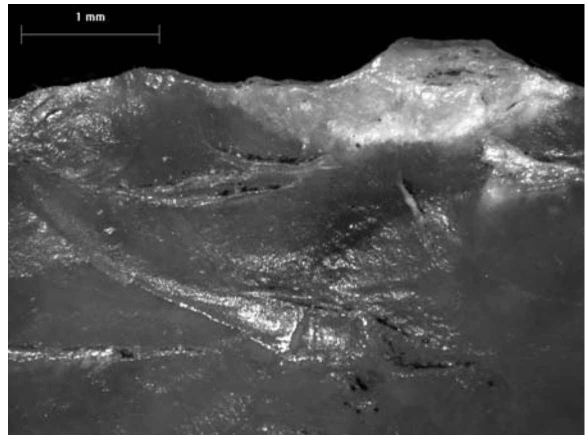



**Figure D-21.10.** Attrition, edge rounding, and shallow polish recorded along lateral margin near distal tip.

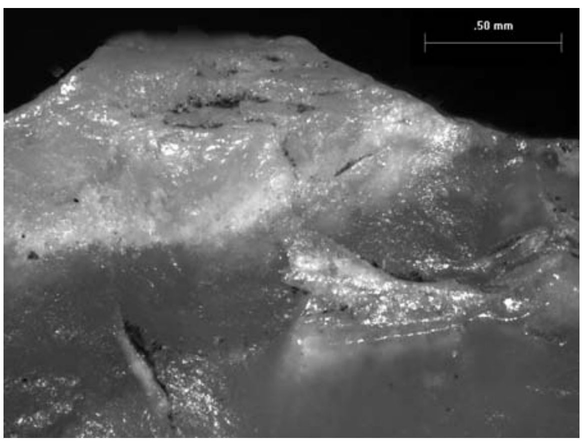



**Figure D-21.11.** Attrition, edge rounding, and shallow polish recorded along lateral margin near distal tip.

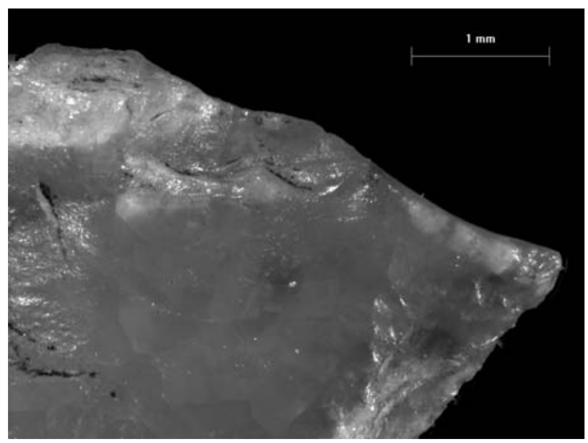



**Figure D-21.12.** Attrition, edge rounding, and well-developed polish recorded at distal tip.

***Artifact ID: 1158***

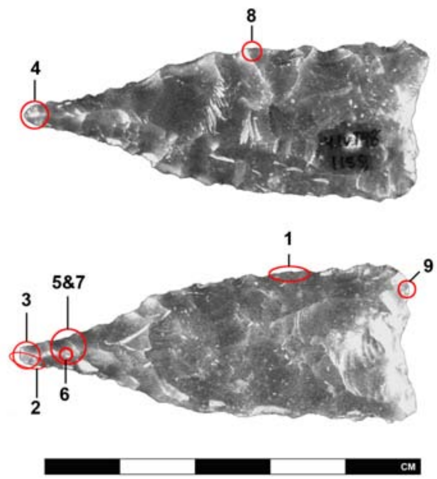



**Figure D-22.** Recycled Projectile Point (Catalog/ID# 1158) from Unit S12W88, Level 12.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Recycled projectile point.

***Characteristics***

**Length:** 51 mm; **Width:** 20 mm; **Thickness:** 7 mm; **Weight:** 6.2 g; **Edge Angle:** 65°; **Portion:** complete; **Raw Material Type:** fine grained, translucent chert; **Alteration:** none observed.

***Use-Wear Pattern***

**Edge Attrition:** distal (spall); **Polish:** proximal-lateral (hafting); **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

***Comments***

The artifact was originally described in the field as a drill crafted from a recycled, untyped triangular point. However, there is no use-wear supporting the artifact's use as a drill. The distal margins are not ground through abrasion and the point lacks any trace of a spiral fracture pattern (spalling). The distal tip does exhibit a minor amount of flaking attrition that is somewhat consistent with impact fracturing. There is also minor etching observed on an interior facet near the distal tip. This attrition is not consistent with the expectations of use-wear and may be remnant abrasion derived from the process of tool production.

The lateral margin at the midpoint of blade exhibits rounding and minor polish consistent with modifications resulting from hafting. Some minor rounding and faint gloss observed along the proximal margin are also suggestive of hafting. It seems likely that the tool was resharpened in the haft, accounting for the unusual taper observed along the distal one-quarter of the blade. If the tool was intended to be used as a drill, it appears never to have engaged in that function.

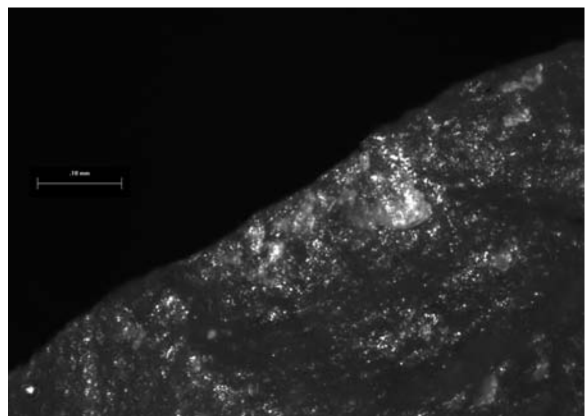


**Figure D-22.01.** Lateral margin near midpoint of blade exhibits edge rounding and shallow polish. Polish may have resulted either from use or possibly hafting.

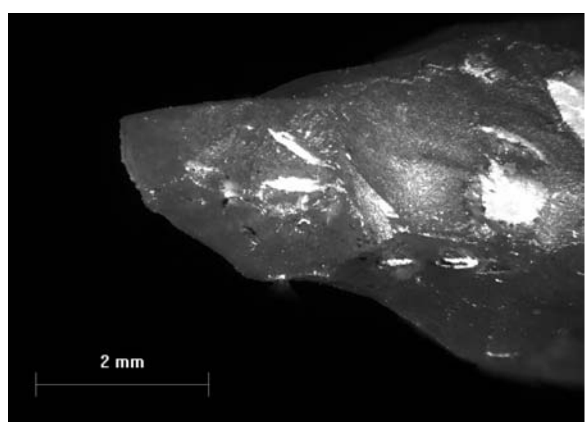



**Figure D-22.02.** Distal tip exhibits attrition consistent with impact fracturing. Attrition pattern does not match the pattern expected of a drill.

continued.

***Artifact ID: 1158***
(continued)

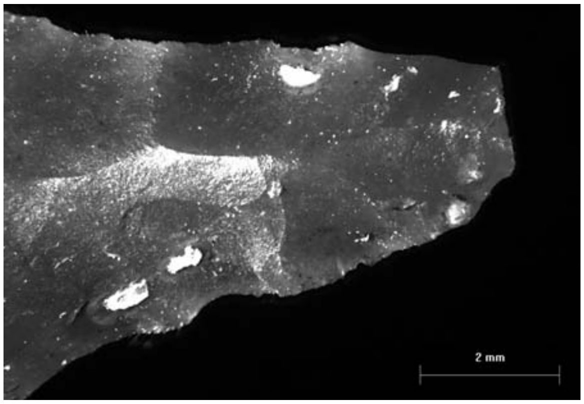



**Figure D-22.03.** Lateral margins at distal tip do not exhibit the pattern of edge removals expected of a drill as the form of the object would suggest.

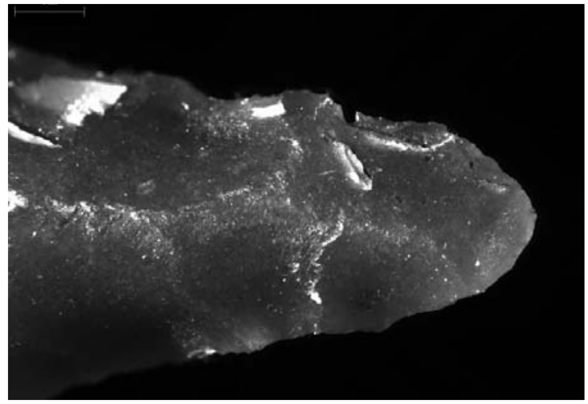


**Figure D-22.04.** Lateral margins at distal tip do not exhibit polish, rounding, or other evidence of wear, and thus are believed to have been resharpened prior to burial.

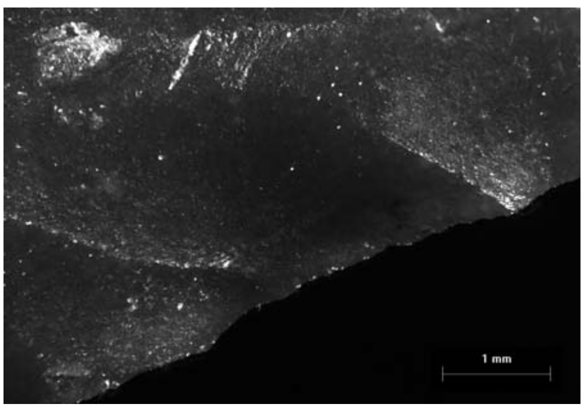



**Figure D-22.05.** Scratching / etching is observed on interior facet near distal tip. This attrition is not consistent with expectations of use-wear and may be remnant from tool production.

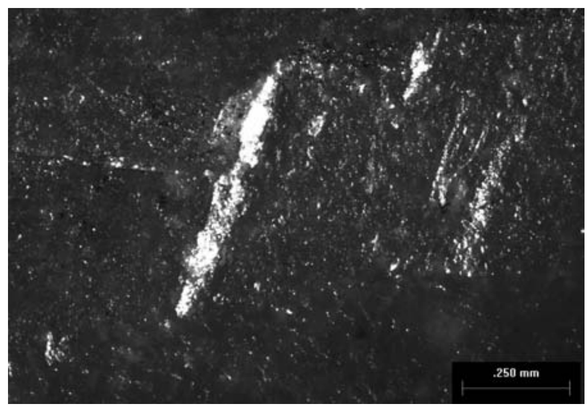



**Figure D-22.06.** Scratches form relatively deep grooves across facet.

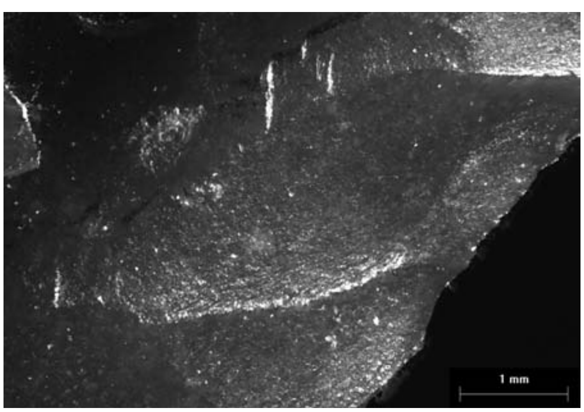



**Figure D-22.07.** Scratches are roughly diagonal to lateral margin.

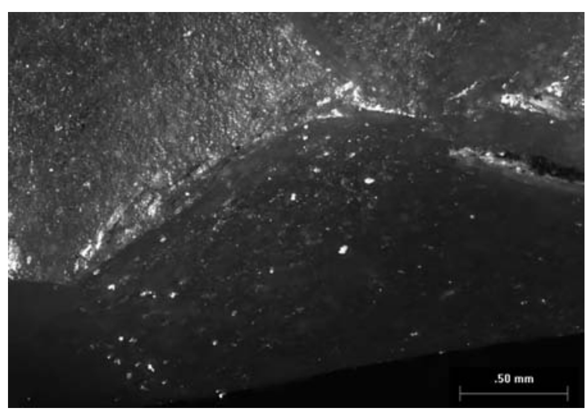



**Figure D-22.08.** Lateral margin at midpoint of blade exhibits rounding and minor polish consistent with modifications resulting from hafting.

continued.

***Artifact ID: 1158***
(concluded)

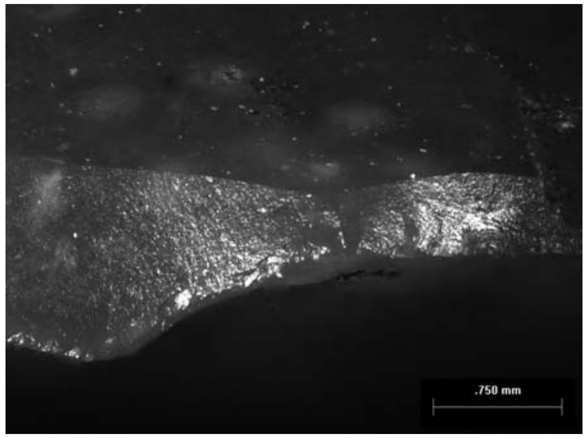



**Figure D-22.09.** Proximal margin exhibits minor rounding and faint gloss that are likely due to hafting-derived modifications.

***Artifact ID: 1249***

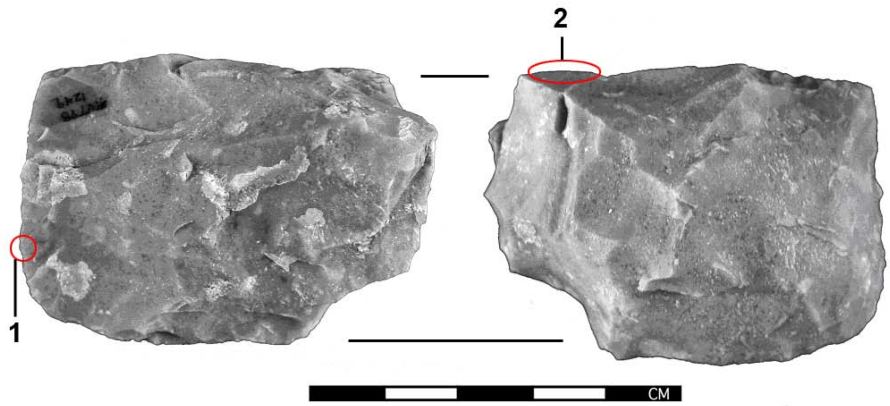



**Figure D-23.** Clear Fork Biface (Adze) (Catalog/ID# 1249) from Unit S20W90, Level 9.

***Classification***

**Artifact Class:** Non-Biface/Uniface; **Artifact Subclass:** Formal (crude); **Artifact Type:** Clear Fork, Adze.

***Characteristics***

**Length:** 57 mm; **Width:** 42 mm; **Thickness:** 23 mm; **Weight:** 59.5 g; **Edge Angle:** 65°; **Portion:** complete (recycled?); **Raw Material Type:** coarse chert; **Alteration:** very minor oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** shallow distal; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-hard.

***Comments***

Lateral margins are dulled (rounded) and exhibit a very shallow polish. This polish is almost certainly the result of hafting.

Distal edge damage is very light and polish is very shallow on both ventral and dorsal faces. The distribution of marginal attrition along the distal edge indicates that the tool was used in a chopping or adzing function.

The shallowness of polish suggests that the tool did not penetrate deeply into the contact material. This argues that the hardness of the contact material was medium-hard, which may indicate that the tool was used on hardwood or bone.

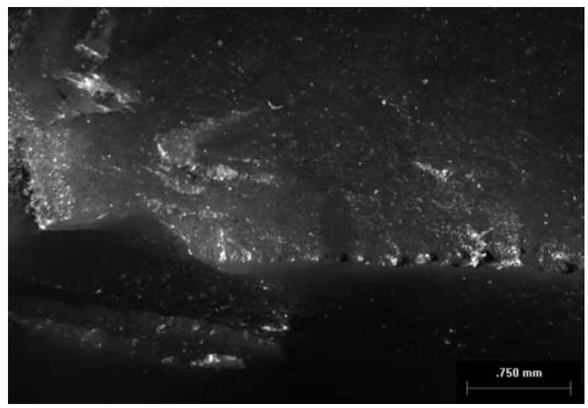



**Figure D-23.01.** Proximal margin exhibits minor rounding.

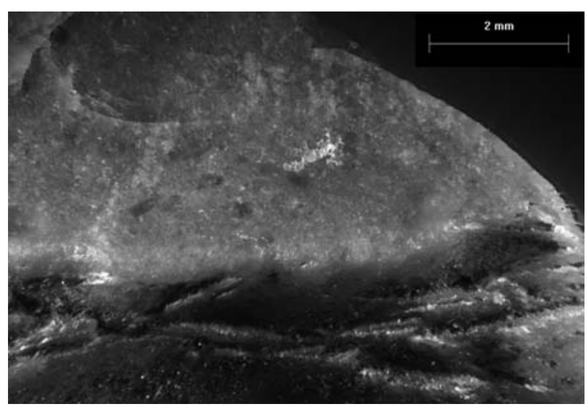



**Figure D-23.02.** Distal margin exhibits fracturing, edge rounding and very shallow polish. Wear most likely resulted from chopping or adzing a medium-hard contact material such as hard wood or bone. Penetration into contact material was shallow.

***Artifact ID: 1292***

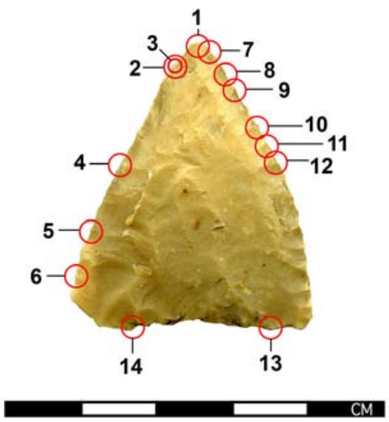



**Figure D-24.** Early Triangular Point (Catalog/ID# 1292) from Unit S36W116, Level 10.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Early Triangular point.

***Characteristics***

**Length:** 38 mm; **Width:** 32 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal-lateral; **Polish:** shallow distal-lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate (very likely based on marginal edge abrasion); **Contact Material Hardness:** soft.

***Comments***

This artifact fits the description of an Early Triangular dart point (Turner and Hester 1983:89). The artifact displays short parallel-oblique flaking and has alternately beveled edges.

The medial basal margin has been thinned, likely in preparation for hafting. Other triangular points in the Buckeye Knoll collection exhibit similar thinning along the basal margin. Edge rounding is observed along the basal margin and at the corners. This form of modification is consistent with expected alterations resulting from abrasion hafting.

The distal tip of the tool displays a spiral fracture that most likely resulted from impact. The lateral margins exhibit step fractures with smooth interior facets. Polish is more developed on fracture planes closer to the tool edge.

The edge modification recorded support the hypothesis that this tool was used as a projectile point.

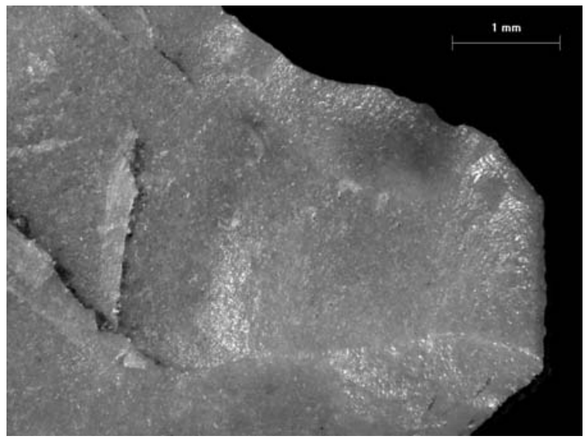



**Figure D-24.01.** Distal tip exhibits attrition consistent with impact fracturing.

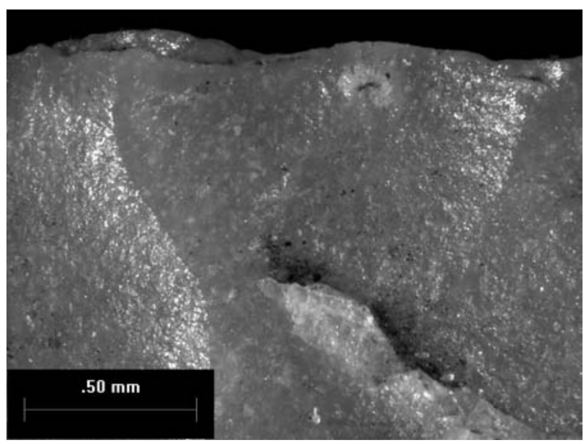



**Figure D-24.02.** Lateral margin near distal end exhibits rounding and shallow, well-developed polish.

continued.

***Artifact ID: 1292***

(continued)

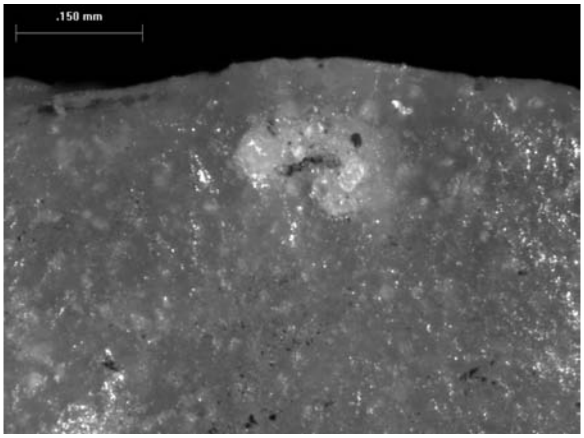



**Figure D-24.03.** Polish development along lateral margin near distal tip.

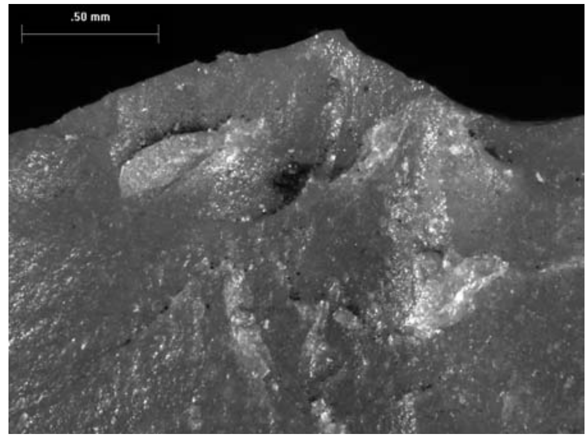



**Figure D-24.04.** Lateral margin near midpoint of blade exhibits modest rounding.

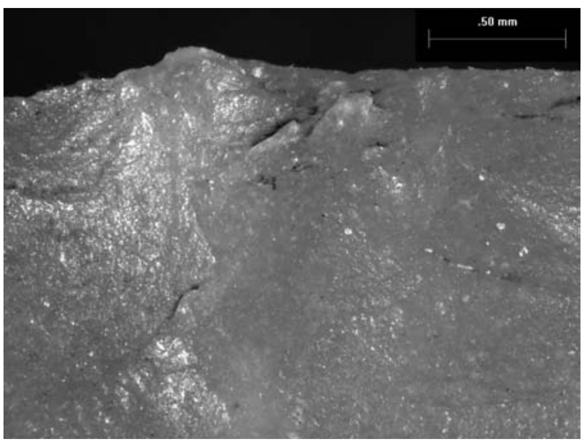



**Figure D-24.05.** Lateral margin near base exhibits some rounding and minor gloss.

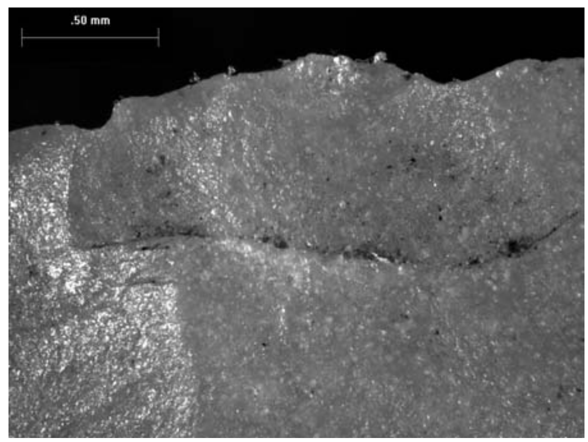



**Figure D-24.06.** Lateral margin above basal corner exhibits facet rounding and poorly-developed gloss. This pattern of modification is consistent with edge wear resulting from hafting.

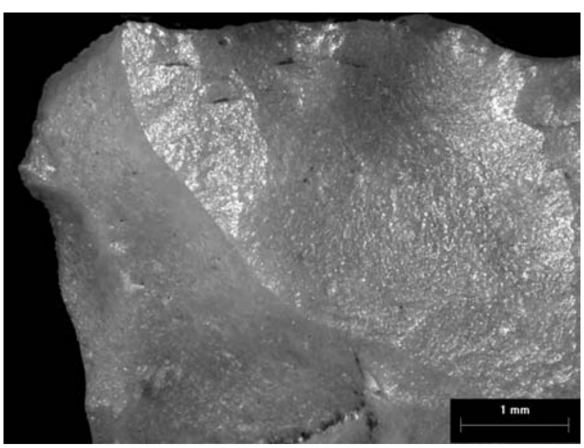



**Figure D-24.07.** Lateral margin at distal tip exhibits edge rounding and deep, well-developed polish.

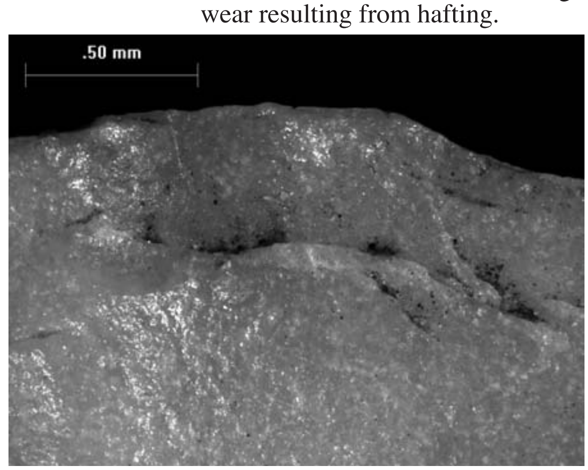



**Figure D-24.08.** Polish observed on lateral margin near distal tip.

continued.

***Artifact ID: 1292***
(concluded)

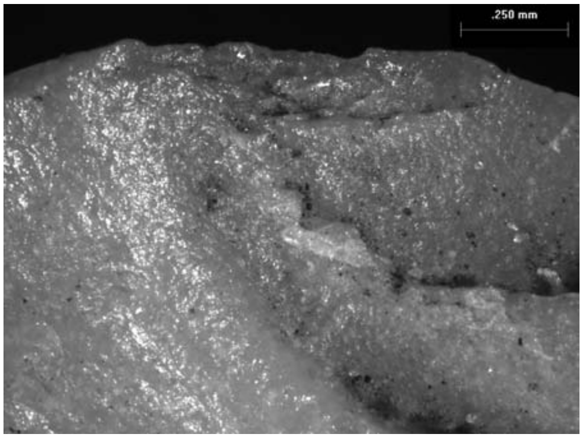



**Figure D-24.09.** Polish and facet rounding observed on lateral margin near distal tip.

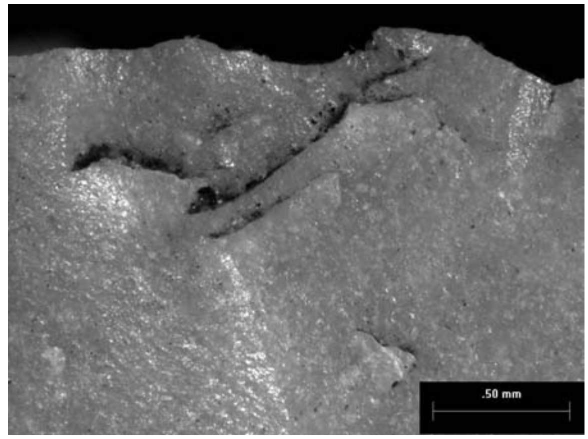



**Figure D-24.10.** Edge modification is not as well developed at midsection as it is nearer the distal tip. Minor edge rounding and faint polish is still observed.

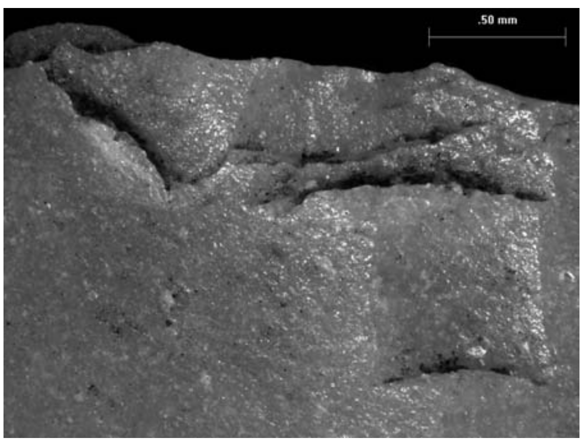



**Figure D-24.11.** Minor edge rounding and polish observed along lateral margin at midpoint of blade.

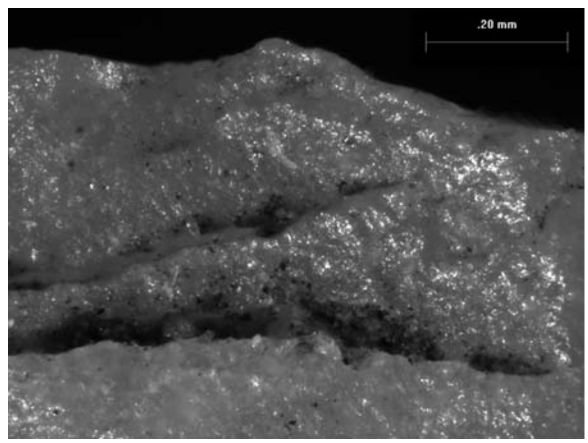



**Figure D-24.12.** Polish and edge rounding recorded along lateral margin at midpoint of blade.

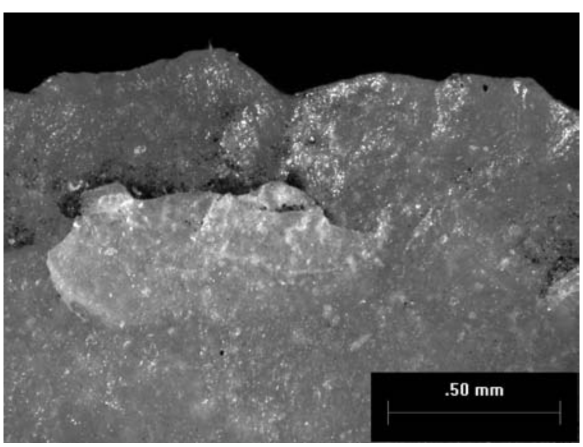



**Figure D-24.13.** Shallow polish is observed along the basal margin of the tool.

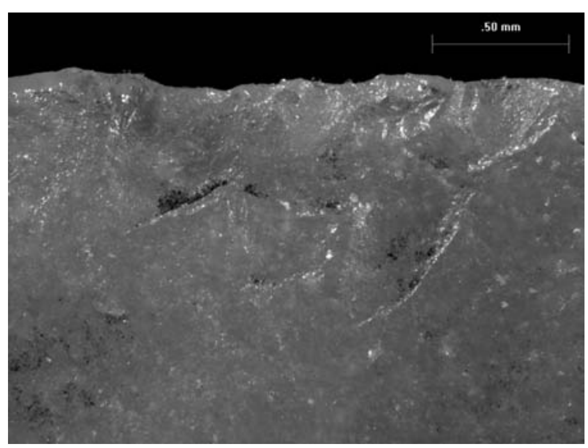



**Figure D-24.14.** Attrition and shallow polish are observed along basal margin of tool.

***Artifact ID: 1298***

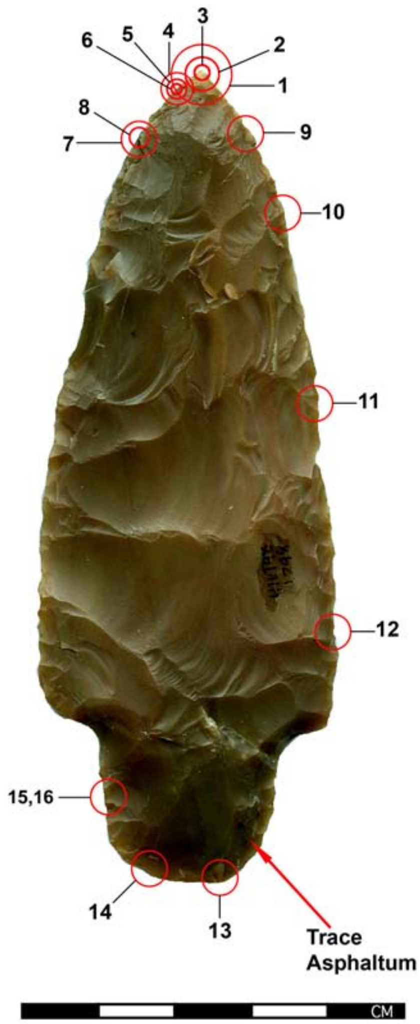



**Figure D-25.** Projectile Point (Catalog/ID# 1298) from Unit S16W84, Level 10.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

***Characteristics***

**Length:** 108 mm (stem=20 mm); **Width:** 41 mm (stem=25 mm); **Thickness:** 10 mm; **Weight:** (unrecorded); **Edge Angle:** 50°; **Portion:** complete; **Raw Material Type:** chert (very fine grained); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal-bifacial; **Polish:** distal; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft/medium-soft.

***Comments***

The chert from which this tool has been constructed is very fine-grained.

Some polish and edge rounding are located along the lateral margins near the distal tip. Polish is shallow, being restricted to the extreme margin. Some attrition can be observed near the distal tip, but it is dissimilar to an impact fracture.

Edge attrition, marginal rounding and polish are generally restricted to the upper one-quarter of the blade. No clear evidence of use-wear is present along the margins on the lower three-quarters of the blade.

Polish and edge rounding are also observed along the basal margin. The stem exhibits small step fractures and very minor polish along its edges. These modifications indicate that the tool was hafted. Supporting this conclusion is a very trace amount of asphaltum caught in a step fracture on the face of the stem (labeled side).

Use-wear analysis supports the hypothesis that this tool was used for piercing or thrusting into a soft to medium-soft contact material, but not likely with any great velocity.

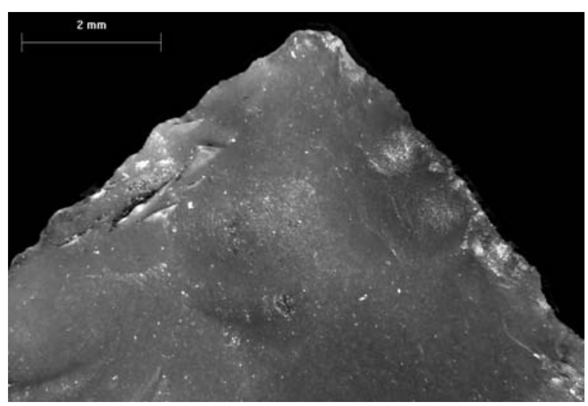



**Figure D-25.01.** Minor attrition noted along lateral margins at distal tip.

continued.

***Artifact ID: 1298***
(continued)

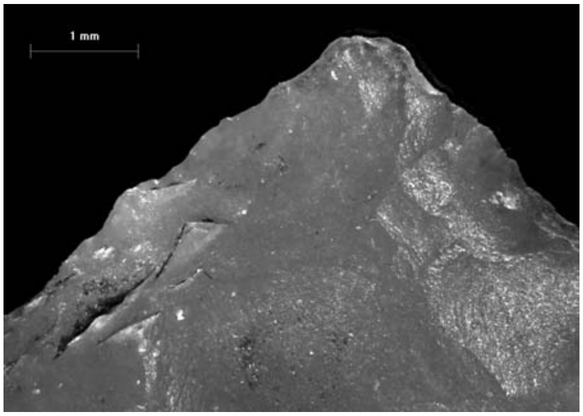



**Figure D-25.02.** Polish at distal tip is poorly-developed and shallow.

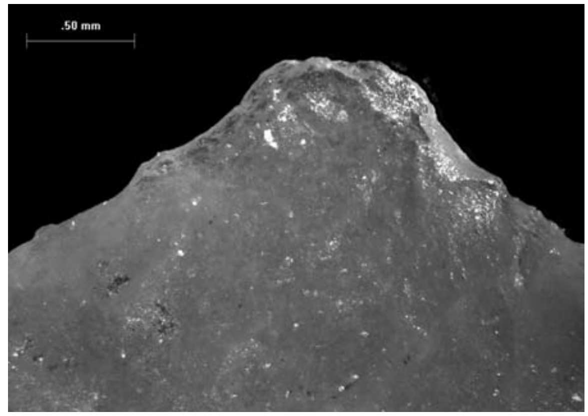



**Figure D-25.03.** Attrition noted at tip is not consistent with impact fracturing.

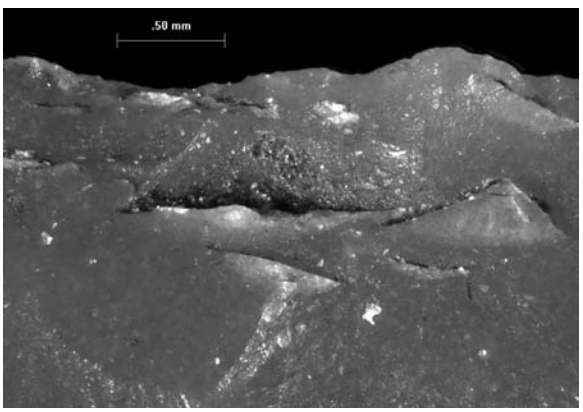



**Figure D-25.04.** Facets along margin at distal tip are not notably modified. In general, the tool exhibits very little evidence of use.

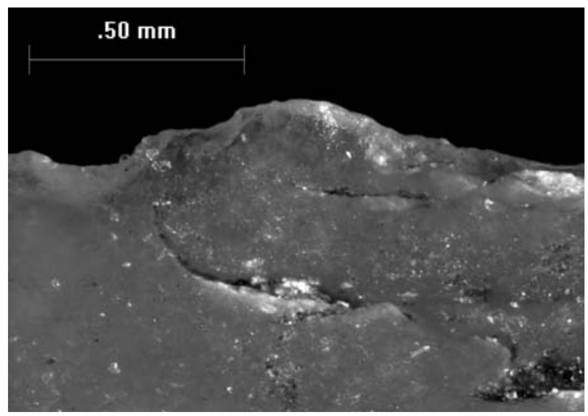



**Figure D-25.05.** Minor edge rounding observed on lateral margin near distal tip.

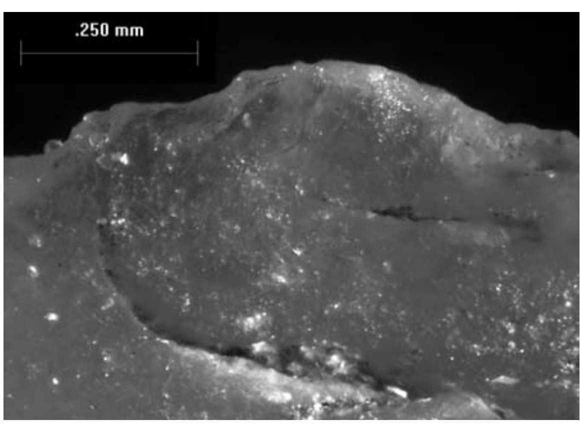



**Figure D-25.06.** Minor edge rounding observed at higher magnification on lateral margin near distal tip.

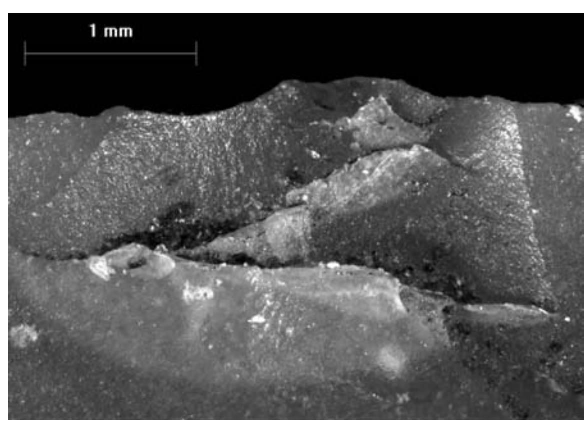



**Figure D-25.07.** Lateral margin along distal quarter of blade showing faint, shallow, poorly-developed polish.

continued.

***Artifact ID: 1298***
(continued)

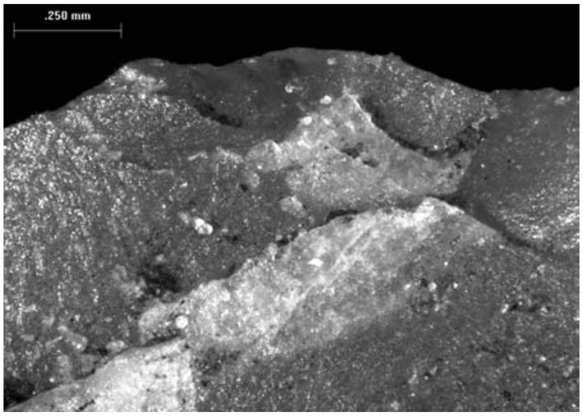



**Figure D-25.08.** Lateral margin along distal quarter of blade observed at higher magnification showing faint, shallow, poorly-developed polish.

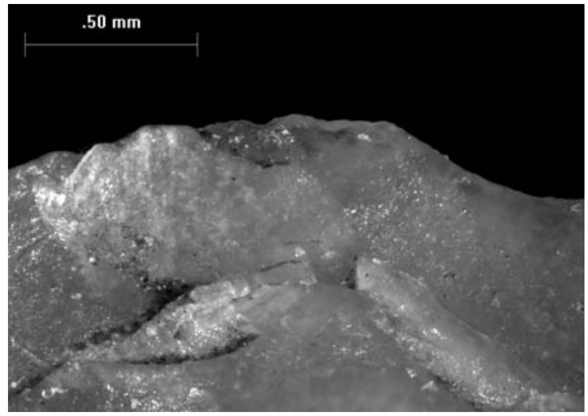



**Figure D-25.09.** Lateral margin along distal quarter of blade showing faint, shallow, poorly-developed polish.

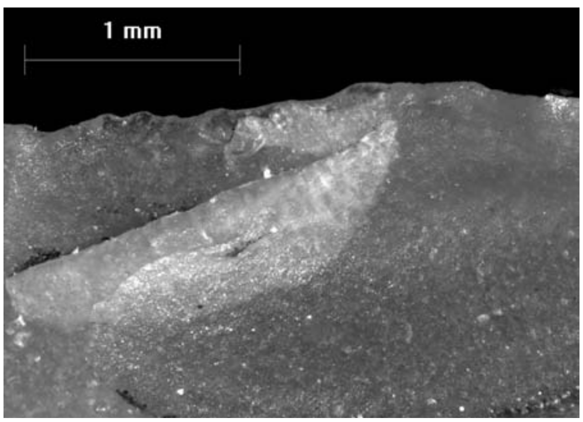



**Figure D-25.10.** Lateral margin along distal quarter of blade showing faint, shallow, poorly-developed polish.

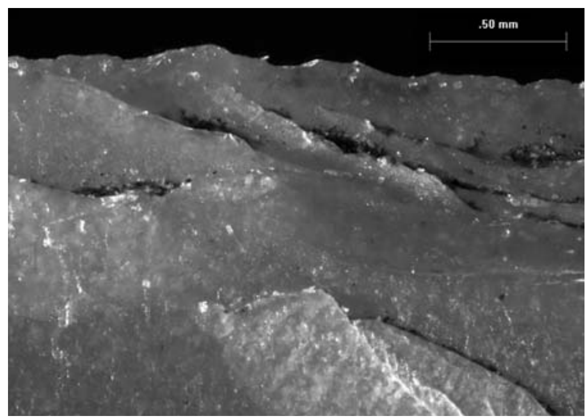



**Figure D-25.11.** Lateral margin observed at midpoint of blade exhibits no edge rounding and no clear evidence of polish development.

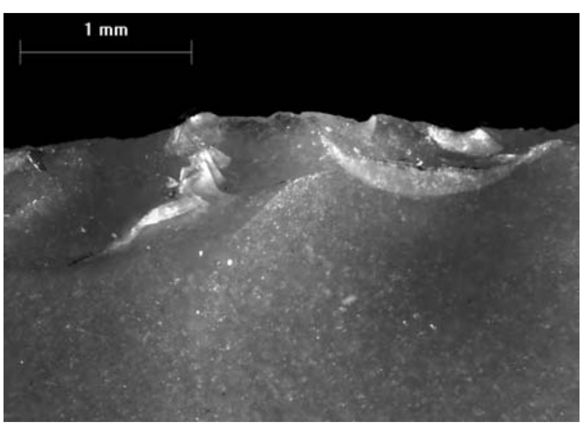



**Figure D-25.12.** Lateral margin at base of blade exhibits no evidence of wear.

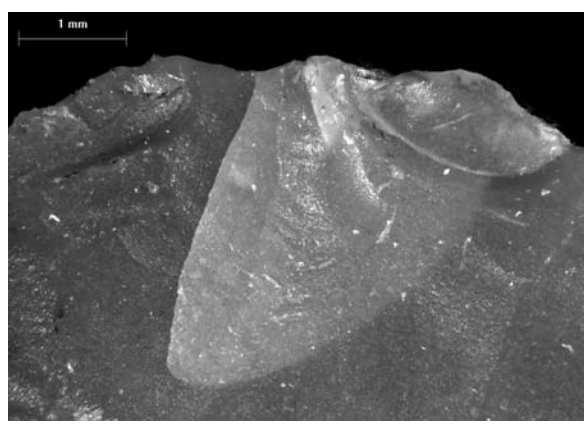



**Figure D-25.13.** Basal margin exhibits minor attrition and faint polish development consistent with hafting-derived modification.

continued.

***Artifact ID: 1298***
(concluded)

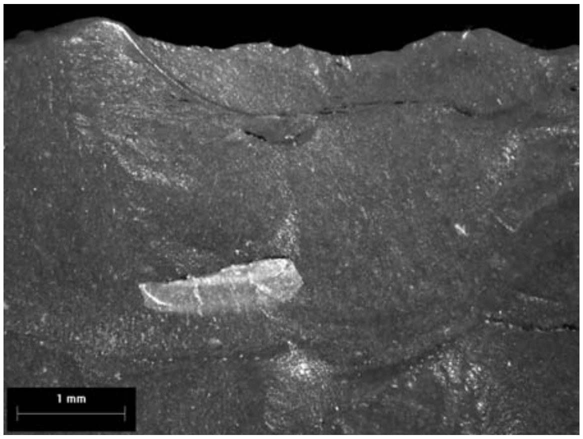



**Figure D-25.14.** Basal margin exhibits minor attrition and faint polish development consistent with hafting-derived modification.

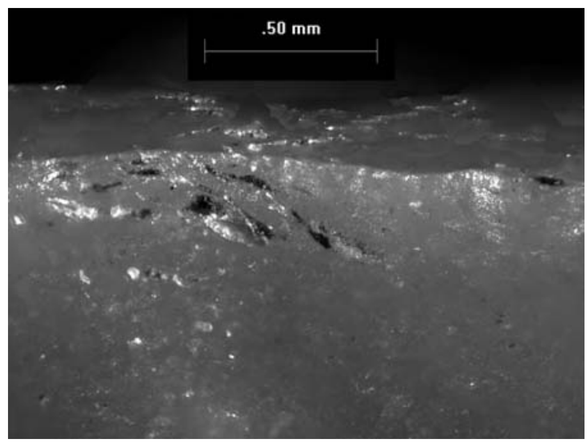



**Figure D-25.15.** Side margin of stem exhibits minor rounding and shallow polish consistent with hafting-derived modification.

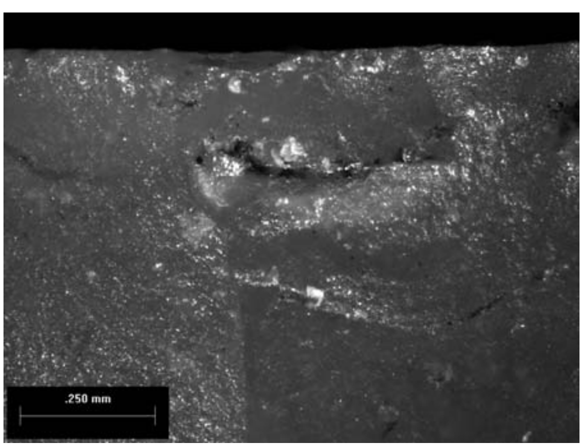



**Figure D-25.16.** Side margin of stem shown at higher magnification exhibiting minor rounding and shallow polish consistent with hafting-derived modification.

***Artifact ID: 1378***

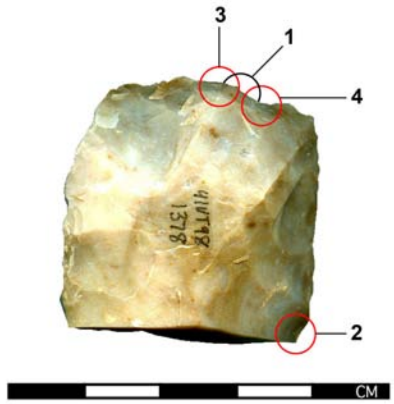



**Figure D-26.** Clear Fork Biface (Adze or Gouge) (Catalog/ID# 1378) from Unit S6W84, Level 23.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Adze or gouge, Clear Fork (?)

***Characteristics***

**Length:** 35 mm; **Width:** 37 mm; **Thickness:** 16 mm; **Weight:** 24.9 g; **Edge Angle:** 85°; **Portion:** distal; **Raw Material Type:** mottled chert; **Alteration:** minor oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal-unifacial; **Polish:** shallow distal (muted); **Battering:** distal; **Etching:** shallow distal; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-hard/hard.

***Comments***

Lateral margins appear abraded and worn (smoothed) with muted polish.

Multiple step and hinge fractures occur along the distal bit, but they are only expressed across the dorsal face. This suggests that the force of impact was not equally distributed at the distal edge. This unidirectional focus in the force of impact during use supports the hypothesis that the tool was used as either an adze or gouge.

Very shallow, dull polish is noted distributed sporadically across the distal bit. Rejuvenation efforts in the form of flake removals are observed along the distal margin. Such efforts were logically focused on resharpening the working bit. However, these modifications render the assessment of function somewhat less certain, as they have removed much of the evidence relating to the tool's original use. The tool may have failed due to a medial snap fracture during recycling.

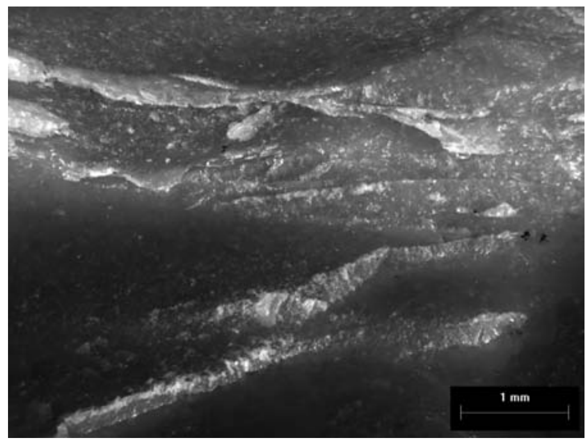



**Figure D-26.01.** Abrasion and shall polish at lateral margin resembles modification resulting from hafting.

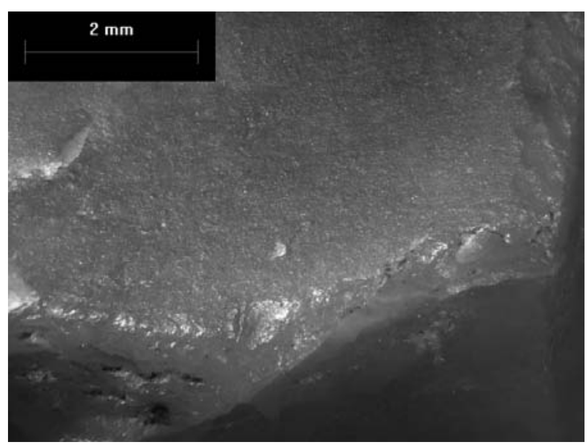



**Figure D-26.02.** Photo shows wear and abrasion at corner, which may suggest that artifact was hafted and used after medial snap fracture.

continued.

***Artifact ID: 1378***
(concluded)

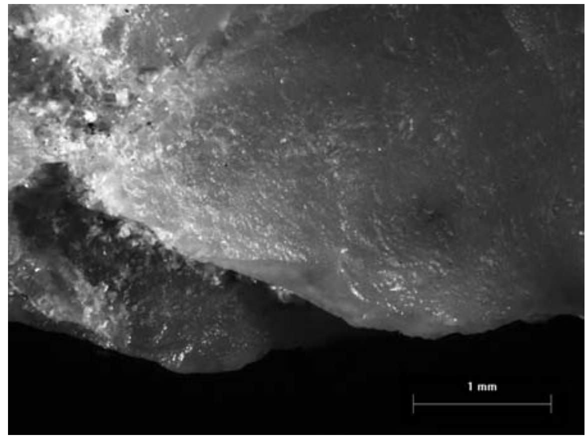



**Figure D-26.03.** Worn and polished edge observed at distal margin. Shallowness of polish suggests contact material was relatively hard as well as siliceous.

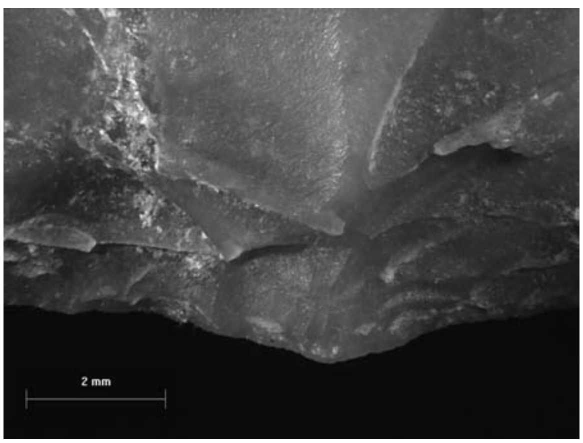



**Figure D-26.04.** Step and hinge fractures recorded at distal margin. Attrition pattern suggests contact with a material of medium-hard hardness such as hardwoods.

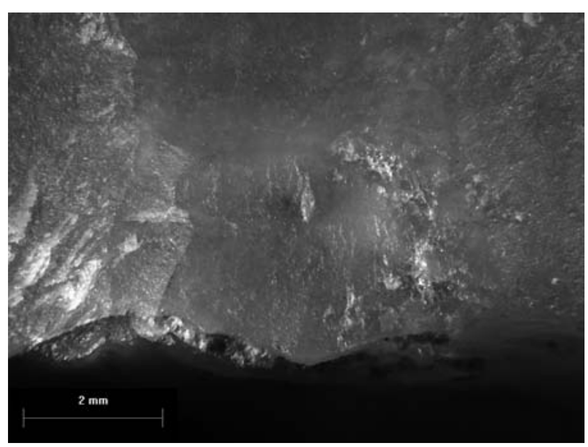



**Figure D-26.05.** Shallow polish observed along distal margin.

## Artifact ID: 1385

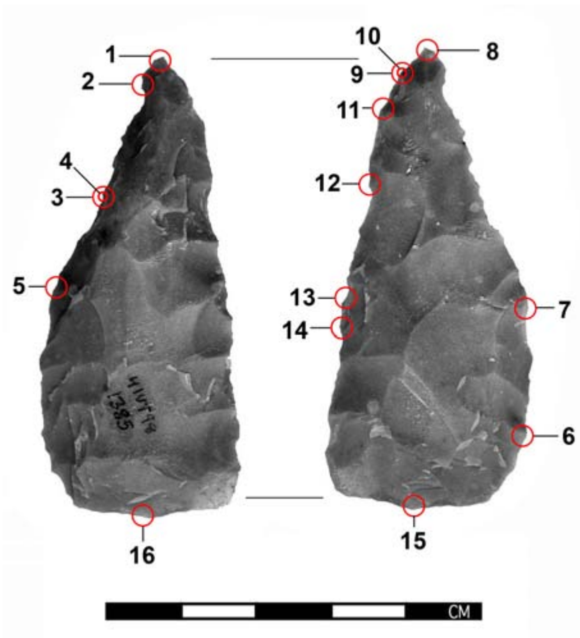



**Figure D-27.** Knife (Catalog/ID# 1385) from Unit S32W117, Level 2.

### Classification

**Artifact Class:** Biface (crude / rejuvenated); **Artifact Subclass:** Informal; **Artifact Type:** knife.

### Characteristics

**Length:** 61 mm; **Width:** 27 mm; **Thickness:** 8 mm; **Weight:** (unrecorded); **Edge Angle:** 50°-60°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

### Use-Wear Pattern

**Edge Attrition:** bilateral-unifacial; **Polish:** some rounding and shallow polish along midpoint of blade; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** none; **Contact Material Hardness:** medium-soft.

### Comments

Distal and proximal edges appear sharp and unworn. Medial margin exhibits minor rounding, minor attrition, and faint, shallow polish. As the observed attrition pattern along the work edges is predominantly unifacial, the artifact was most likely used in a whittling function rather than slicing. Based on it design, the artifact may represent a recycled form.

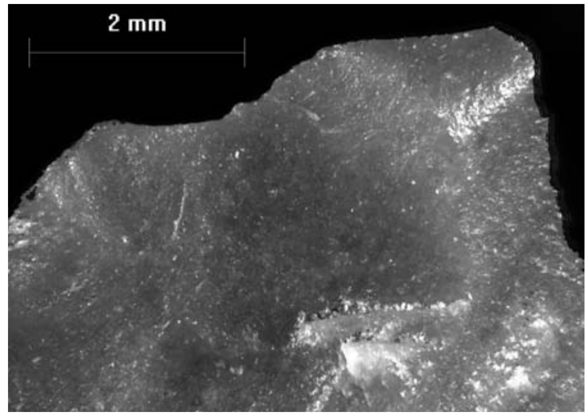



**Figure D-27.01.** Distal tip exhibits sharp, unworn edges.

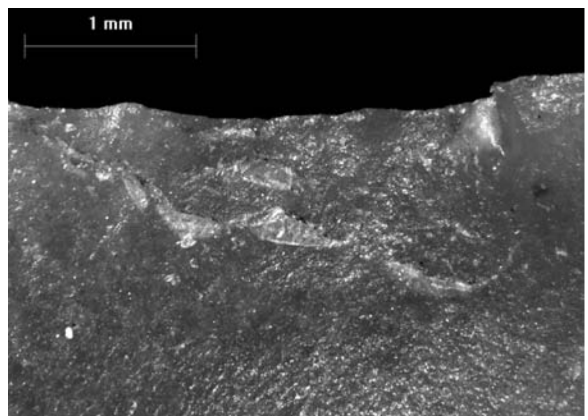



**Figure D-27.02.** Lateral margin near tip exhibits sharp terminations. Edge appears to be unworn.

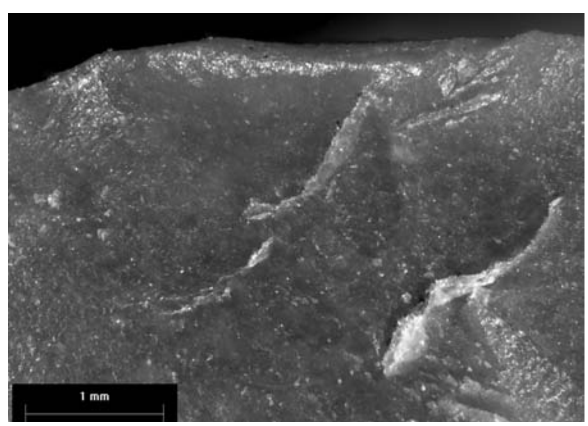



**Figure D-27.03.** Lateral margin at midpoint of blade exhibits edge rounding.

continued.

***Artifact ID: 1385***
(continued)

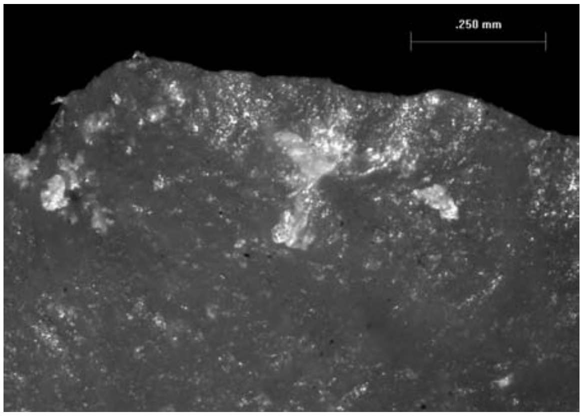



**Figure D-27.04.** Lateral margin at midpoint of blade shows edge attrition and silica deposition consistent with use against a medium-soft contact material.

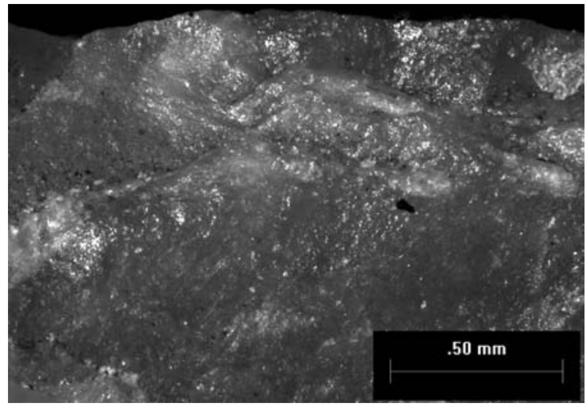



**Figure D-27.05.** Lateral margin near midpoint of blade exhibits minor facet rounding along edge and shallow polish.

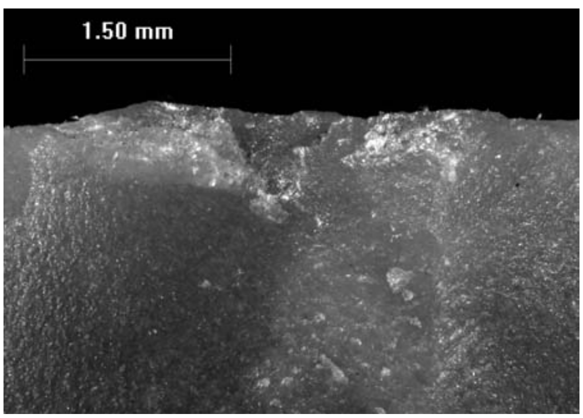



**Figure D-27.06.** Lateral margin near base does not exhibit evidence of wear.

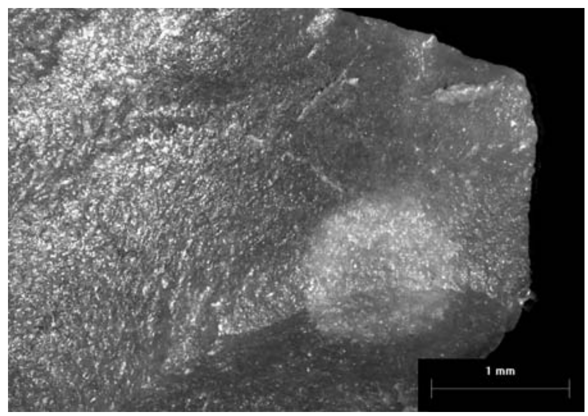



**Figure D-27.07.** Evidence for modification is ambiguous at tip.

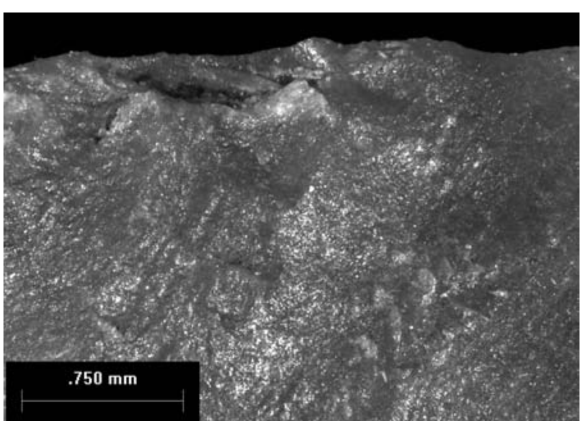



**Figure D-27.08.** Lateral margin near tip exhibits some possible edge rounding.

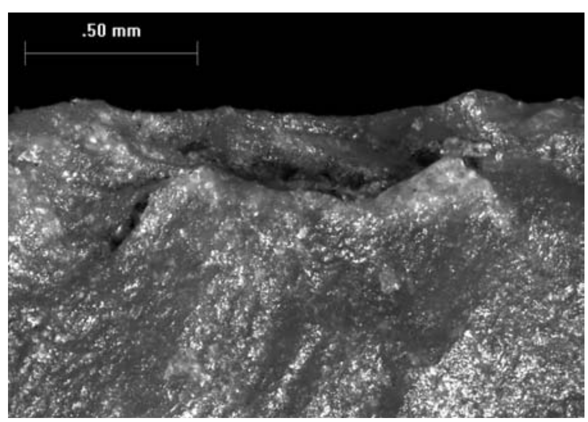



**Figure D-27.09.** Lateral margin near tip shown at higher magnification exhibiting minor edge rounding.

continued.

***Artifact ID: 1385***
(concluded)

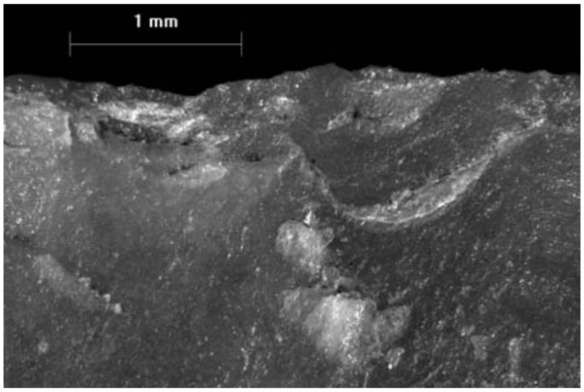



**Figure D-27.10.** Lateral margin along upper quarter of blade showing fracturing along edge. Fractures are more likely remnant from tool manufacture than use-derived attrition.

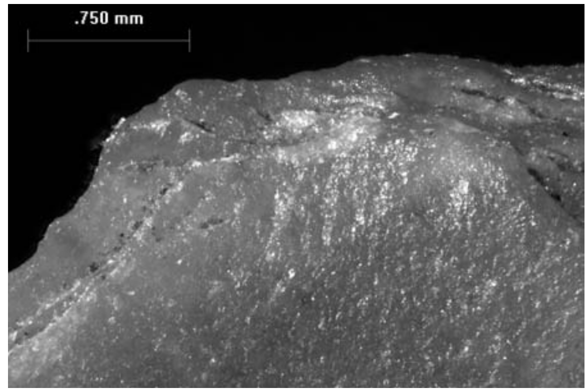



**Figure D-27.11.** Lateral margin near midpoint exhibits minor edge rounding.

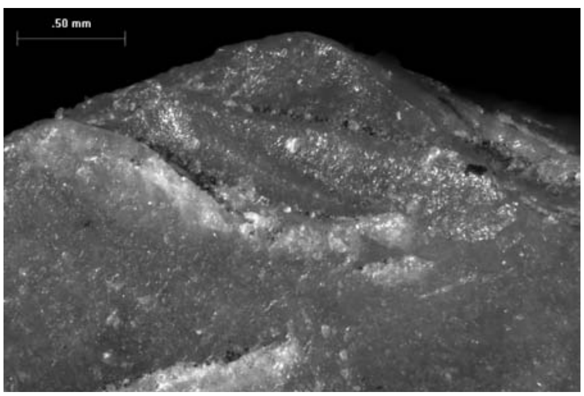



**Figure D-27.12.** Lateral margin near midpoint exhibits minor edge rounding and shallow polish.

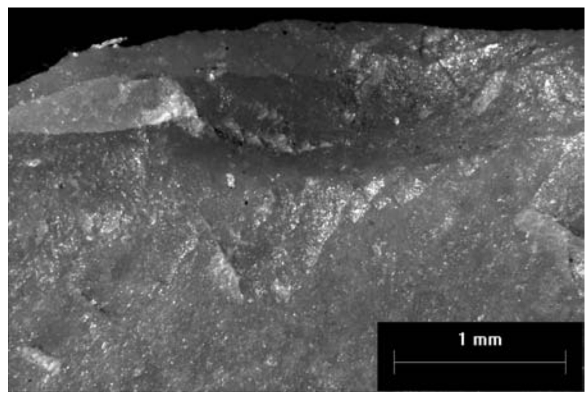



**Figure D-27.13.** Lateral margin near midpoint (closer to base) does not exhibit unambiguous evidence of edge rounding. Most evidence of wear is restricted to margins along midsection of blade.

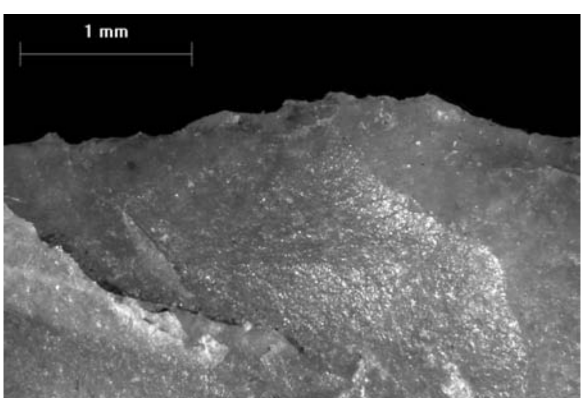



**Figure D-27.14.** Basal edge does not exhibit use-derived modification.

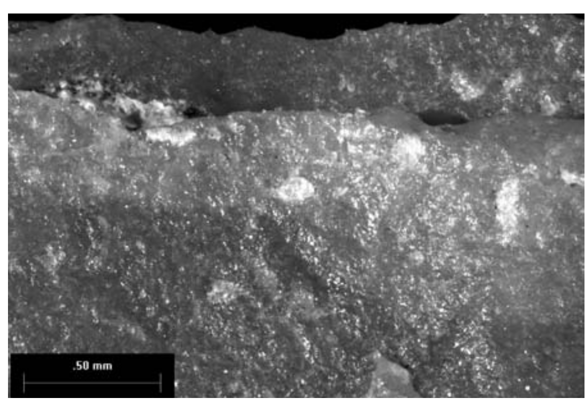



**Figure D-27.15.** Basal edge does not exhibit use-derived modification.

***Artifact ID: 1580***

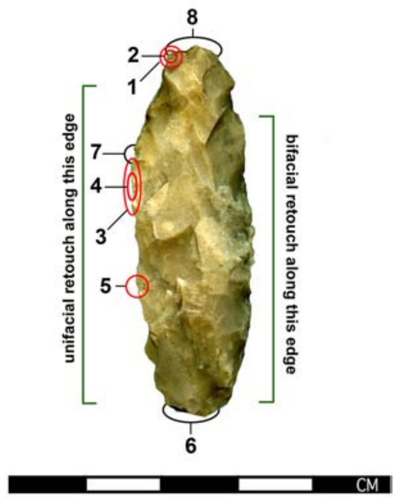



**Figure D-28.** Projectile Point(?) (Catalog/ID# 1580) from Unit S12W90, Level 16.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate (crude); **Artifact Type:** Projectile point (?).

***Characteristics***

**Length:** 49 mm; **Width:** 16 mm; **Thickness:** 7 mm; **Weight:** (unrecorded); **Edge Angle:** 65°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** shallow marginal; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate; **Contact Material Hardness:** medium (medium-hard).

***Comments***

The wear pattern recorded on this artifact fits the attribute expectations of a projectile point. Polish and rounding are noted along the lateral margins on the proximal half of the blade. This modification is thought to have resulted from hafting. There is no clear evidence of modification along the proximal margin. A modest polish is observed along the lateral margin on the distal half of the blade. This polish is most strongly exhibited on facets and protrusions.

The distal tip exhibits what is most likely an impact fracture replete with distally emanating flake removals terminating in step fractures. Edge modification also can be observed along the lateral margins. One margin exhibits unifacial pressure retouch, while the other exhibits delicate bilateral retouch.

Edge production along the proximal one-quarter of the blade appears crude. While there is clear evidence that this tool was used, it appears never to have been as finely crafter as other similar tools in the collection.

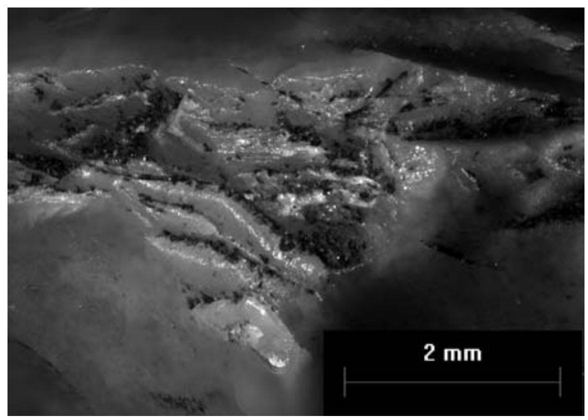



**Figure D-28.01.** Fracturing, edge rounding and shallow polish observed at distal margin. Fracturing may have resulted from impact, but fractured facets have become well-rounded and polished.

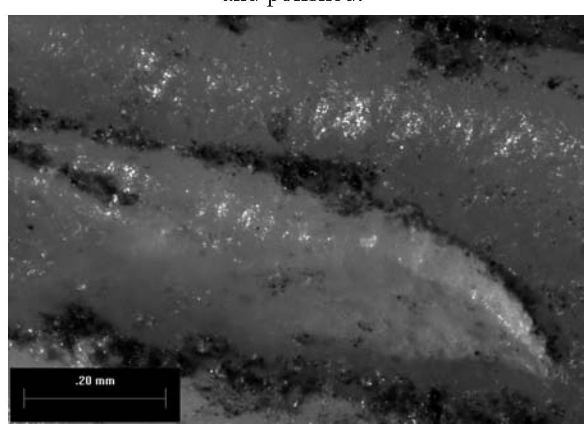



**Figure D-28.02.** Fracturing, edge rounding and shallow polish observed at higher magnification along distal margin.

continued.

***Artifact ID: 1580***
(concluded)

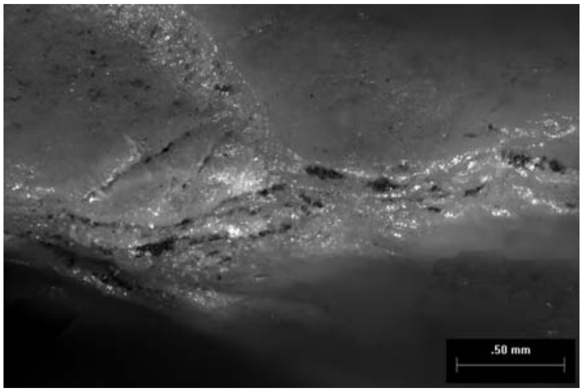



**Figure D-28.03.** Lateral margin at midpoint of blade exhibits step fractures and moderate facet rounding.

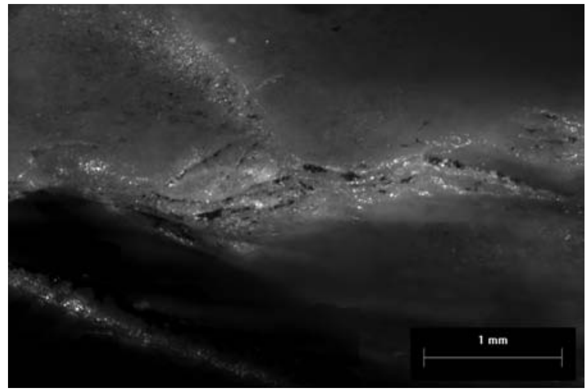



**Figure D-28.04.** Attrition observed along lateral margin near midpoint of blade does not appear to favor one face over the other, suggesting an even motion such as slicing or thrusting.

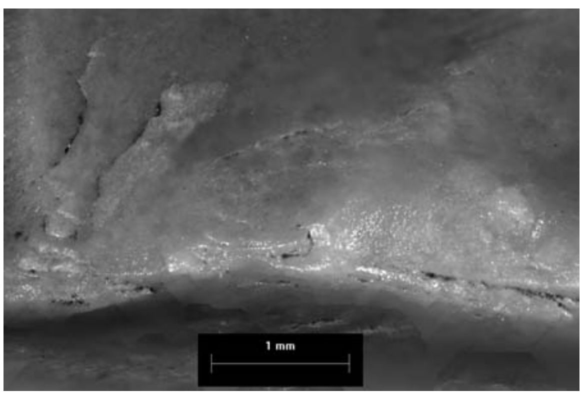



**Figure D-28.05.** Lateral margin at proximal mid-section exhibits edge rounding.

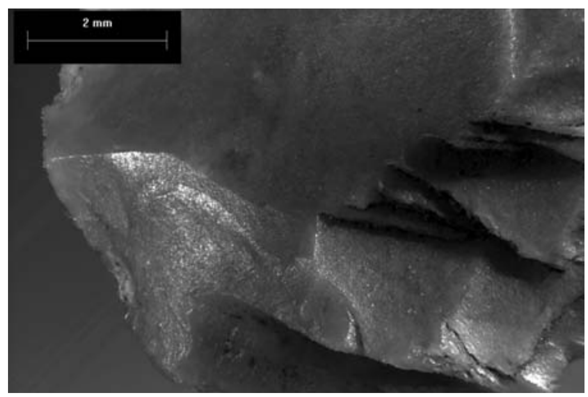



**Figure D-28.06.** Proximal margin does not exhibit modification.

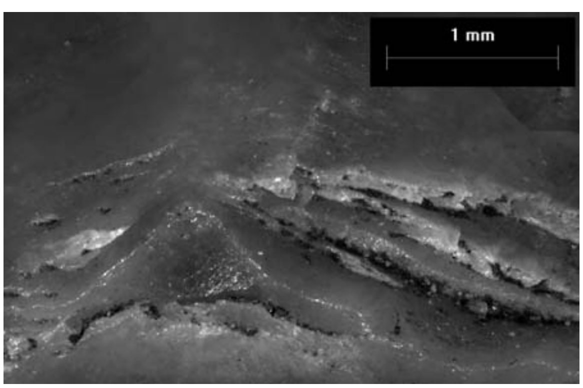



**Figure D-28.07.** Fracturing along lateral margin at distal midsection shows minor edge rounding.

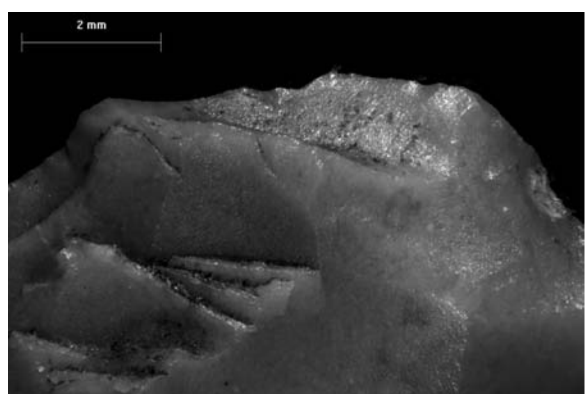



**Figure D-28.08.** Distal margin has possible impact fracture that has been remodeled through edge rounding and shal-low polish development.

***Artifact ID: 1581***

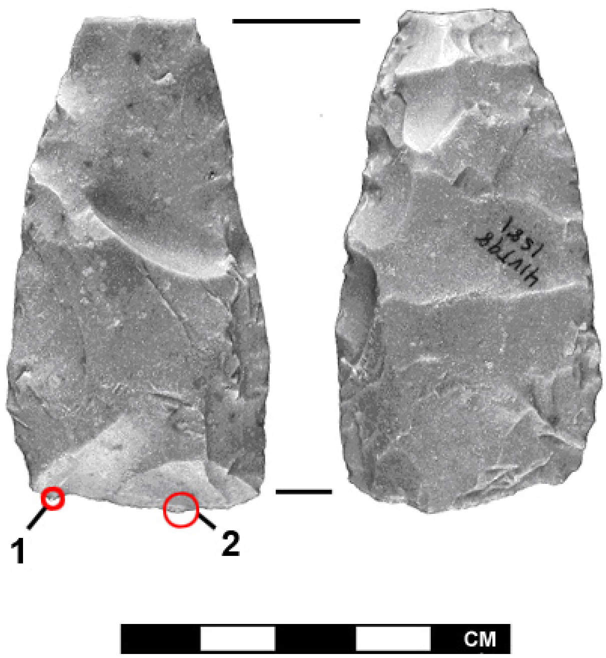



**Figure D-29.** Adze (Catalog/ID# 1581) from Unit S12W90, Level 16.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Adze.

***Characteristics***

**Length:** 65 mm; **Width:** 34 mm; **Thickness:** 13 mm; **Weight:** 30.3 g; **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** coarse chert; **Alteration:** none observed.

***Use-Wear Pattern***

**Edge Attrition:** distal-bifacial; **Polish:** shall distal (dorsal), deep distal (ventral); **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-hard.

***Comments***

Shallow polish is observed along the distal margin, appearing deeper along the ventral surface. Deep polish along the proximal margin is present. This modification is undoubtedly the result of hafting. The tool's edges each display very shallow polish and are dulled through rounding. One edge (right, from dorsal view) appears to have been intentionally ground. The opposite lateral margin appears dulled (rounded), but no evidence of grinding is observed. Upper left corner of bit (dorsal view) displays the greatest evidence of wear, exhibiting deep ventral-focused polish and pronounced step fractures on each face.

The use-wear pattern observed supports defining the tool as an adze. The contact material would most likely have been of medium-hard hardness.

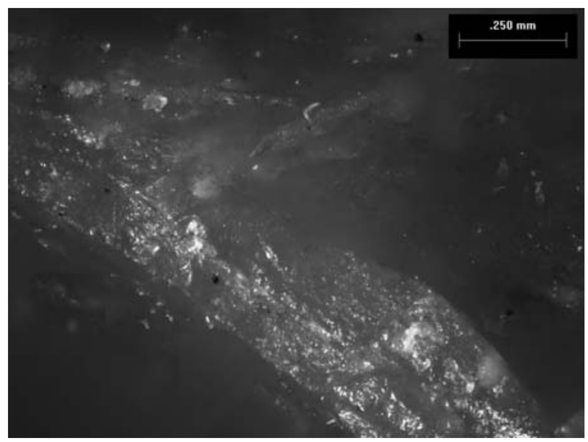



**Figure D-29.01.** Edge attrition along distal margin has been rounded and a shallow, well-developed polish can be seen along edge.

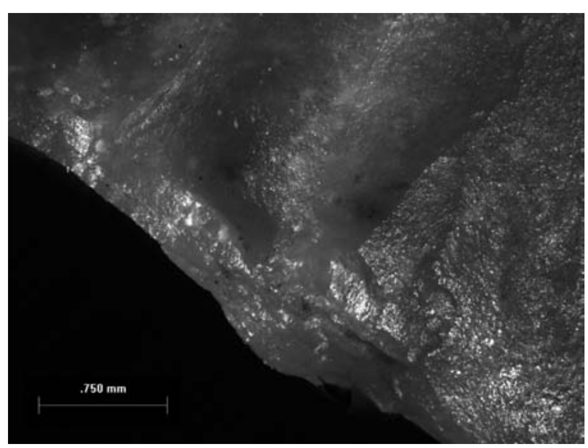



**Figure D-29.02.** Edge rounding and polish noted along distal margin.

*Artifact ID: 1642*

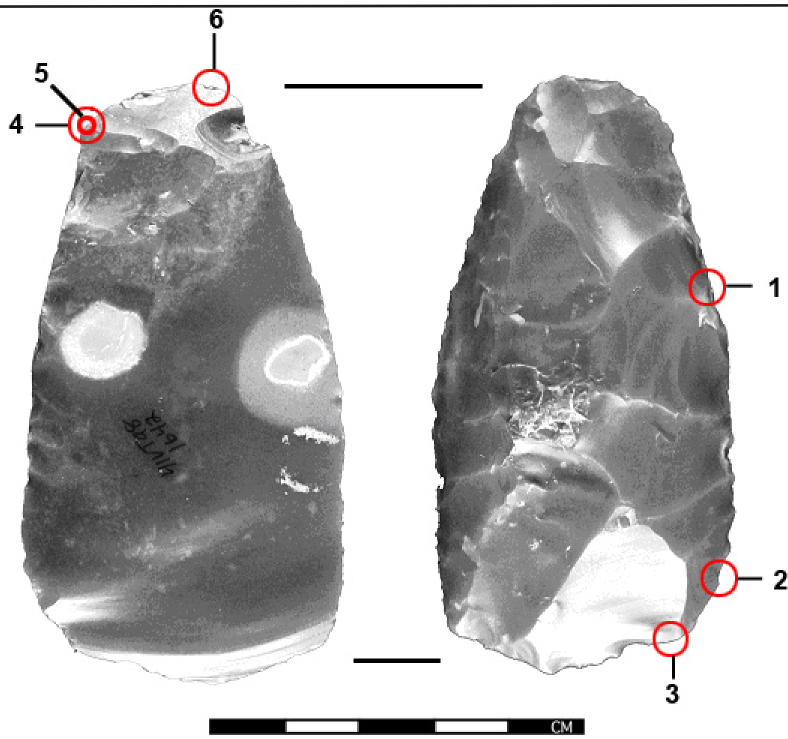



**Figure D-30.** Sub-Uniface (Catalog/ID# 1642) from Unit S12W90, Level 17.

***Classification***

**Artifact Class:** Sub-uniface (modified flake blank; **Artifact Subclass:** Formal; **Artifact Type:** Unidentified.

***Characteristics***

**Length:** 80 mm; **Width:** 42 mm; **Thickness:** 15 mm; **Weight:** 55.0 g; **Edge Angle:** 70° (biface); 60° (unifaces); 55° (distal bit); 80° (base); **Portion:** complete; **Raw Material Type:** fine grained chert; **Alteration:** indeterminate for thermal alteration.

***Use-Wear Pattern***

**Edge Attrition:** unifacial; **Polish:** proximal, lateral; **Battering:** none observed; **Etching:** indeterminate (possibly at base); **Hafting Polish Observed:** indeterminate; **Contact Material Hardness:** soft/ medium-soft.

***Comments***

Artifact was likely crafted from a macro-flake. The quality of the raw material is exceptional, exhibiting some of the finest-grained chert seen in the collection. While there is no definitive evidence to state that the raw material was thermally altered (in terms of color or luster), such a glassy consistency is seldom observed without the material having been heat treated.

The area identified as the distal bit is an unfinished edge of what may have been a large flake. Minor attrition is noted along this edge, but it cannot be unequivocally attributed to use. One of the lateral margins is bifacially worked (left from dorsal view) and exhibits many step fractures along with areas of poorly developed polish and possible edge grinding. The opposite margin is only unifacially modified (right from dorsal view) and is intricately worked with fine pressure flaking producing a smooth edge. However, there is no evidence of wear along this margin. Absence of wear on the unifacially modified lateral margin is inexplicable. Minor traces of attrition on the bifacial margin that appear use-derived may reflect recycling.

The proximal base exhibits the greatest evidence of use-derived wear. Nearly all edge facets along the margin exhibit modestly developed polish and unifacially-focused attrition. It seems possible that what

continued.

***Artifact ID: 1642***
(concluded)

has been described as the proximal base was actually the working bit of the tool, although it is also possible that the attrition and polish observed reflects hafting. The unifacial attrition pattern would best correlate with a scraping action.

It is entirely possible that this tool was never used. Furthermore, it seems possible that it was never intended as a tool. Given the extraordinary properties of the raw material used, this artifact may represent a ritual fetish.

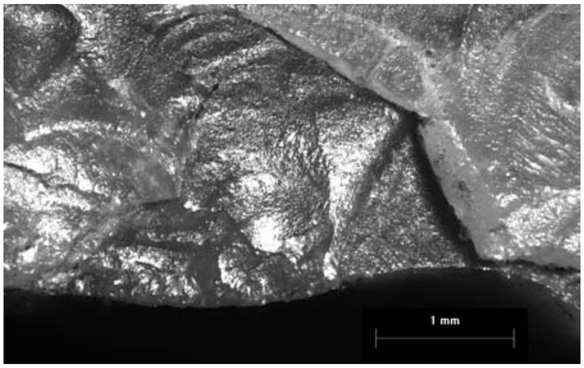



**Figure D-30.01.** Bifacially modified lateral margin near midpoint of tool exhibits poorly-developed polish and minor edge rounding.

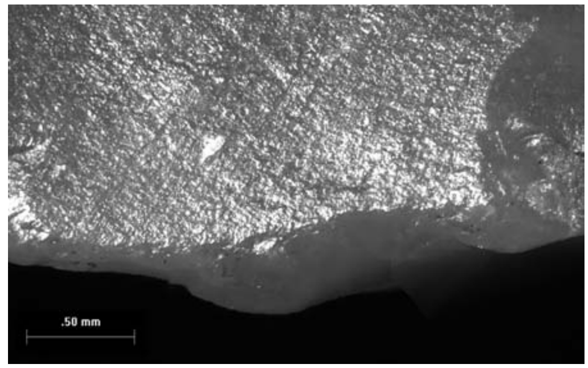



**Figure D-30.02.** Lateral margin near distal end of form exhibits minor edge rounding and poorly-developed polish.

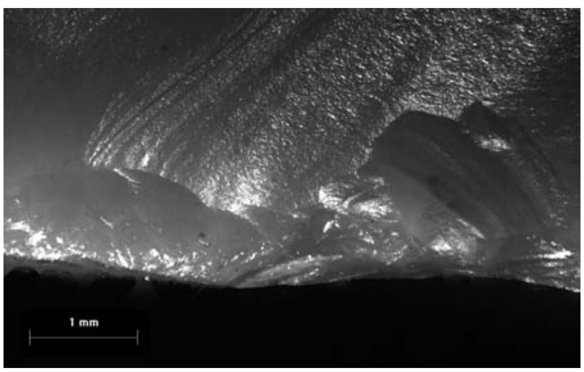



**Figure D-30.03.** Attrition observed along distal margin.

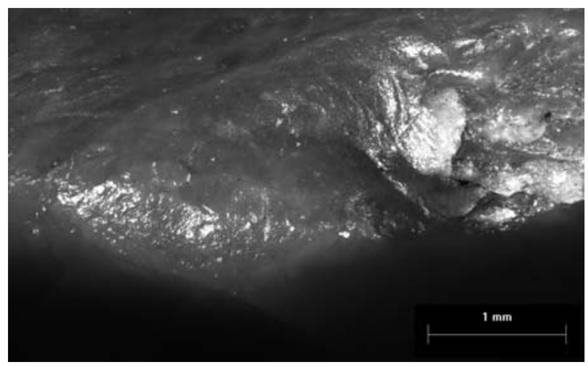



**Figure D-30.04.** Well-developed polish and edge rounding observed near proximal end of form.

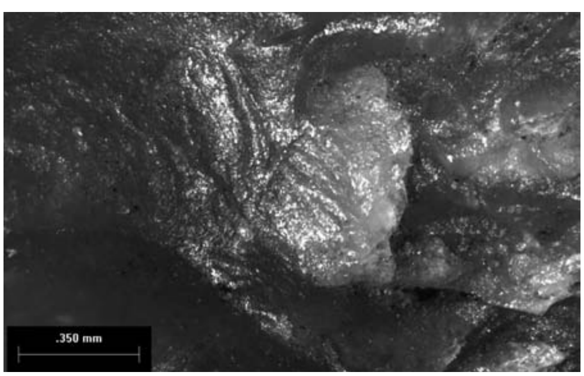



**Figure D-30.05.** Polish developed along proximal margin shown at higher magnification.

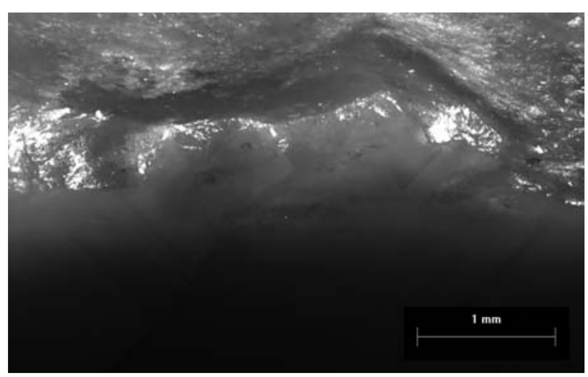



**Figure D-30.06.** Attrition and well-developed polish observed along proximal margin.

## *Artifact ID: 1716*


**Figure D-31.** Awl (Catalog/ID# 1716) from Unit S12W86, Level 11.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Awl.

### *Characteristics*

**Length:** 33 mm; **Width:** 12 mm; **Thickness:** 5 mm; **Weight:** 1.9 g; **Edge Angle:** 55-60°; **Portion:** distal fragment; **Raw Material Type:** banded chert; **Alteration:** none observed.

### *Use-Wear Pattern*

**Edge Attrition:** distal; **Polish:** distal-lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

### *Comments*

This artifact has been described elsewhere as a distal drill fragment based on field observations. However, this ascription is unsupported by either use-wear (bilaterial-unifacial attrition is absent) or edge angle. Use-wear in the form of flake removals is concentrated at the distal tip, though light polish is also evident on lateral margins proximal to the tip.

Spiral fractures (spalls) transverse to the lateral margin at the tip are evident, but are not fully consistent in form with drilling, as the lateral margins and the distal margin lack the sort of abrasive attrition that typically results in ground edges.

Some morphologic similarity to Dalton awls is noted (see Morse 1997:21-22). Flake removals emanating from the distal tip suggest that the tip and distal edges, were points of contact during use. The wear is most consistent with the motion and style of use typical of an awl.

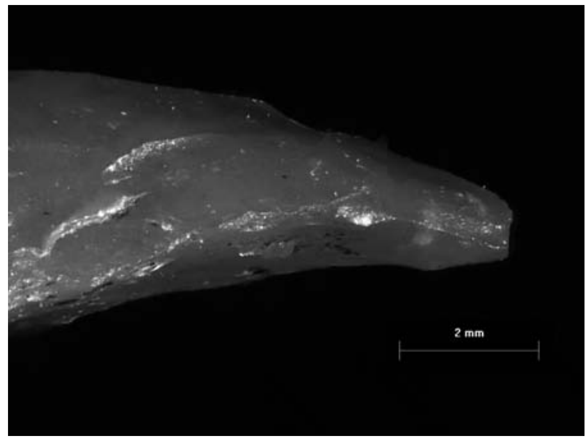



**Figure D-31.01.** Margin at distal tip does not exhibit the pattern of attrition and flake removals expected of a drill, while general form of tool does not match expectations for a projectile point.

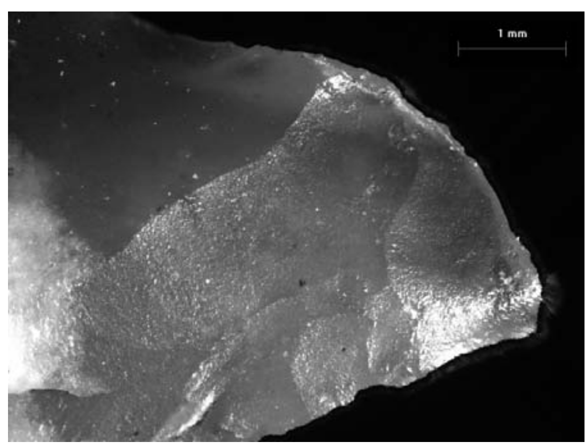



**Figure D-31.02.** Spiral fractures at tip are not fully consistent with drilling, but they do suggest a twisting motion of use.

continued.

***Artifact ID: 1716***
(concluded)

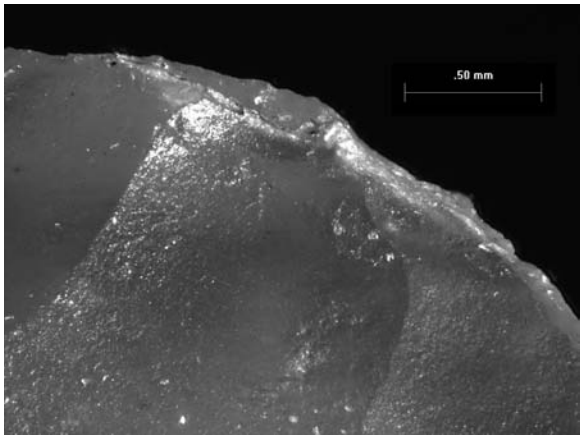



**Figure D-31.03.** Fractures at margin have resulted from flake removals. Fracture facets show minor rounding.

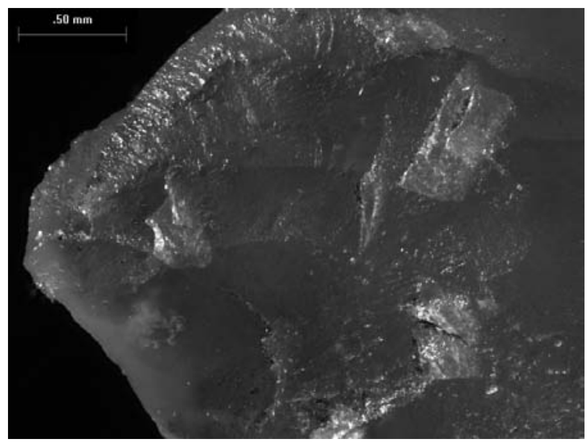



**Figure D-31.04.** Flake removals emanating from distal tip suggest that the tip, as well as distal edges, was a point of contact during use. The wear is consistent with use as an awl.

*Artifact ID: 1723*

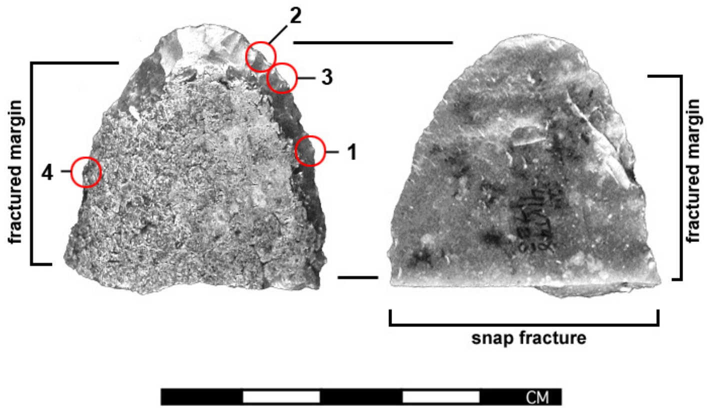



**Figure D-32.** Scraper (Catalog/ID# 1723) from S12W86, Level 12.

*Classification*

**Artifact Class:** Non-Biface/Uniface (likely a altered flake fragment); **Artifact Subclass:** Informal; **Artifact Type:** Scraper.

*Characteristics*

**Length:** 34 mm; **Width:** 34 mm; **Thickness:** 9 mm; **Weight:** 11.5 g; **Edge Angle:** 55°; **Portion:** fragment; **Raw Material Type:** chert; **Alteration:** none observed.

*Use-Wear Pattern*

**Edge Attrition:** lateral unifacial; **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

*Comments*

This artifact represents an informal tool. It was likely crafted from a modified cortical flake. The dorsal face retains approximately 75 percent cortex. The cortex appears smooth, hard, and polished—indicative of river cobbles and gravels.

All margins show attrition and polish. One lateral margin appears fractured, and this margin exhibits traces of wear on remnant high points and facet ridges. The fracture may be the result of either resharpening or the structural weakness of the edge (as the edge is largely comprised of cortex). The pattern of attrition observed favors the dorsal face of the flake significantly. The more intact margin (opposite the fractured margin) is worn to a smooth outline. This edge is well rounded and exhibits highly developed polish. This, together with the attrition pattern observed, suggests that the artifact functioned as a scraper.

Given its expedient nature and form, the tool was not likely used for a long duration prior to discard.

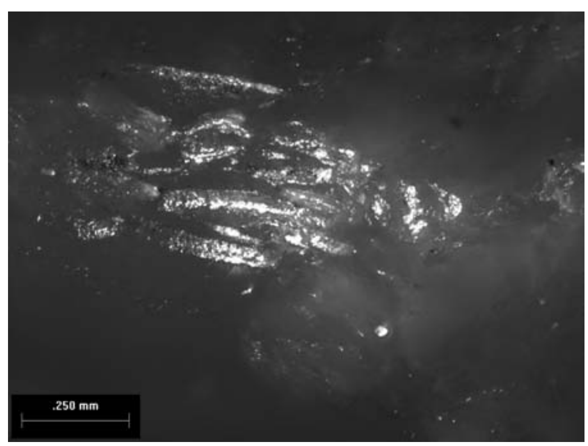



**Figure D-32.01.** Lateral margin exhibits edge rounding and well-developed polish.

continued.

***Artifact ID: 1723***
(concluded)

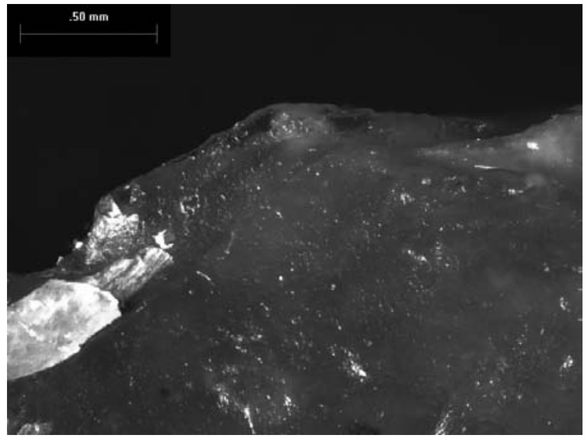



**Figure D-32.02.** Distal margin exhibits attrition and polish.

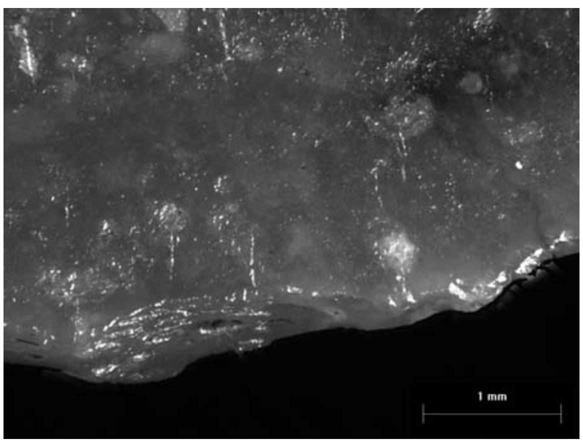



**Figure D-32.03.** Lateral margin near distal bit exhibits edge rounding and well-developed polish. Pattern of wear suggests use with a contact material of soft to medium-soft hardness.

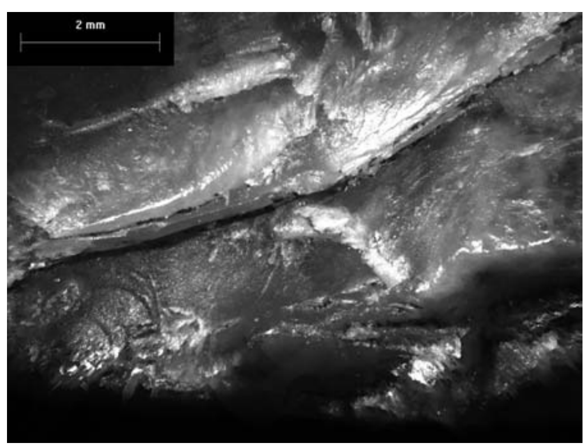



**Figure D-32.04.** Rounded and polished edge and facets observed along lateral margin.

***Artifact ID: 1830***

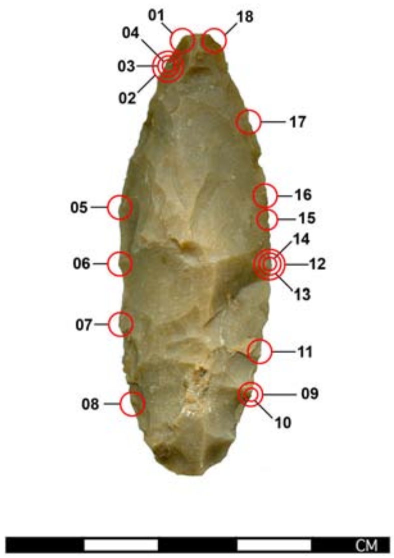



**Figure D-33.** Projectile Point/Multifunctional Tool (Catalog/ID# 1830) from S12W74, Level 16.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal (crude); **Artifact Type:** Projectile/Multi-functional.

***Characteristics***

**Length:** 59 mm; **Width:** 21 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal/bilateral-bifacial; **Polish:** shallow lateral; **Battering:** distal (crushed); **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

***Comments***

Artifact fits description of a Lerma dart point in accordance with Turner and Hester (1983:116).

The greatest degree of edge-wear observed on the tool occurs medially. Multiple step terminations and shallow polish are observed along both lateral margins. Edges are moderately rounded, but ridges and facets along the margins are not particularly worn. Interestingly, the pattern of edge attrition expresses a clear tendency toward favoring one face over the other, but it is not strictly unifacial.

Lateral margins along basal one-third of the blade exhibit rough, unmodified step fractures. Some polish is observed along ridges and high points along one face. This is almost certainly derived from hafting. Damage to the distal margin at its point is consistent with impact crushing.

The wear pattern observed is enigmatic and does not clearly fit the characteristics of a specific tool form. This object may have been used as a projectile, but not exclusively. Greater wear recorded along the lateral margins suggests that the primary function of the tool may have been cutting. Alternatively, the lack of edge wear along the distal one-quarter of the blade and the crushed tip may be an artifact of rejuvenation efforts.

Edge attrition, step fractures, and minor rounding observed along lateral margin near base are consistent with modifications resulting from hafting.

continued.

***Artifact ID: 1830***
(continued)

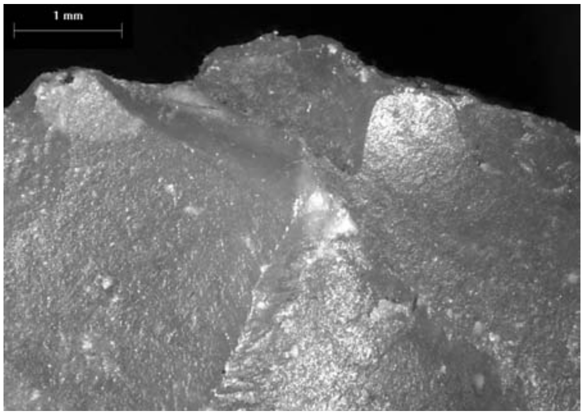



**Figure D-33.01.** Fractured margin observed near distal tip.

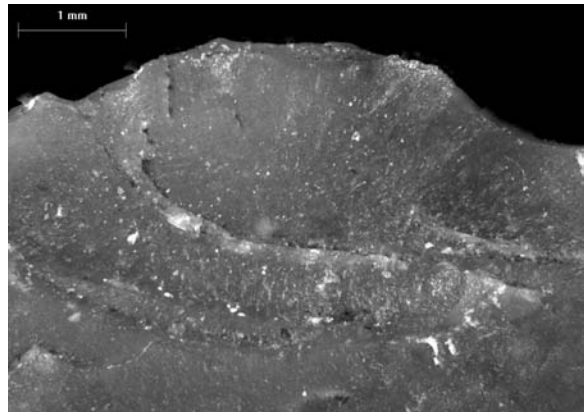



**Figure D-33.02.** Fractured margin near tip exhibits edge rounding and very shallow polish.

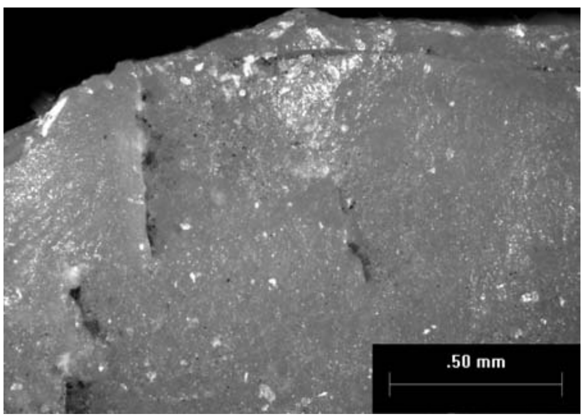



**Figure D-33.03.** Fractured margin near tip observed at higher magnification. Polish is restricted to extreme margin.

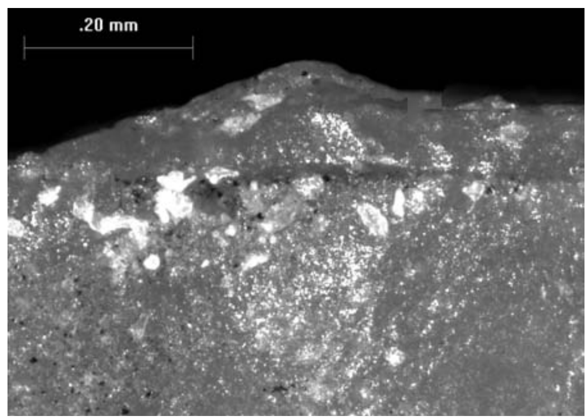



**Figure D-33.04.** Fractured margin near tip observed at higher magnification. Edge damage and silica deposits can be observed along polished margin.

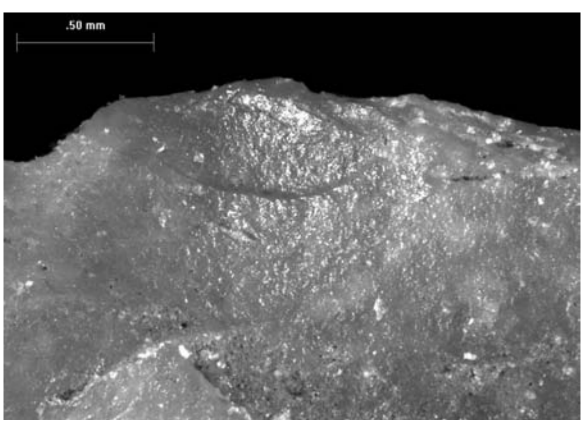



**Figure D-33.05.** Lateral margin along upper midpoint of blade showing edge rounding and shallow polish.

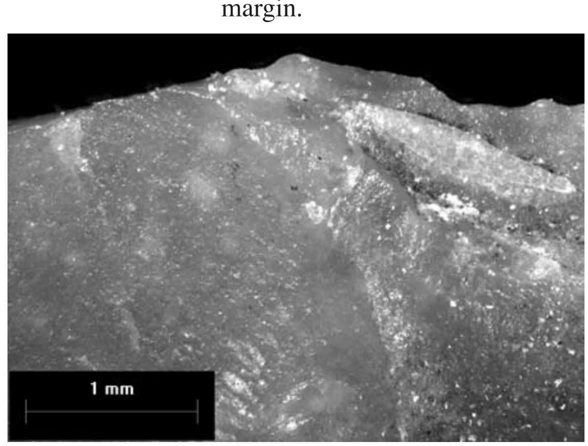



**Figure D-33.06.** Lateral margin at midpoint may exhibit very minor rounding.

continued.

***Artifact ID: 1830***
(continued)

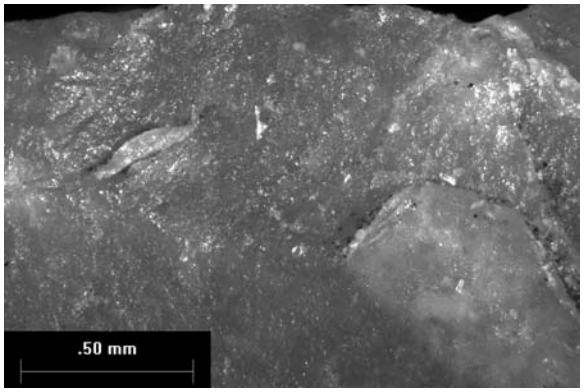



**Figure D-33.07.** Edge attrition, step fractures, and minor rounding observed along lateral margin may be evidence of hafting.

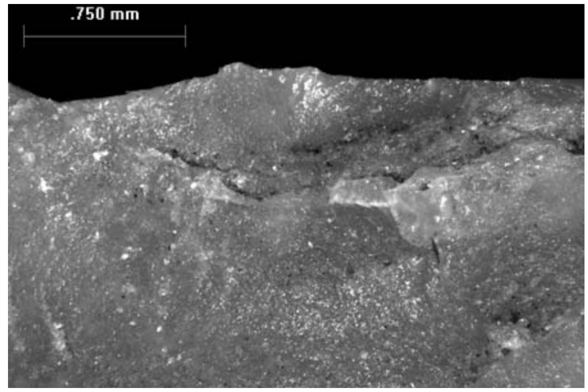



**Figure D-33.08.** Edge attrition, step fractures, and minor rounding observed along lateral margin near base are consistent with modification caused by hafting.

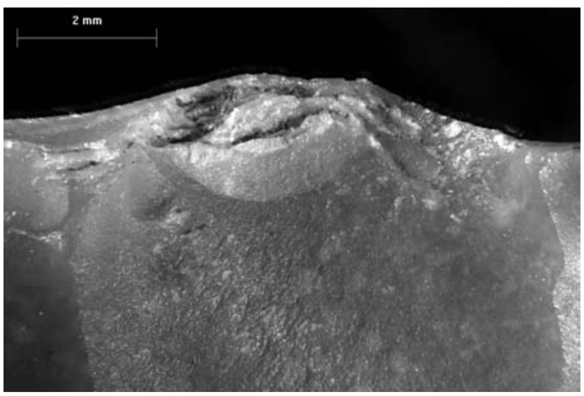



**Figure D-33.09.** Edge attrition, step fractures, and minor rounding observed along lateral margin near base are consistent with modification caused by hafting.

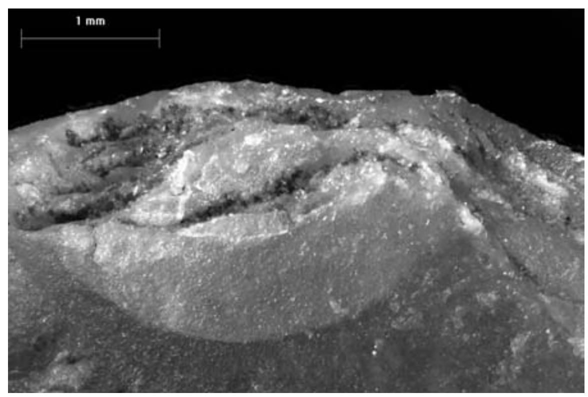



**Figure D-33.10.** Edge attrition, step fractures, and minor rounding observed at greater magnification along lateral margin near base are consistent with modification caused by hafting.

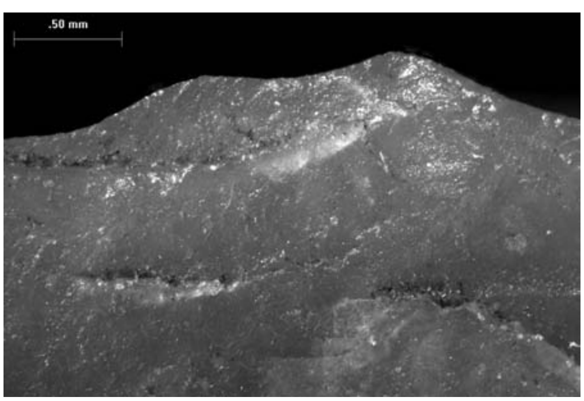



**Figure D-33.11.** Edge attrition, step fractures, and minor rounding observed along lateral margin near base are consistent with modification caused by hafting.

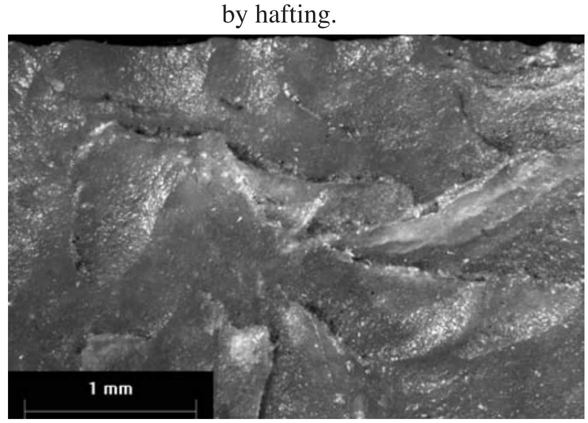



**Figure D-33.12.** Edge attrition, step fractures, minor rounding, and shallow polish observed along lateral margin at midsection may be consistent with modification caused by hafting.

continued.

***Artifact ID: 1830***
(concluded)

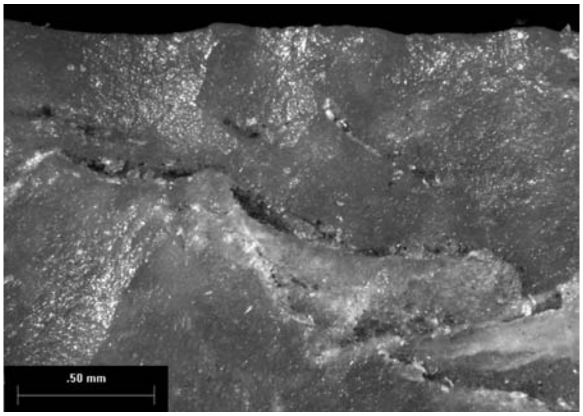



**Figure D-33.13.** Edge attrition, step fractures, minor rounding, and shallow polish observed at higher magnification along lateral margin at midsection.

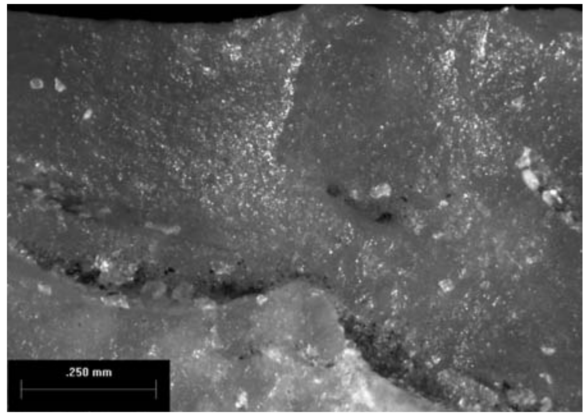



**Figure D-33.14.** Edge attrition, step fractures, minor rounding, and shallow polish observed at higher magnification along lateral margin at midsection.

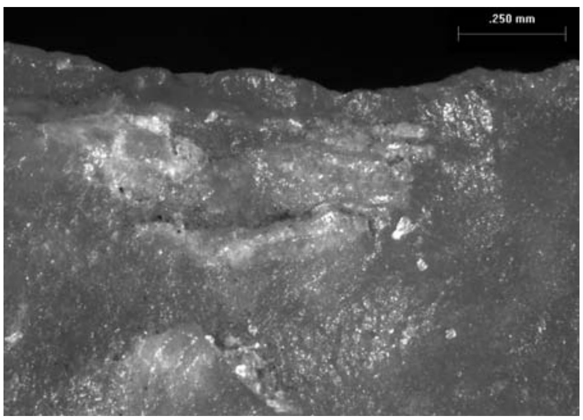



**Figure D-33.15.** Edge rounding and shallow polish observed along lateral margin near midsection of blade.

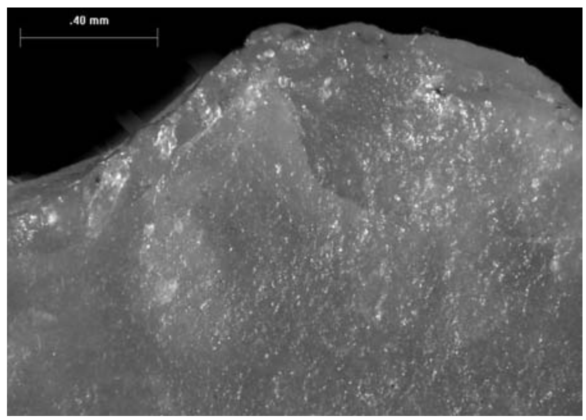



**Figure D-33.16.** Edge attrition and shallow polish observed on lateral margin near midsection of blade.

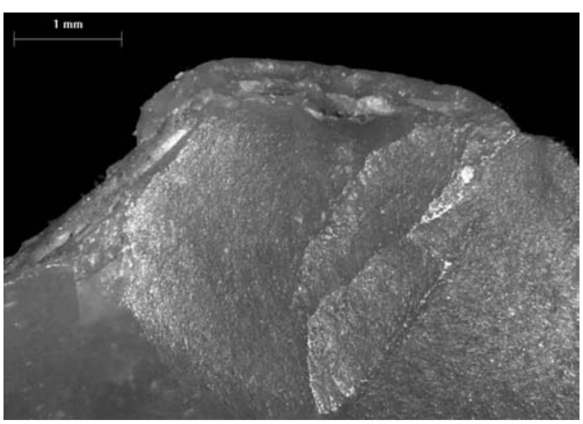



**Figure D-33.17.** Edge attrition observed along lateral margin in upper quarter of blade.

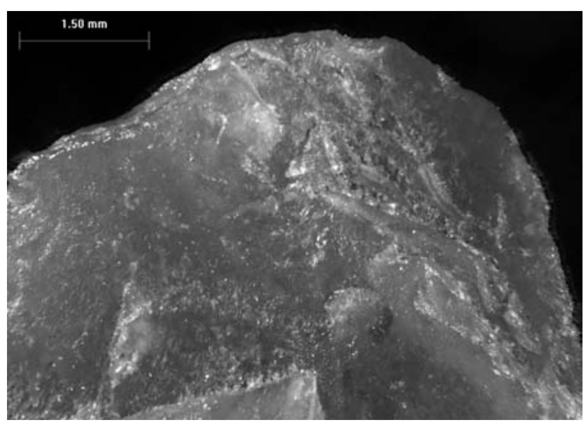



**Figure D-33.18.** Edge attrition and shallow polish observed along lateral margin. Damage to margin at point is consistent with impact crushing.

***Artifact ID: 1844***

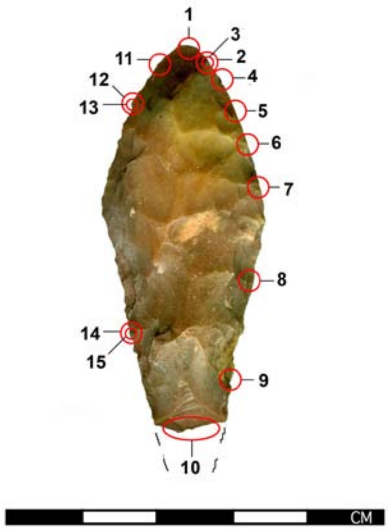



**Figure D-34.** Projectile Point (Catalog/ID# 1844) from S18W18, Level 11.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile (most likely).

***Characteristics***

**Length:** 52 mm; **Width:** 23 mm; **Thickness:** 11 mm; **Weight:** (unrecorded); **Edge Angle:** 65°; **Portion:** complete; **Raw Material Type:** chert (medium-to-fine grained); **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** indeterminate (bilateral-bifacial); **Polish:** deep lateral (possibly vitrification); **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate (polish observed may be vitrification); **Contact Material Hardness:** soft (possibly medium-soft).

***Comments***

This artifact was labeled a Lerma dart point. A clear torque (bending) fracture has removed an undetermined portion of the base. A second fracture has also removed a portion of the tip. The distal fracture was most likely caused by either torque or impact, but its cause cannot be more accurately discerned given the evidence available.

Step fractures are noted along the length of the lateral margins. Lateral margins from mid-point to tip area show flaking attrition and rounding indicative of contact with soft to medium-soft contact material (more likely soft, with excessive fracturing caused by increased brittleness of material).

The presence and distribution of polish is obscured by thermal alteration.

The artifact is lanceolate in cross-section, and basally thinned. Soft-hammer removals have left a rough medial ridge. Edges have been beveled through pressure retouch, often terminating in step and hinge fractures.

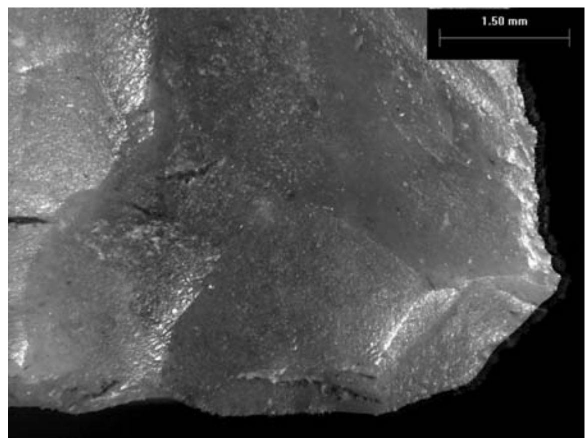



**Figure D-34.01.** Distal attrition is consistent with impact fracture.

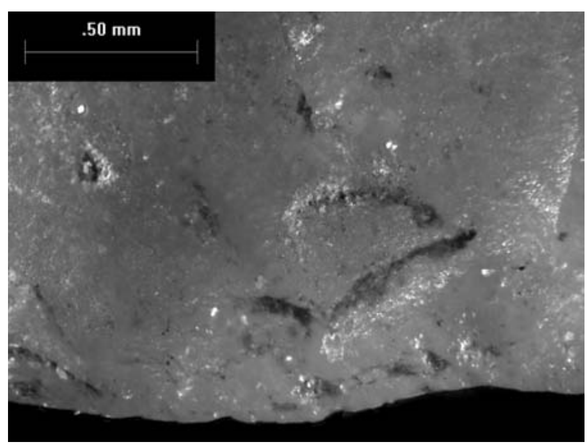



**Figure D-34.02.** Lateral margin at distal tip exhibiting edge rounding and well-developed polish.

continued.

***Artifact ID: 1844***
(continued)

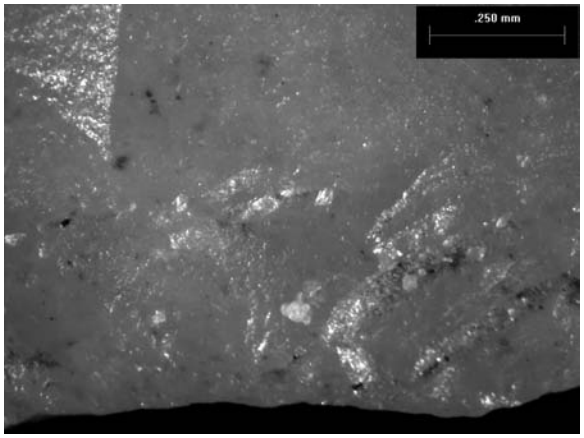



**Figure D-34.03.** Lateral margin at distal tip exhibiting edge rounding and well-developed polish.

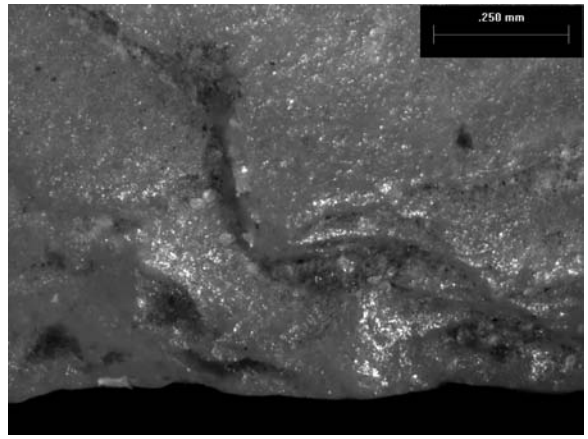



**Figure D-34.04.** Lateral margin near distal tip exhibiting edge and facet rounding, shallow polish, and silica deposits.

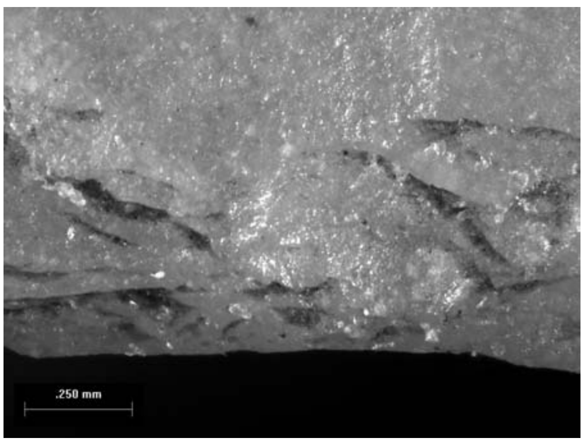



**Figure D-34.05.** Lateral margin near distal tip exhibits edge and facet rounding. Silica deposits can also be observed.

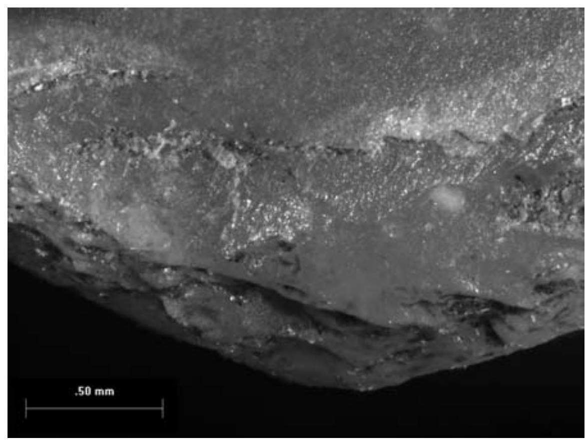



**Figure D-34.06.** Lateral margin near midpoint of blade exhibits shallow polish.

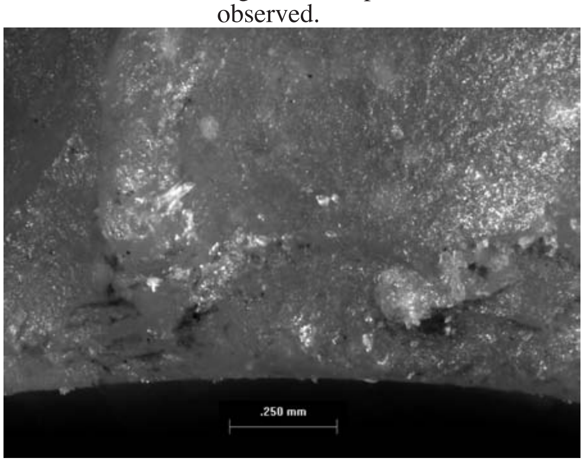



**Figure D-34.07.** Margin at lateral corner exhibits minor edge rounding and silica deposits.

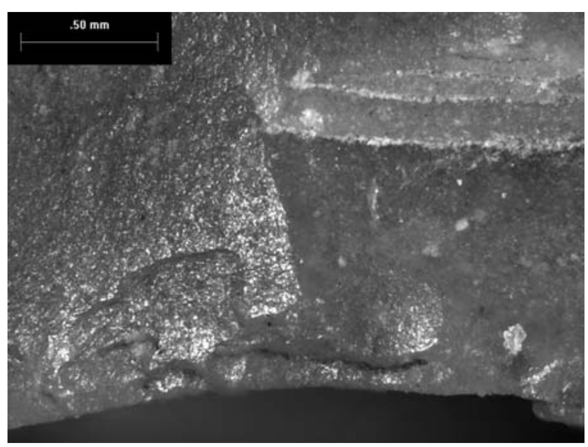



**Figure D-34.08.** Lateral margin along stem shows edge rounding and faint polish. This pattern of modification is consistent with hafting.

continued.

***Artifact ID: 1844***
(continued)

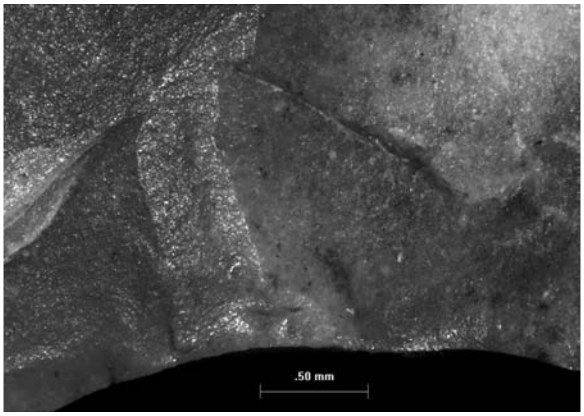



**Figure D-34.09.** Lateral margin along stem near basal fracture shows minor edge rounding and faint gloss.

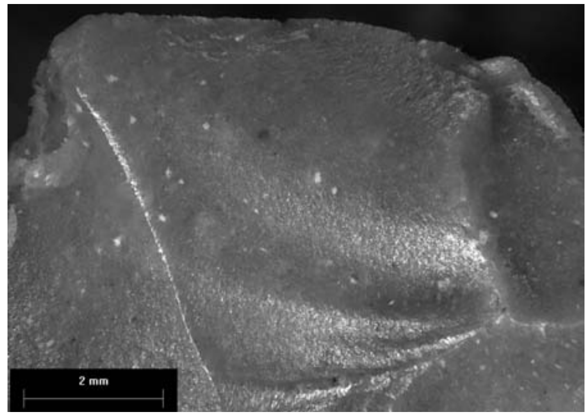



**Figure D-34.10.** Torque fracture observed at base on tool.

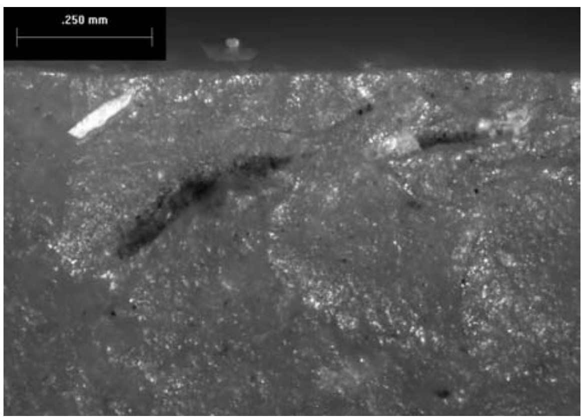



**Figure D-34.11.** Lateral margin near distal tip exhibits faint gloss and silica deposits.

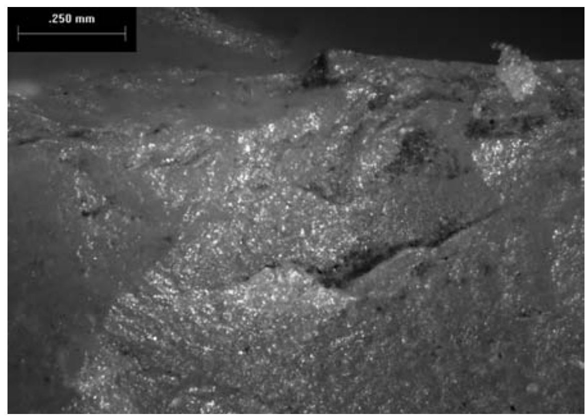



**Figure D-34.12.** Attrition, edge rounding, and silica deposits observed along lateral margin near midpoint of blade.

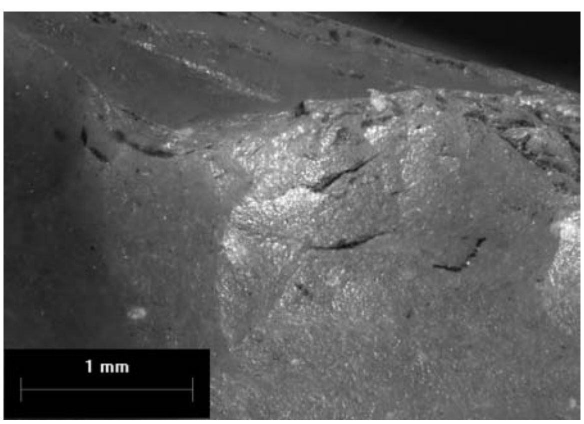



**Figure D-34.13.** Attrition, edge rounding, and silica deposits observed along lateral margin near midpoint of blade at lower magnification.

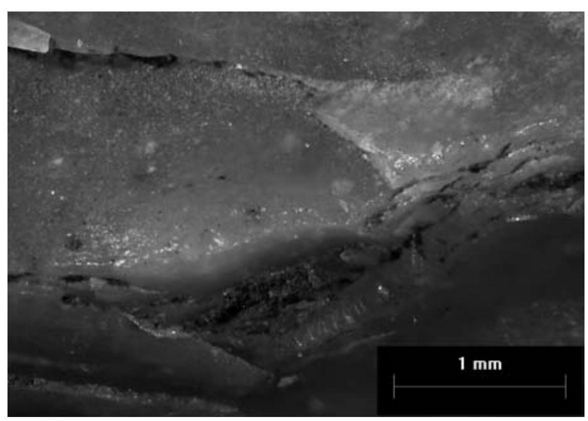



**Figure D-34.14.** Edge rounding and shallow polish observed along midsection of stem.

continued.

***Artifact ID: 1844***
(concluded)

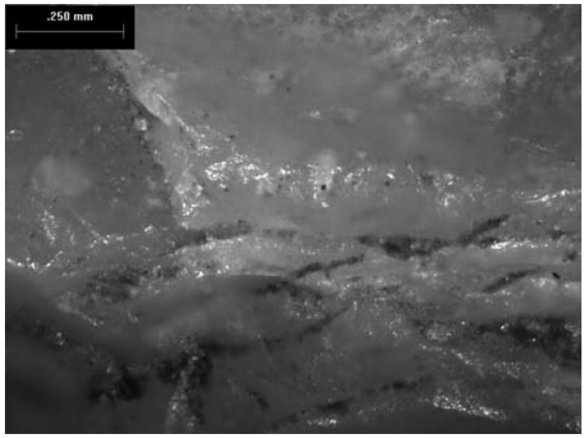



**Figure D-34.15.** Edge rounding and shallow polish observed along midsection of stem at higher resolution.

**Artifact ID: 1853**

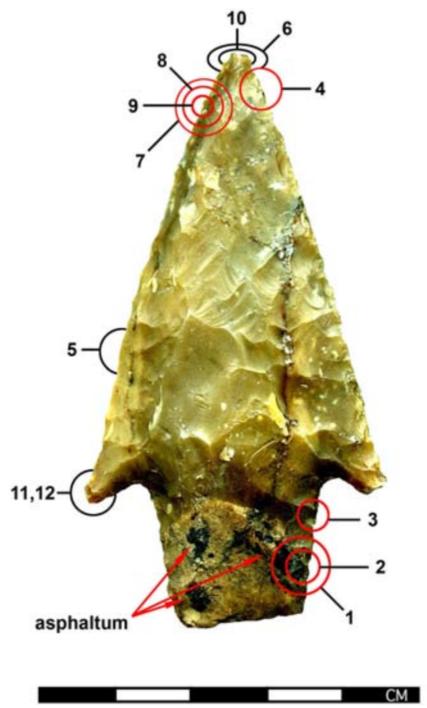



**Figure D-35.** Knife/Bulverde Point (Catalog/ID# 1853) from S29W118, Level 18.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile/Knife/Bulverde Dart Point.

### *Characteristics*

**Length:** 75 mm; **Width:** 41 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (fine grain); **Alteration:** none.

### *Use-Wear Pattern*

**Edge Attrition:** distal, lateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

### *Comments*

This artifact fits the description of a Bulverde dart point (Turner and Hester 1983:73). The distal point exhibits an impact fracture that has removed a small fragment of the tip. This fracture pattern supports characterizing the tool form as a projectile point.

The entire lateral margin exhibits edge rounding and shallow polish. Barbs located at the base of the blade display modest attrition, slight rounding, and polished facets and margins. This pattern of wear suggests that the entire blade edge was used against a medium-soft contact material. It remains possible that this artifact was used as a knife as well as a projectile. This would help to explain the wear and polish noted on the barbs.

The stem is slightly contracting and beveled basally. The base clearly exhibits a masticate (asphaltum?) in several areas, imbedded into fractures. The stem also displays basal, lateral, and facial polish indicative of hafting.

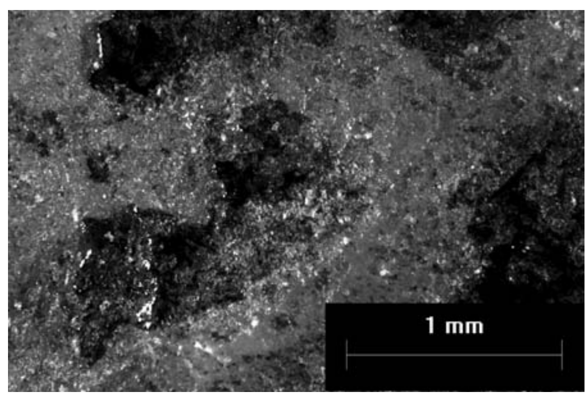



**Figure D-35.01.** View of asphaltum observed on basal stem.

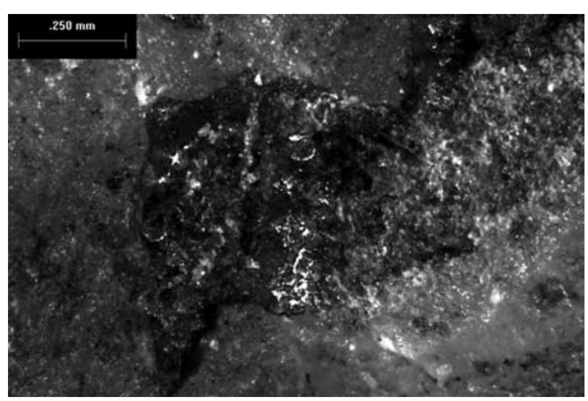



**Figure D-35.02.** Asphaltum observed at higher magnification.

continued.

***Artifact ID: 1853***
(continued)

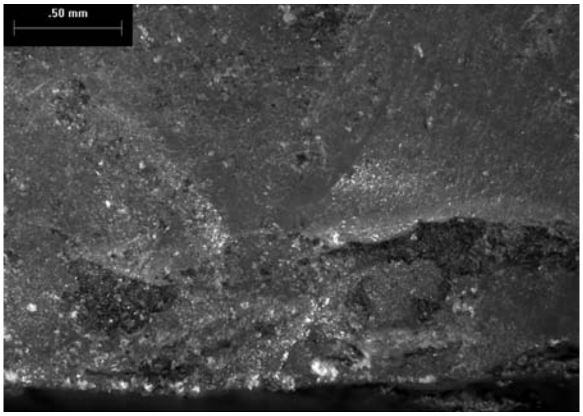



**Figure D-35.03.** View of lateral margin along basal stem. Asphaltum can be seen imbedded in fractures. Very slight edge rounding is observed.

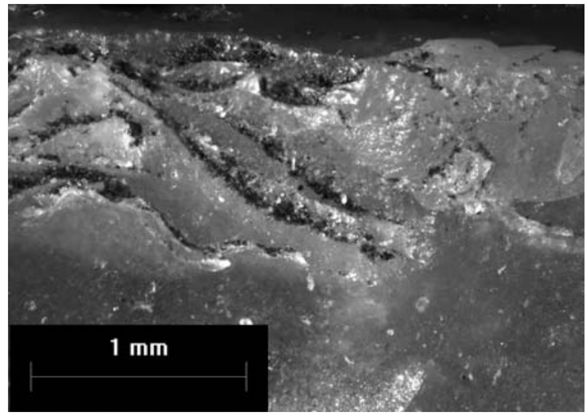



**Figure D-35.04.** Lateral margin near tip showing step fractures and edge rounding.

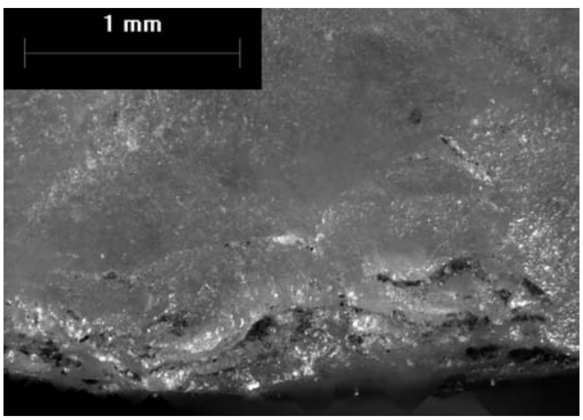



**Figure D-35.05.** Attrition and shallow polish observed along lateral margin near midpoint of blade.

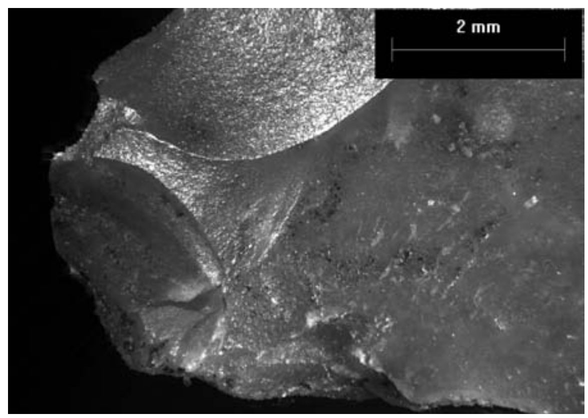



**Figure D-35.06.** Edge damage observed at distal tip is consistent with impact fracturing.

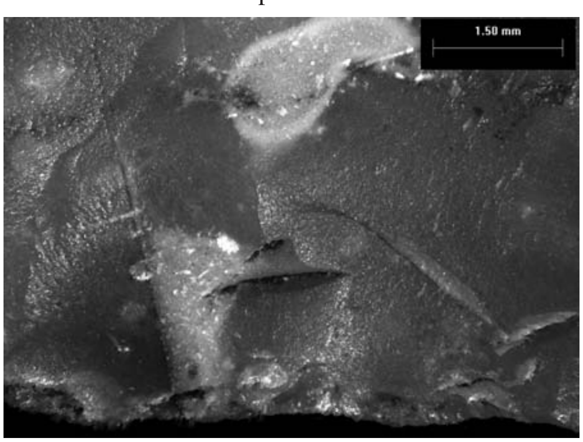



**Figure D-35.07.** Edge damage recorded along lateral margin near distal point.

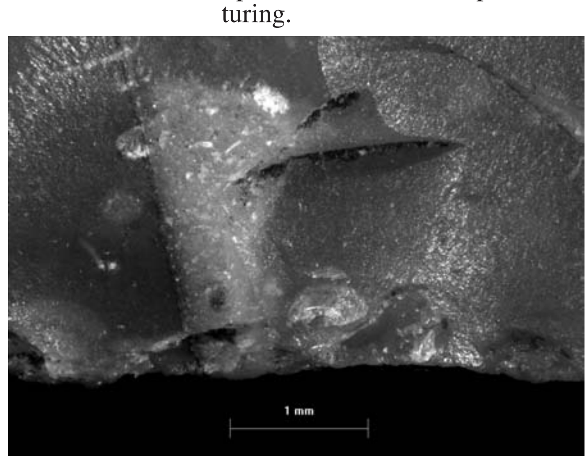



**Figure D-35.08.** Edge damage along lateral margin observed at higher magnification.

continued.

***Artifact ID: 1853***
(concluded)

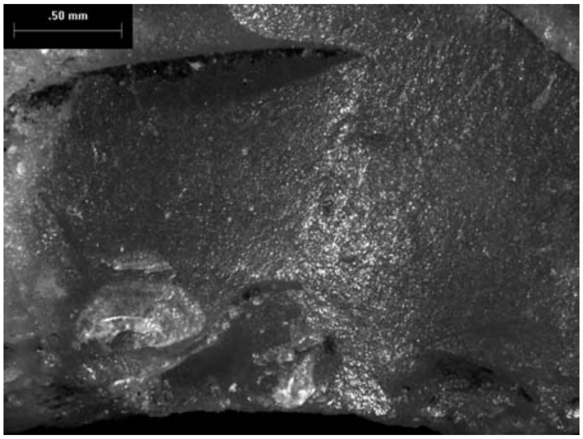



**Figure D-35.09.** Edge damage along lateral margin observed at higher magnification. Minor edge rounding and faint polish can be seen at extreme margin.

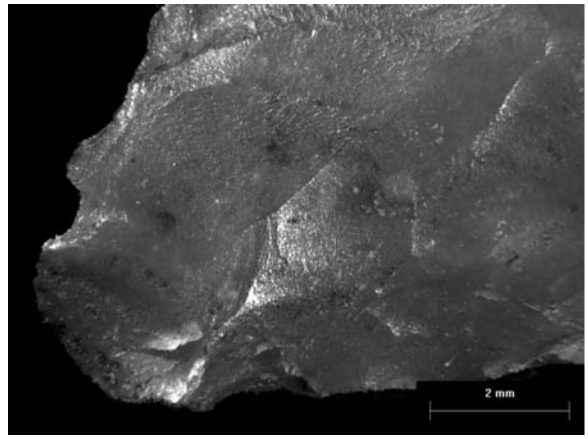



**Figure D-35.10.** Edge damage observed at distal tip is consistent with impact fracturing.

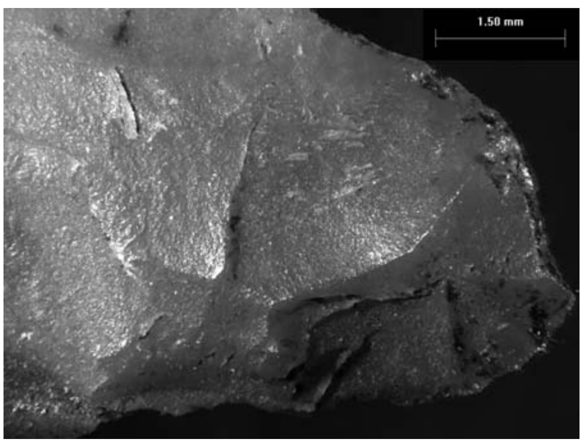



**Figure D-35.11.** Attrition and edge rounding observed on barb. The pattern of wear observed suggests that the entire blade edge was used against a medium-soft contact material.

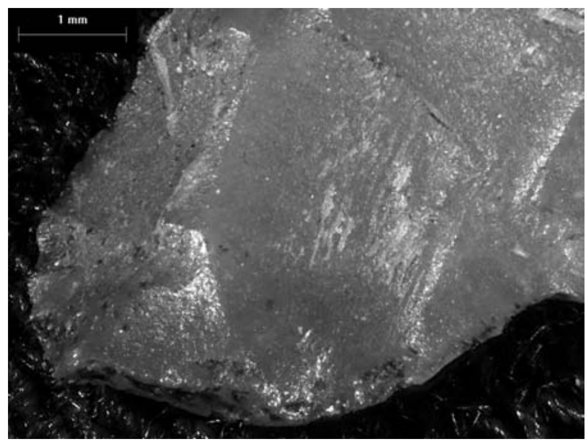



**Figure D-35.12.** Alternate view of edge rounding and attrition observed on barb.

***Artifact ID: 1867***

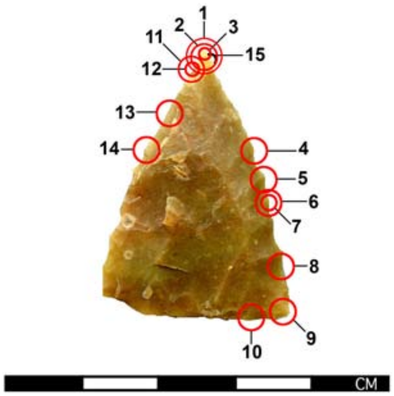



**Figure D-36.** Early Triangular Point (Catalog/ID# 1867) from S18W18, Level 12.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile (Early Triangular).

***Characteristics***

**Length:** 36 mm; **Width:** 26 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** indeterminate (possibly heated).

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** distal, shallow-lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

***Comments***

This artifact fits the description of Early Triangular points described by Turner and Hester (1983:89). The specimen is characterized by parallel-oblique flaking and displays alternately beveled lateral edges.

Attrition flaking is somewhat developed at the distal tip, but is not observed along the lateral margins. Minor attrition attributable to hafting is noted along the basal margin. The best indication of wear comes from edge rounding and polish formation rather than flaking. This seems to suggest that the hardness of the contact material was relatively soft.

The distal tip exhibits the greatest evidence of wear. The bit is worn smooth, but does not exhibit a clear impact fracture. Flake facets at the distal margin are, likewise, worn and rounded. High points along the lateral margins tend to exhibit some rounding and shallow polish, but not to the extent observed at the tip.

Basal corners and the basal margin exhibit relatively deep polish. The basal margin exhibits greater incidence of step fractures than any other edge. This wear pattern is strong evidence in support of the artifact having been hafted.

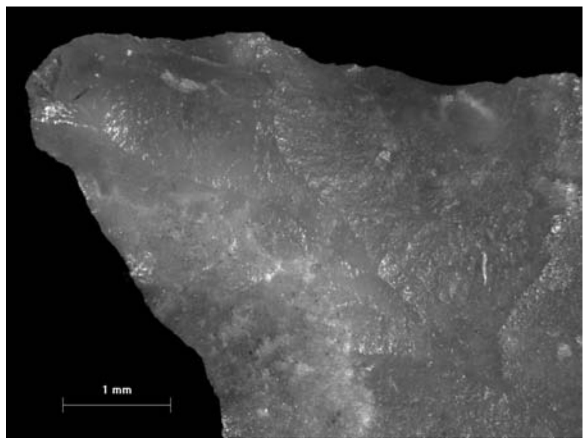



**Figure D-36.01.** Marginal attrition and well-developed polish noted on distal margin.

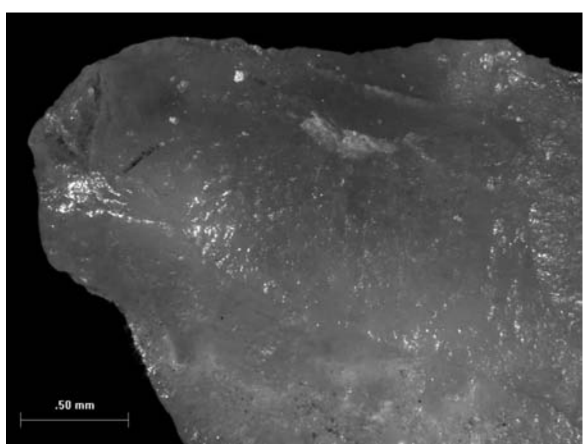



**Figure D-36.02.** Marginal attrition and polish on distal margin observed at greater magnification.

continued.

***Artifact ID: 1867***
(continued)

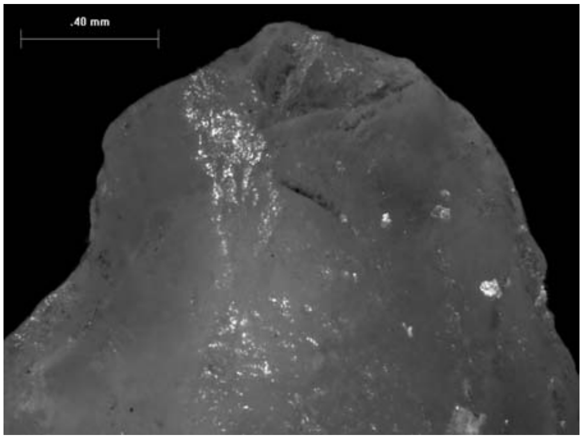



**Figure D-36.03.** Marginal attrition, polish, and silica deposits located on distal margin observed at greater magnification.

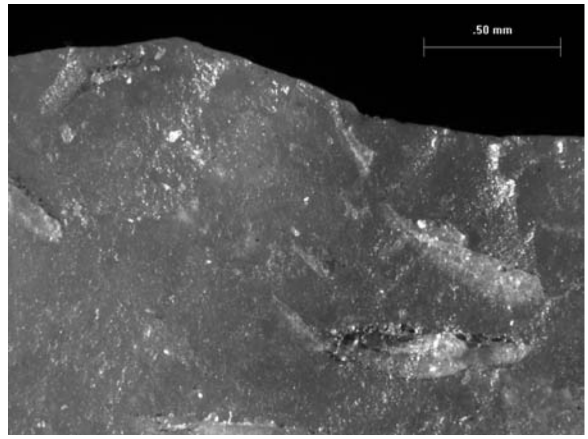



**Figure D-36.04.** Lateral margin at midpoint of blade exhibits minor edge rounding.

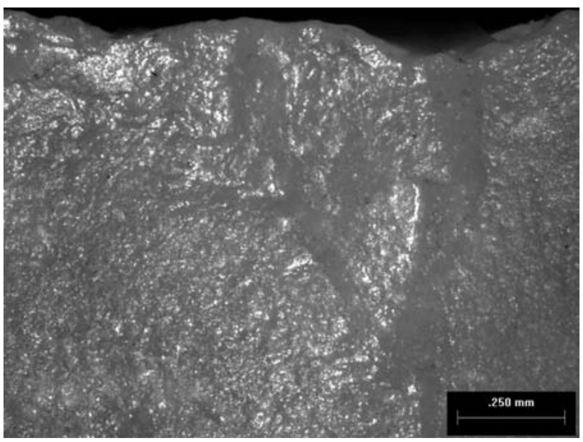



**Figure D-36.05.** Lateral margin at midpoint of blade here exhibits edge rounding and shallow polish.

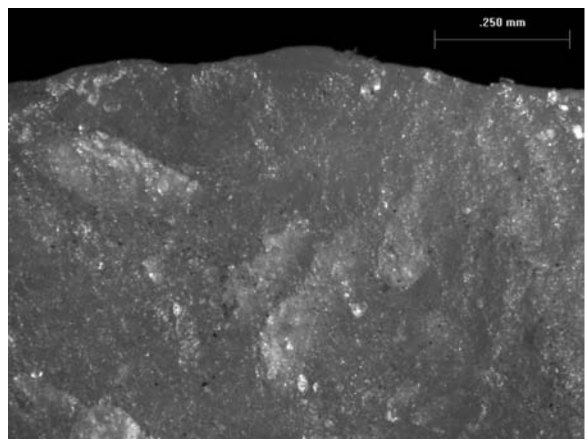



**Figure D-36.06.** Silica deposits noted on lateral margin near midpoint of blade.

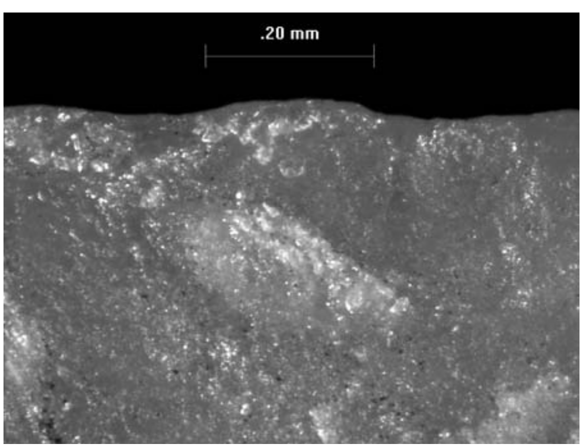



**Figure D-36.07.** Silica deposits observed at higher magnification on lateral margin near midpoint of blade.

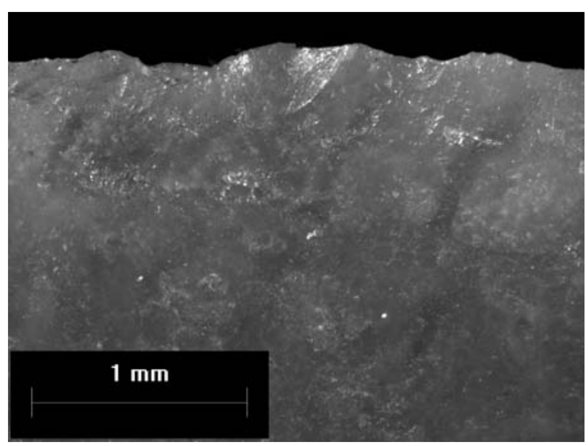



**Figure D-36.08.** No modification is noted on lateral margin near basal corner.

continued.

***Artifact ID: 1867***
(continued)

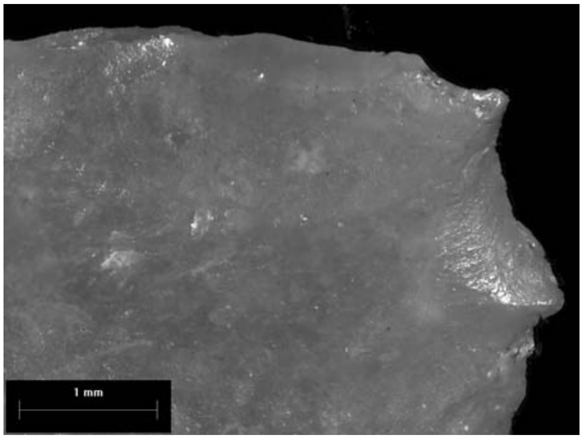



**Figure D-36.09.** Basal corner exhibits minor attrition and faint, shallow polish.

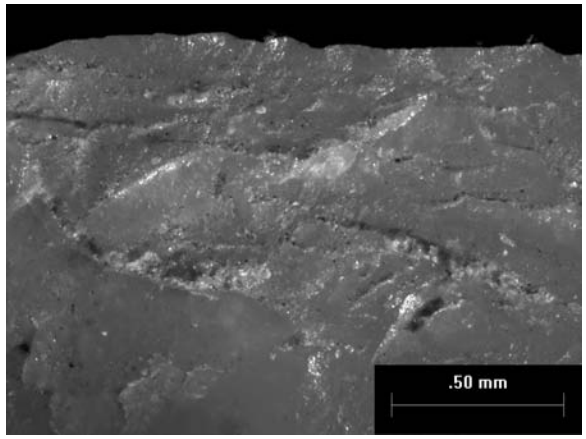



**Figure D-36.10.** Basal margin exhibits minor edge and facet rounding.

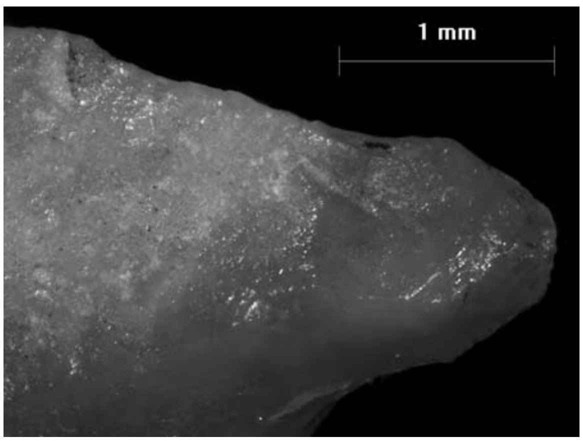



**Figure D-36.11.** Lateral margin near distal tip exhibits rounding and faint, shallow polish.

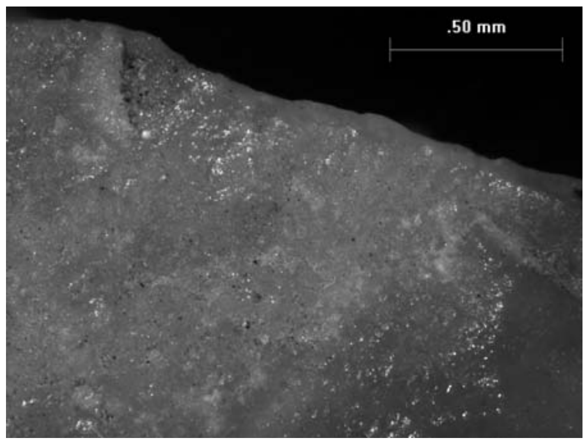



**Figure D-36.12.** Rounding and polish on distal lateral margin observed at higher magnification.

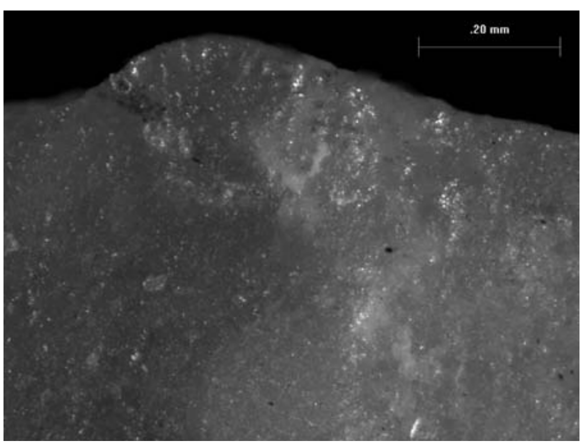



**Figure D-36.13.** Edge rounding and shallow, poorly-developed polish observed on lateral margin near midpoint of blade.

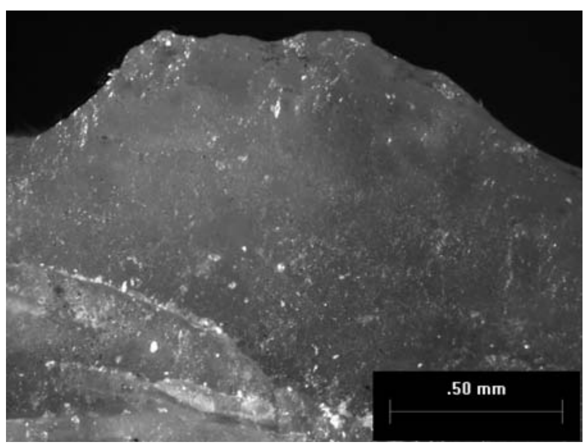



**Figure D-36.14.** Lateral margin at midpoint of blade exhibits minor edge rounding.

continued.

***Artifact ID: 1867***
(concluded)

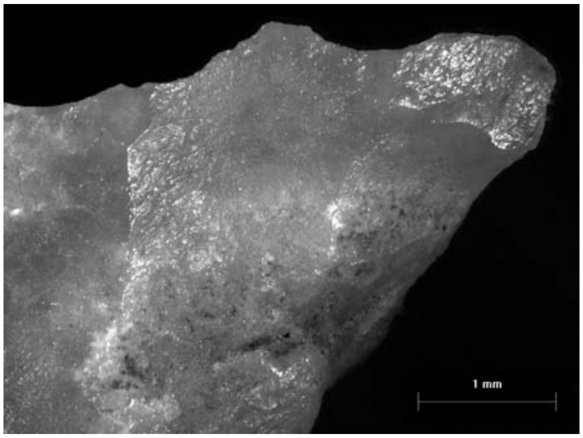



**Figure D-36.15.** Lateral margin near distal tip exhibits rounding and faint, shallow polish. Well-developed polish is observed at distal tip.

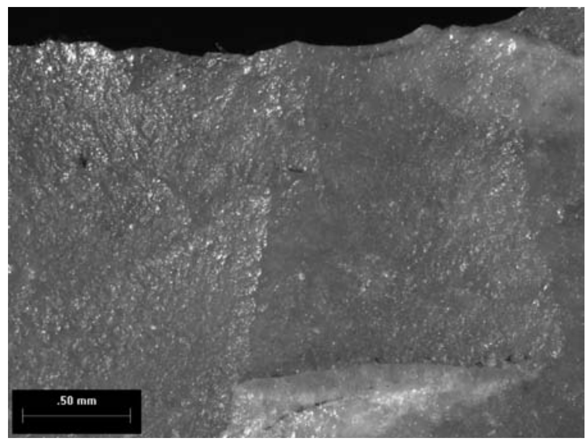



**Figure D-36.16.** Lateral margin at midpoint of blade exhibits minor edge rounding.

***Artifact ID: 1891***

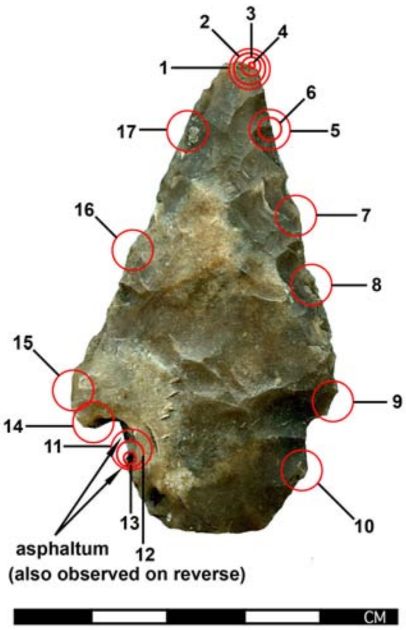



**Figure D-37.** Morhiss Point (Catalog/ID# 1891) from S29W118, Level 18.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife (Morhiss point).

### *Characteristics*

**Length:** 63 mm; **Width:** 36 mm; **Thickness:** 7 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grain, mottled); **Alteration:** none.

### *Use-Wear Pattern*

**Edge Attrition:** distal-lateral; **Polish:** distal-lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

### *Comments*

The distal margin exhibits fractures, attrition, and distribution of polish that are consistent with projectile use. Minor attrition and shallow polish are observed along the lateral margins on the distal quarter of the blade.

Lateral margins exhibit bilateral-bifacial attrition pattern with moderately developed, fairly deep polish. Wear and polish extend the length of the margin from tip to barb.

The basal margin is proximally tapered, while the sides of the stem are roughly finished with step terminations across the margin. Remnant traces of asphaltum are observed imbedded into fractures along the lateral margin of the stem (bifacially distributed).

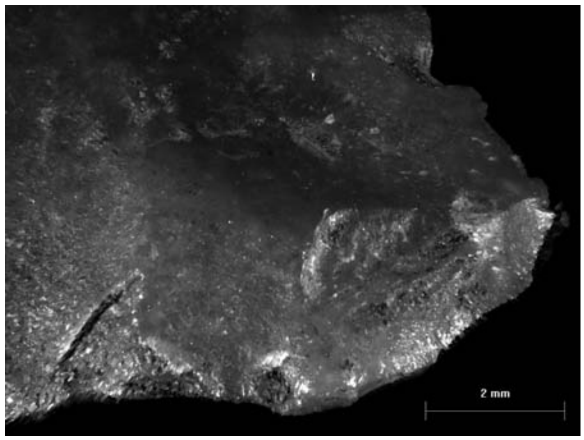



**Figure D-37.01.** Distal margin exhibits fractures, attrition, and distribution of polish that is consistent with projectile use.

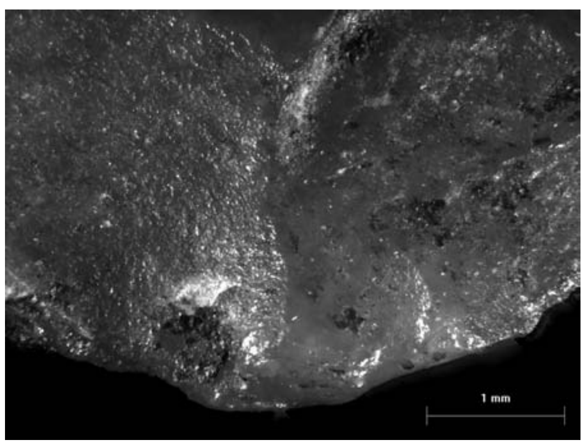



**Figure D-37.02.** Edge rounding and well-developed polish recorded on margin at distal tip.

continued.

***Artifact ID: 1891***
(continued)

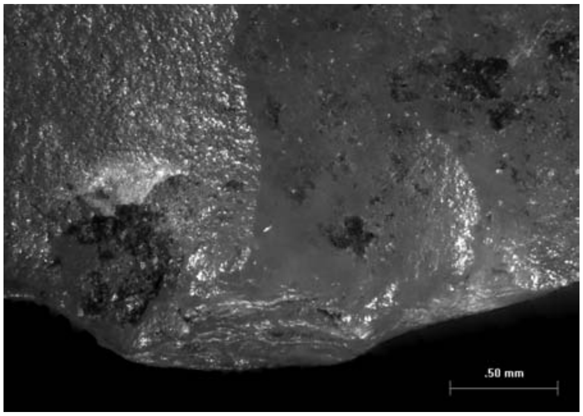



**Figure D-37.03.** Edge rounding and well-developed polish recorded on margin at distal tip, shown at higher magnification.

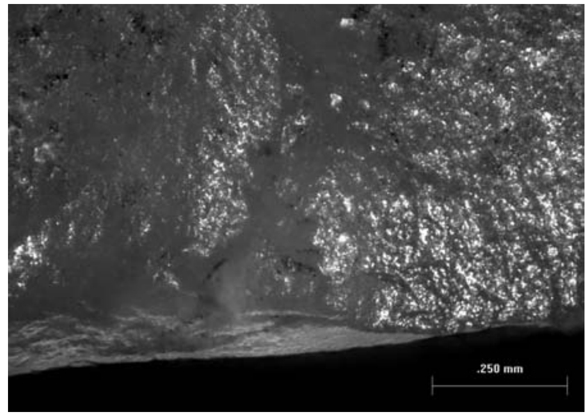



**Figure D-37.04.** Higher magnification view of edge rounding and polish recorded on margin at distal point.

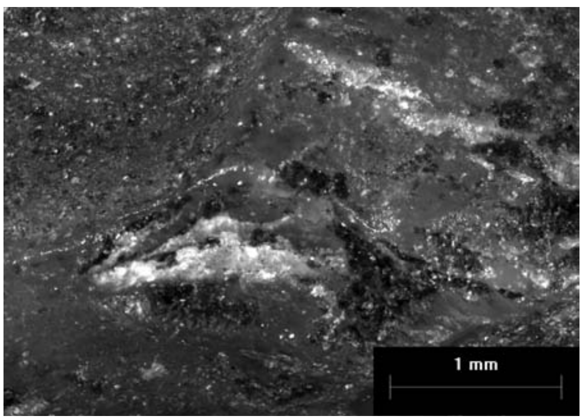



**Figure D-37.05.** Minor attrition and shallow polish observed along lateral margin on distal quarter of blade.

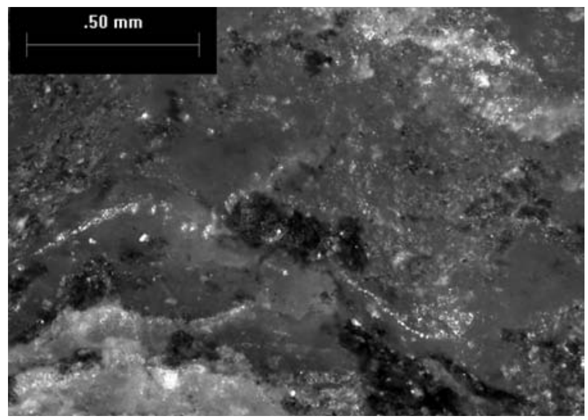



**Figure D-37.06.** Minor attrition and shallow polish observed along lateral margin on distal quarter of blade shown here at higher magnification.

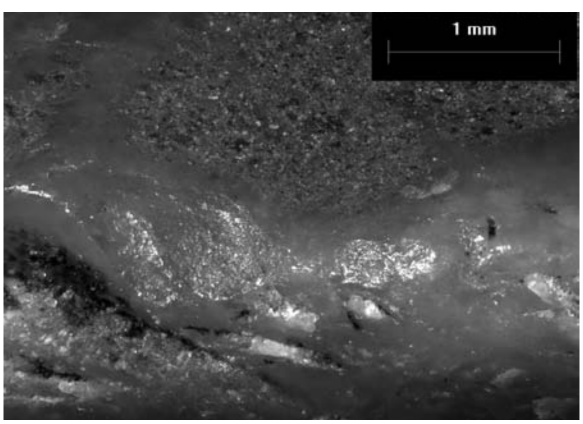



**Figure D-37.07.** Minor attrition and shallow polish observed along lateral margin near midpoint of blade.

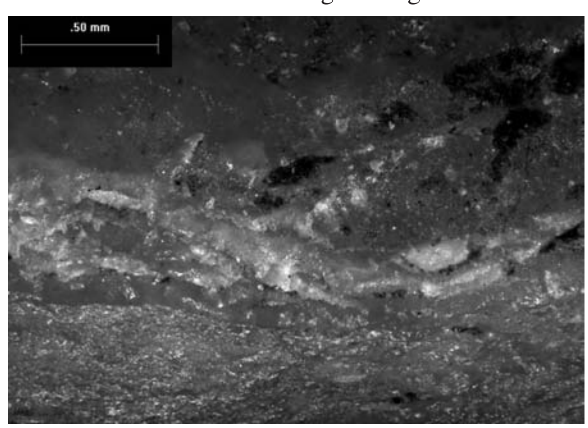



**Figure D-37.08.** Minor attrition and edge rounding observed along lateral margin near midpoint of blade.

continued.

***Artifact ID: 1891***
(continued)

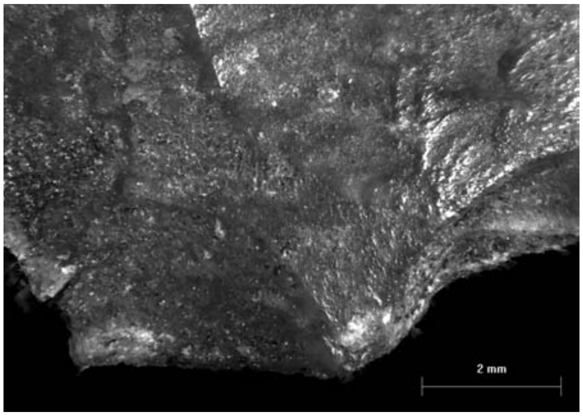



**Figure D-37.09.** Edge attrition and shallow polish observed at base of blade on barb.

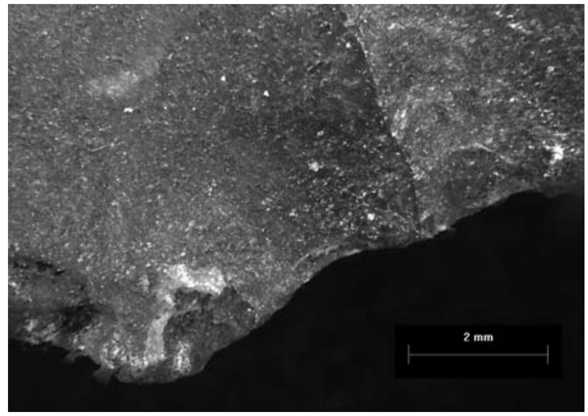



**Figure D-37.10.** Minor edge rounding and faint gloss observed along lateral margin of stem.

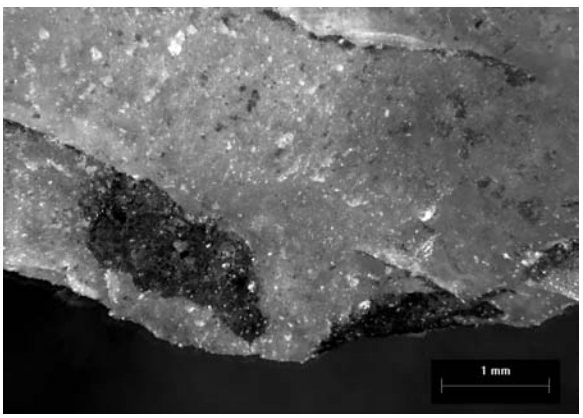



**Figure D-37.11.** Remnant asphaltum embedded in fractures along lateral margin of stem.

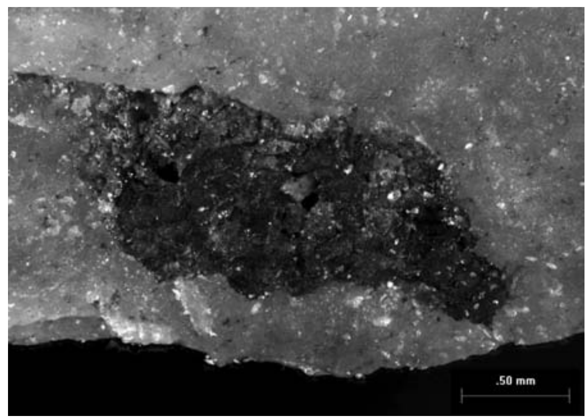



**Figure D-37.12.** Remnant asphaltum observed on near lateral margin of stem.

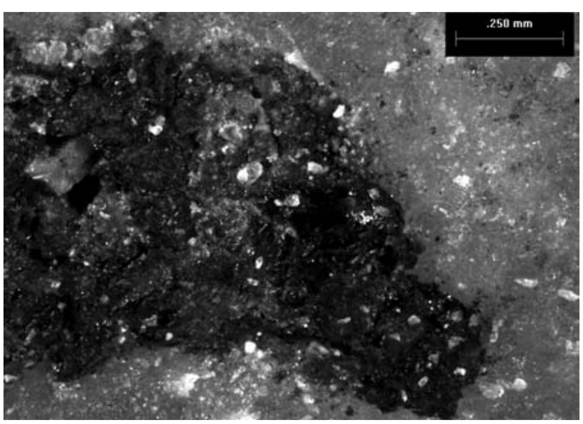



**Figure D-37.13.** Remnant asphaltum observed on near lateral margin of stem shown at higher magnification.

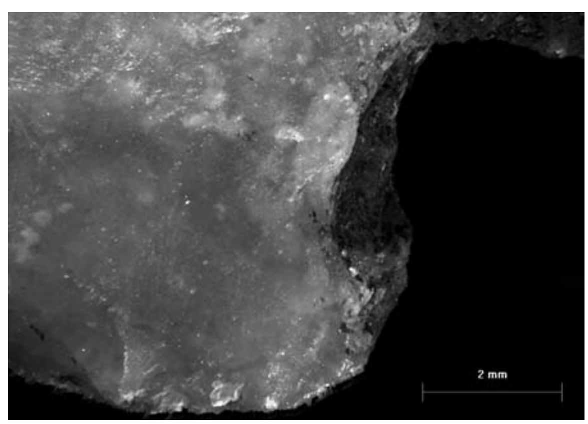



**Figure D-37.14.** Edge rounding observed on barb.

continued.

***Artifact ID: 1891***
(concluded)

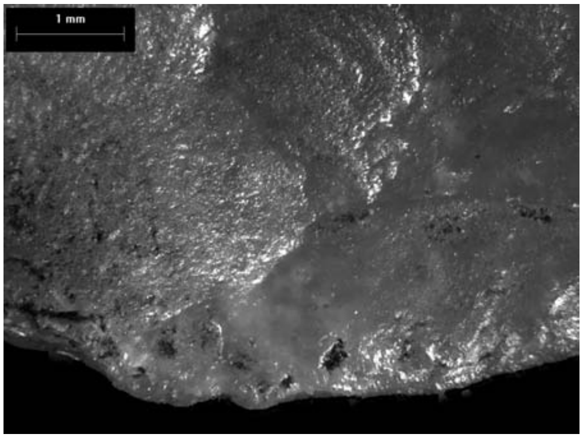



**Figure D-37.15.** Edge rounding and shallow polish observed on barb.

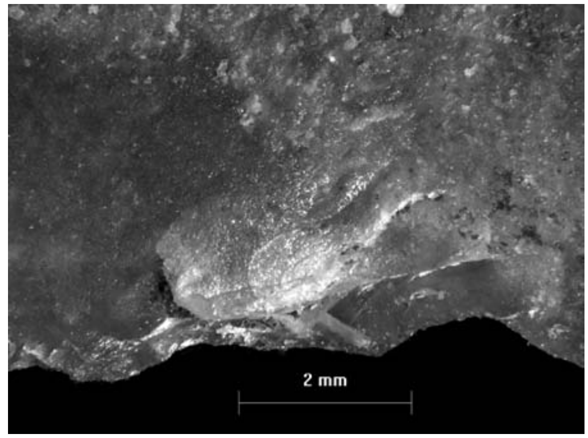



**Figure D-37.16.** Edge attrition and shallow, poorly-developed polish noted along lateral margin near midpoint of blade.

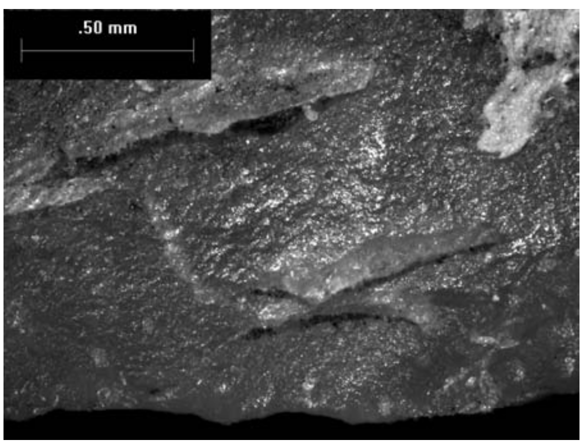



**Figure D-37.17.** Rounding of edge and facets and shallow, poorly-developed polish recorded along lateral margin at distal midsection of blade.

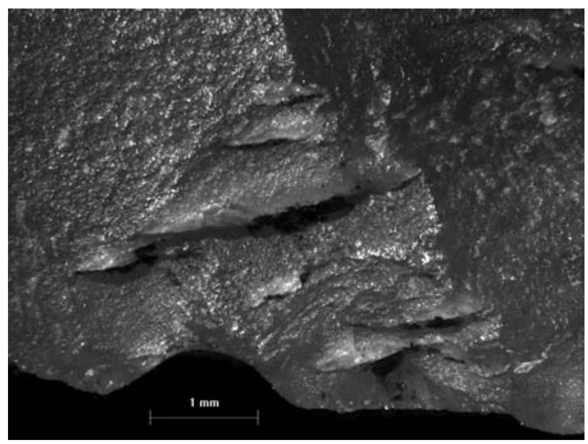



**Figure D-37.18.** Rounding of edge and facets, minor attrition, and shallow, poorly-developed polish recorded along lateral margin at distal midsection of blade.

***Artifact ID: 1919***

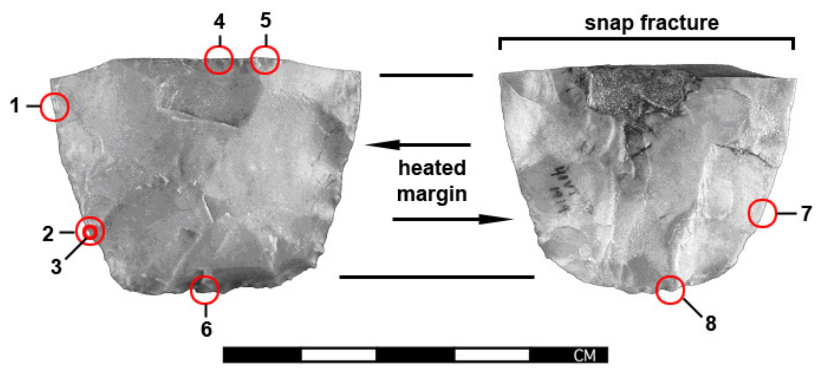



**Figure D-38.** Adze or Gouge (Catalog/ID# 1919) from S4W12, Level 14.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate (fragmentary, most likely formal); **Artifact Type:** Adze or Gouge.

***Characteristics***

**Length:** 31 mm; **Width:** 40 mm; **Thickness:** 11 mm; **Weight:** 15.2 g; **Edge Angle:** 60° (distal); 50° (lateral); 80° (proximal); **Portion:** distal (recycled); **Raw Material Type:** fine grained chert; **Alteration:** thermal and oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal-lateral, secondary proximal; **Polish:** shallow (all margins), edges dulled; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

***Comments***

The preserved distal bit of this tool form resembles a Clear Fork adze/gouge in design (convex dorsal, concave ventral surface; rounded bit). However, the lateral margins are more finely worked than has been described for many Clear Fork tools.

Lateral margins exhibit polish, which is more strongly developed along the thermally altered margin (right from dorsal view). The difference in polish development is likely due to the vitrification of material along the heated margin.

Distal attrition (flake removals and shallow polish) favors the ventral face, but it is largely bifacial. Shallow polish is also noted along the distal and lateral margins. This pattern of wear along the distal margin suggests the tool was used as an adze against a contact material of medium hardness.

Attrition and polish are noted on the proximal snap fracture. The lateral and proximal margins were likely used for scraping following the snap fracture that caused the failure of the original tool form.

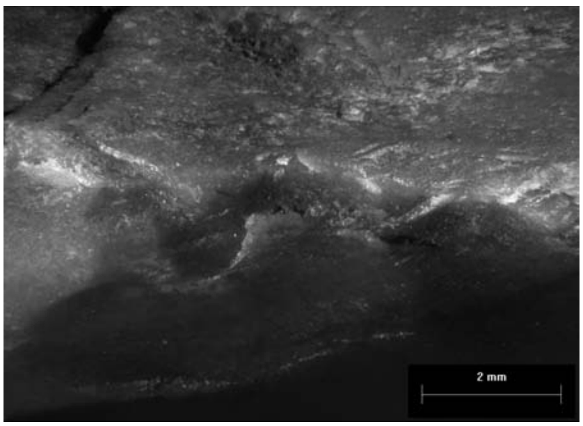



**Figure D-38.01.** Edge rounding observed along lateral margin near snap fracture.

continued.

***Artifact ID: 1919***
(continued)

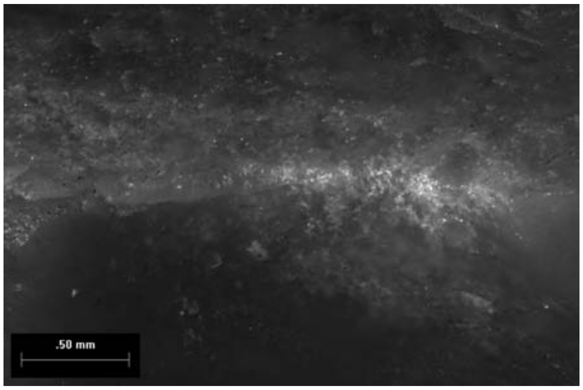



**Figure D-38.02.** Edge rounding and polish development observed along lateral margin near distal edge.

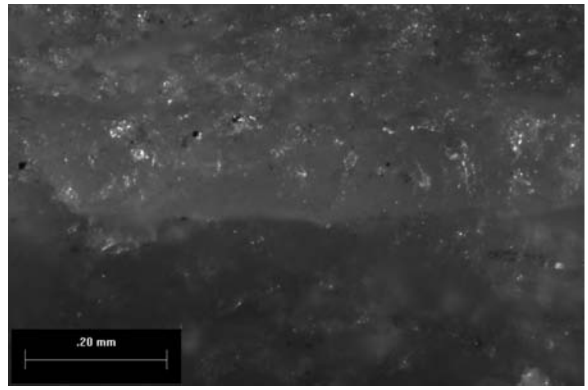



**Figure D-38.03.** Edge rounding and polish development observed along lateral margin near distal edge shown at higher magnification.

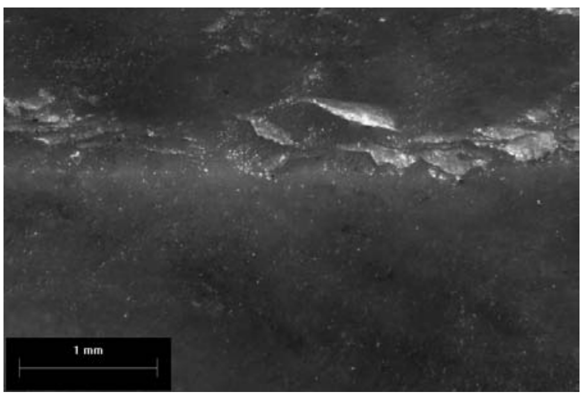



**Figure D-38.04.** Unifacial attrition observed along basal fracture edge.

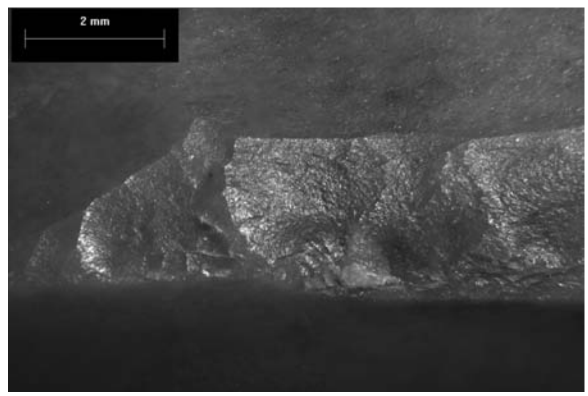



**Figure D-38.05.** Unifacial attrition observed along basal fracture edge. Attrition pattern suggest that the fracture margin was used for scraping following failure of the original tool form.

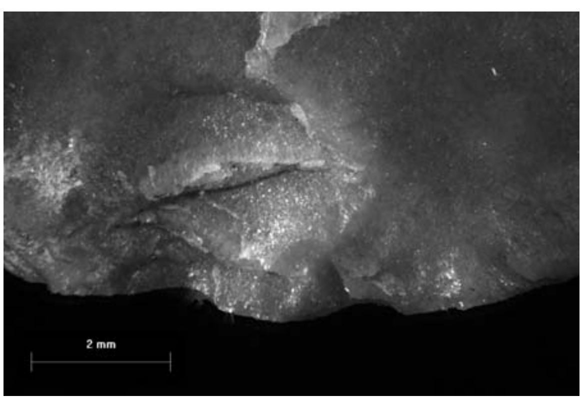



**Figure D-38.06.** Attrition and shallow polish observed along distal margin (favoring ventral face). Pattern of wear along this margin suggests the likelihood that the tool was used for adzing against a contact material of medium hardness.

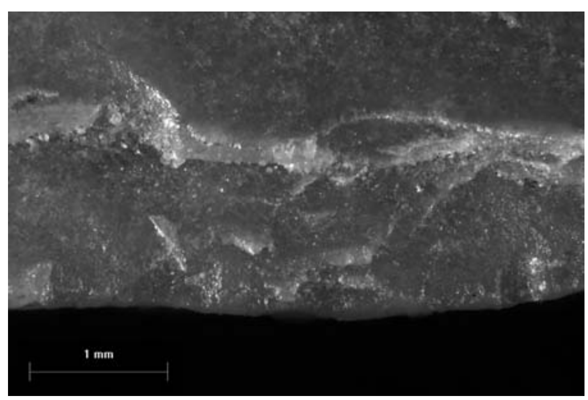



**Figure D-38.07.** Edge rounding and polish development observed along lateral margin near distal edge.

continued.

***Artifact ID: 1919***
(concluded)

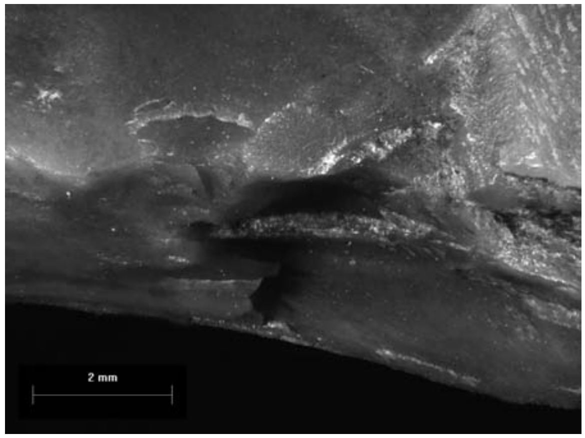



**Figure D-38.08.** Distal attrition is shown here to be largely unifacial, suggesting adzing rather than chopping.

***Artifact ID: 1940***

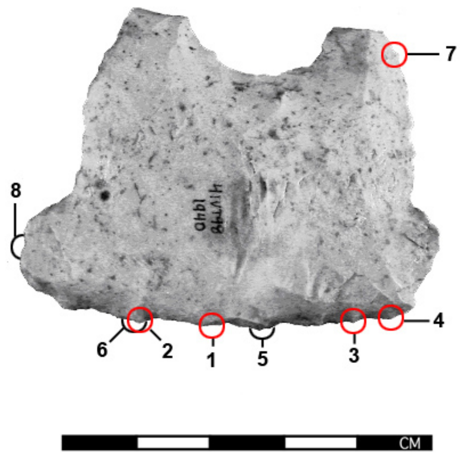



**Figure D-39.** Adze (Secondary Use) (Catalog/ID# 1940) from S14W84, West Wall Fall.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal (most likely / altered through recycling); **Artifact Type:** Adze (secondary use).

***Characteristics***

**Length:** 43 mm; **Width:** 56 mm; **Thickness:** 10 mm; **Weight:** 25.2 g; **Edge Angle:** 60-65°; **Portion:** complete; **Raw Material Type:** coarse chert; **Alteration:** thermal (minor, tip only).

***Use-Wear Pattern***

**Edge Attrition:** distal-bifacial; **Polish:** shallow lateral and distal; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

***Comments***

Artifact resembles the recycled base of a Pedernales point. However, basal notch lacks flute-like flaking (Turner and Hester 1985).

Polish is present on most lateral edges, but is best developed along the sides of the stem, the lower margin on the barbs, and along the distal bit.

Distal attrition is bifacial with well-developed step fractures occurring on either surface. Polish development is near equal on either side of the distal margin, extending slightly deeper on the ventral face.

The wear pattern observed suggests that the tool was used as an adze rather than a scraper. The distal margin is also too jagged to have served as a scraper as it would have damaged a soft or medium-soft contact material.

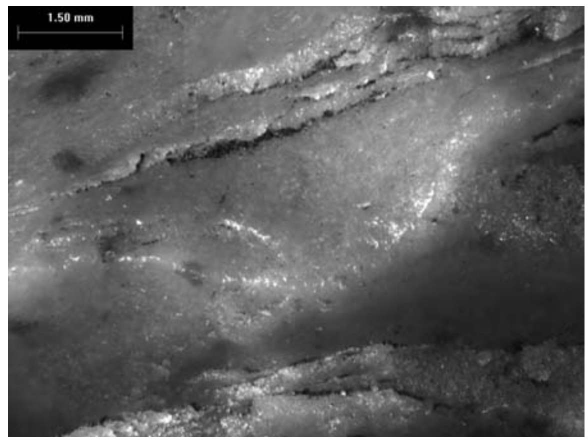



**Figure D-39.01.** Edge rounding and shallow polish observed along distal margin. Tool is most likely a recycled projectile point and the distal margin is a rejuvenated snap fracture.

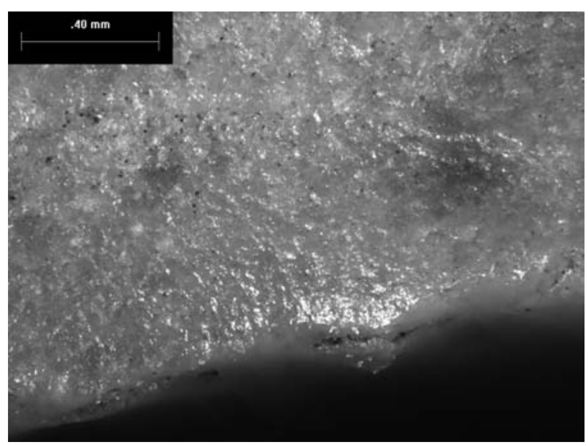



**Figure D-39.02.** Polish noted along distal margin. Polish is developed bifacially, but attrition pattern is largely unifacial.

continued.

***Artifact ID: 1940***
(concluded)

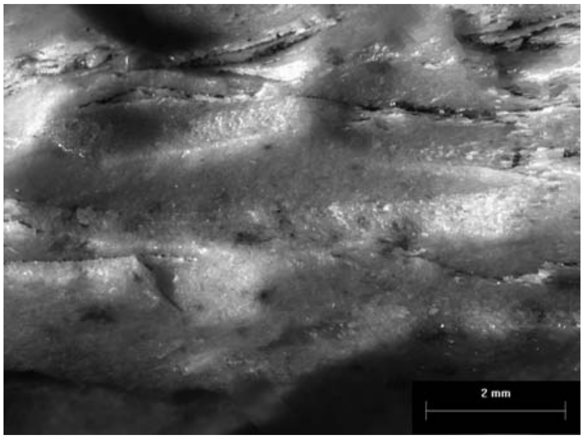



**Figure D-39.03.** Edge damage observed along distal margin. Damage is not consistent with used as an adze rather than as a scraper.


**Figure D-39.04.** Edge damage recorded along distal margin.

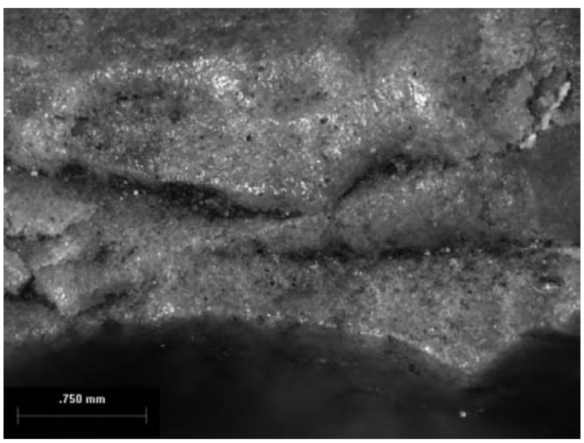



**Figure D-39.05.** Edge damage and shallow polish observed along distal margin.

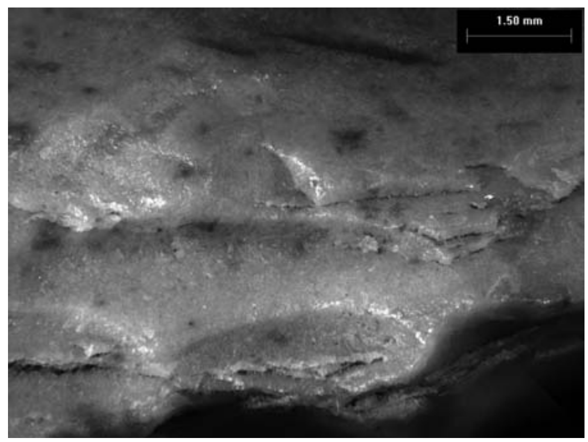



**Figure D-39.06.** Attrition and facet rounding recorded along distal margin.

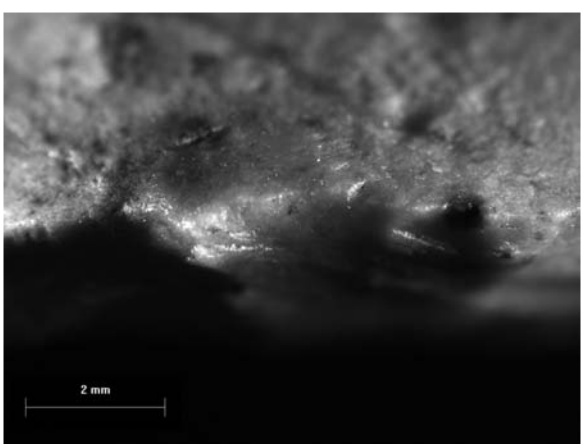



**Figure D-39.07.** Edge rounding recorded along lateral margin of hafting element.

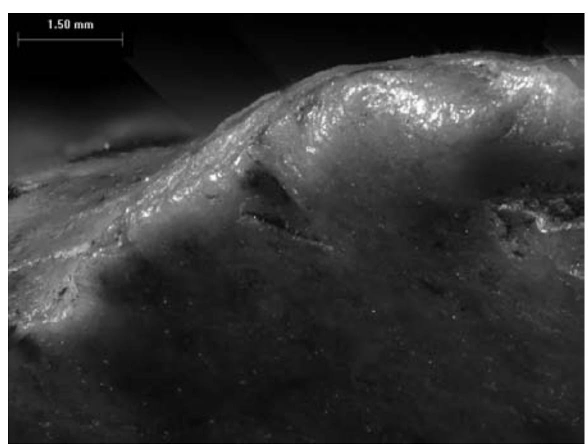



**Figure D-39.08.** Edge rounding and polish observed along margin of barb.

## Artifact ID: 1943

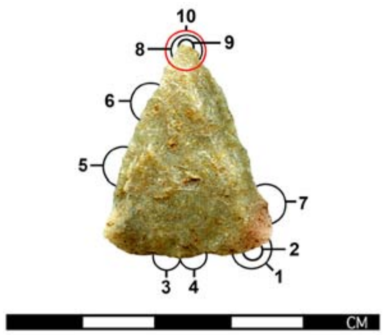



**Figure D-40.** Projectile Point(?) (Catalog/ID# 1943) from S14W86, Level 8.

### Classification

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile (?).

### Characteristics

**Length:** 29 mm; **Width:** 23 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chalcedony (?); **Alteration:** thermal.

### Use-Wear Pattern

**Edge Attrition:** multi-lateral/unifacial, distal; **Polish:** indeterminate; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

### Comments

This artifact was produced through bilateral percussion flaking on a flake (most likely). A glossy sheen covers the entirety of the object, indicative of thermal alteration. Most edges appear rounded at the margins, and some of this rounding is certainly due to vitrification.

The distal point exhibits attrition, but it is questionable as to whether this damage was caused by an impact fracture. The fracture margins are rounded and glossy. In general, vitrification has obscured all definitive use markers. Based on the edge wear observed, there is a slight possibility that the artifact functioned as a scraper.

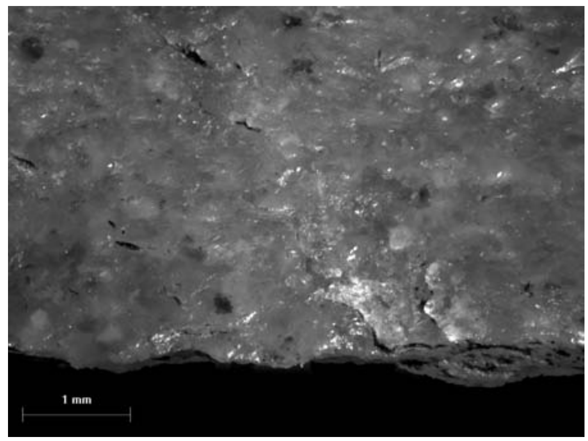



**Figure D-40.01.** Like most other edge areas on the artifact, the basal margin shown here exhibits some rounding and a thick glossy sheen. The rounding and sheen are the result of thermal alteration. Most traces of use have been obscured from vitrification.

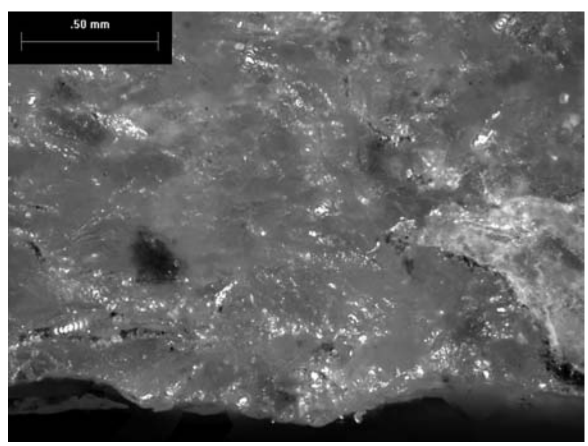



**Figure D-40.02.** The rounding and sheen noted along basal margin are the result of thermal alteration. Vitrification has obscured most traces of use.

continued.

***Artifact ID: 1943***
(continued)

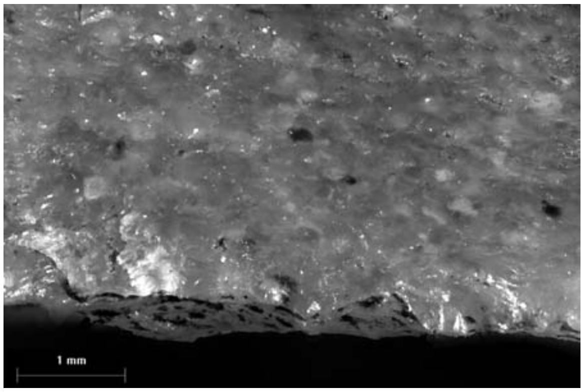



**Figure D-40.03.** The rounding and sheen noted along basal margin are the result of thermal alteration. Vitrification has obscured most traces of use.

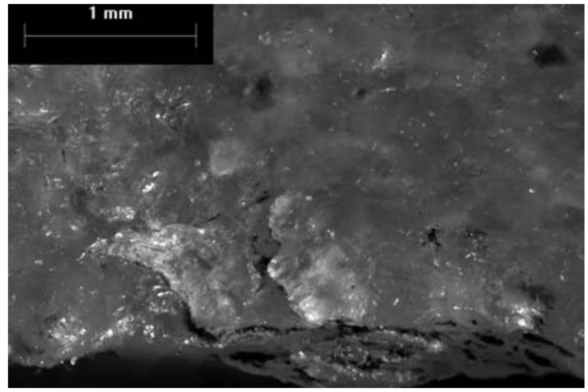



**Figure D-40.04.** The rounding and sheen noted along basal margin are the result of thermal alteration. Vitrification has obscured most traces of use.

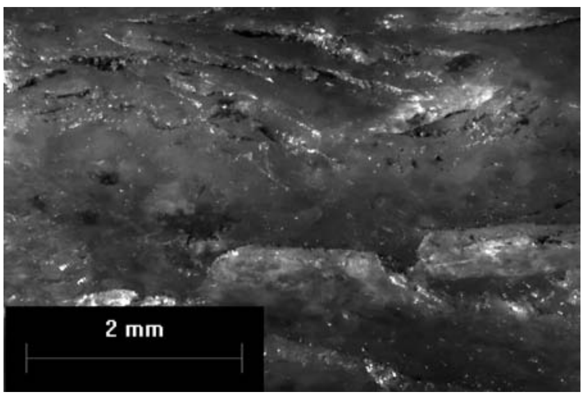



**Figure D-40.05.** The rounding and sheen noted along lateral margin are the result of thermal alteration. Vitrification has obscured most traces of use.

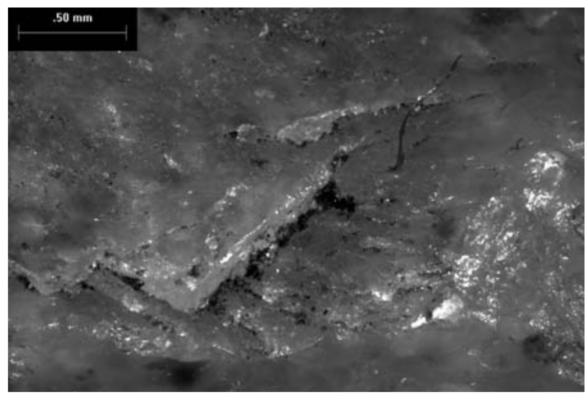



**Figure D-40.06.** The rounding and sheen noted along lateral margin are the result of thermal alteration. Vitrification has obscured most traces of use.

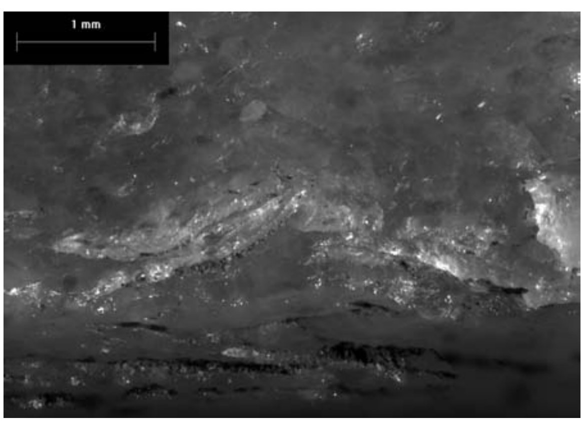



**Figure D-40.07.** The rounding and sheen noted along lower lateral margin are the result of thermal alteration. Vitrification has obscured most traces of use.

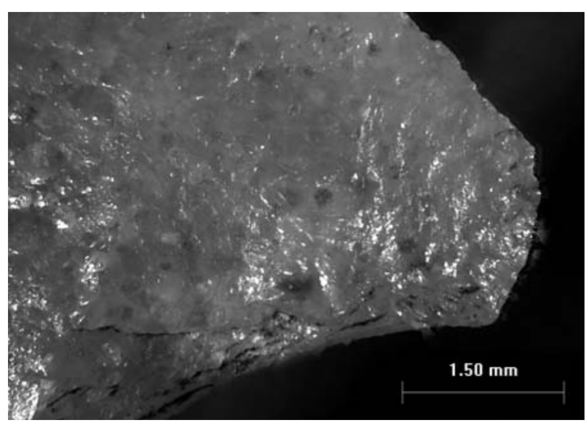



**Figure D-40.08.** Some attrition is observed at distal tip. The pattern of attrition is not inconsistent with impact fracturing.

continued.

***Artifact ID: 1943***
(concluded)

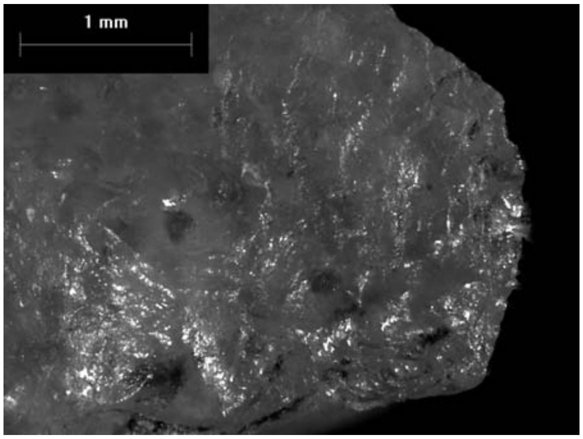



**Figure D-40.09.** Attrition at distal tip shown at greater magnification.

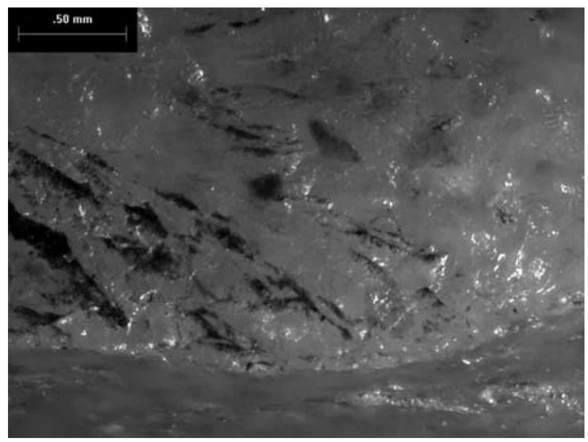



**Figure D-40.10.** Attrition at distal tip shown at greater magnification

*Artifact ID: 1995*

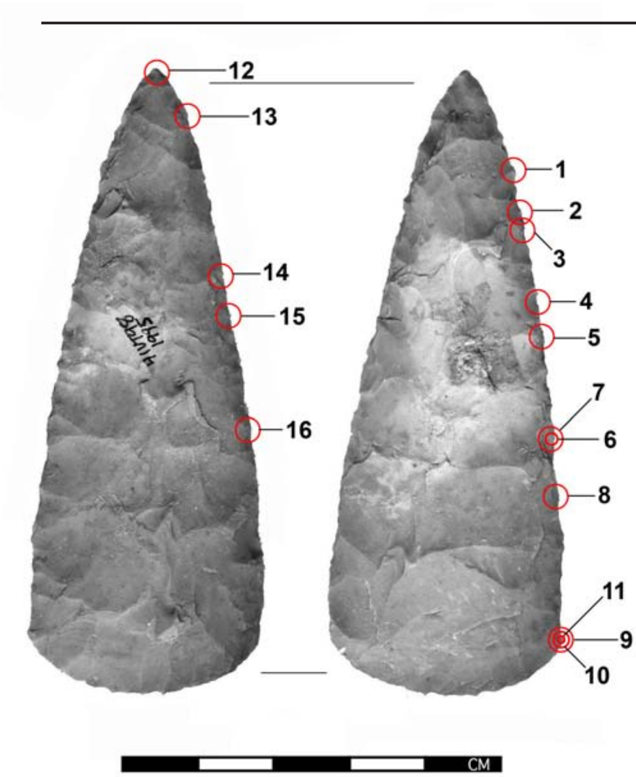



**Figure D-41.** Knife (Catalog/ID# 1995) from S12W88, Level North Wall Fall.

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

*Characteristics*

**Length:** 83 mm; **Width:** 32 mm; **Thickness:** 7 mm; **Weight:** (unrecorded); **Edge Angle:** 50°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

*Use-Wear Pattern*

**Edge Attrition:** distal-lateral; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft to medium-soft.

*Comments*

The distal point of the blade exhibits edge rounding and a well-developed polish. However, there is no attrition observed at the tip that is consistent with impact fracturing. This suggests that the tool was not a projectile point, but more likely a knife.

The lateral margins along the medial section of the blade exhibit the greatest amount of polish, suggesting that the tool was used in whittling or carving rather than slicing. In cutting or slicing, the distribution of polish is expected to be more evenly distributed along the length of the blade edge. Very little attrition is associated with the edge modification observed at the blade's midsection. This suggests that the tool was used with a soft to medium-soft contact material.

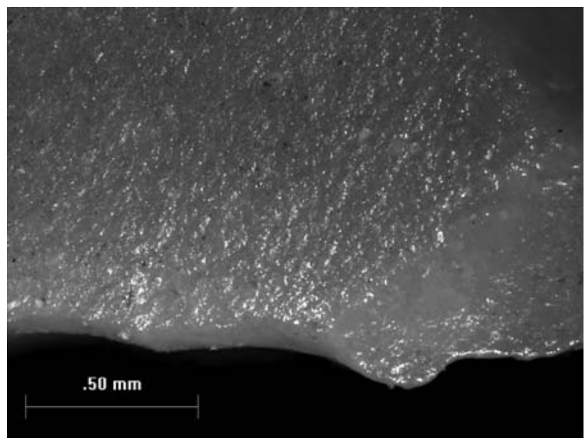



**Figure D-41.01.** Edge rounding and shallow polish noted along lateral margin of distal quarter of blade.

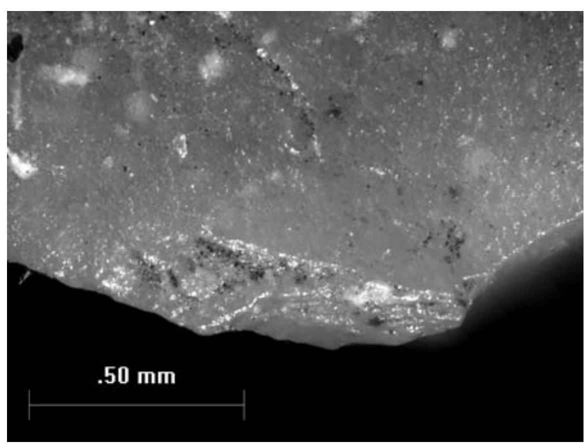



**Figure D-41.02.** Lateral margin along distal quarter of blade exhibits edge attrition and shallow polish on margin and interior facets.

continued.

***Artifact ID: 1995***
(continued)

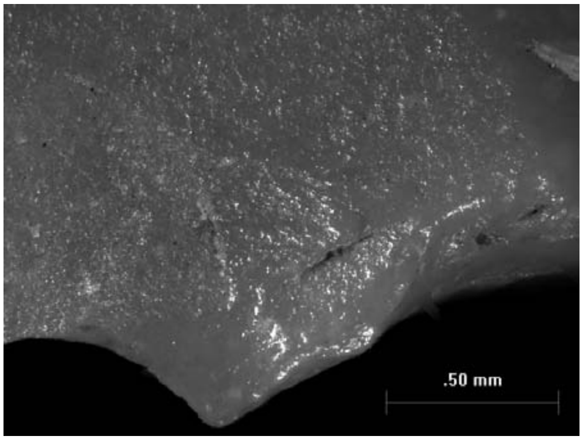



**Figure D-41.03.** Edge rounding and shallow polish noted along lateral margin of distal quarter of blade.

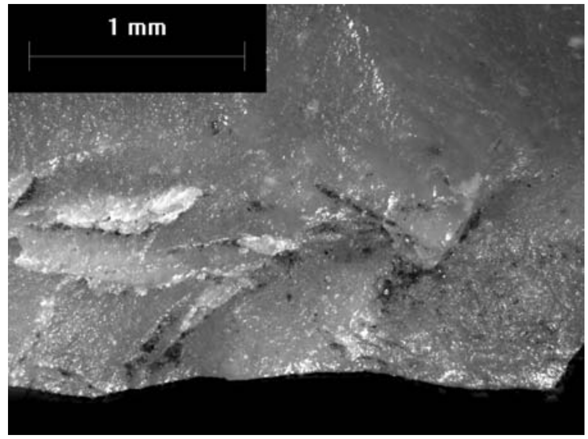



**Figure D-41.04.** Edge rounding and shallow polish observed along lateral margin near midsection of blade.

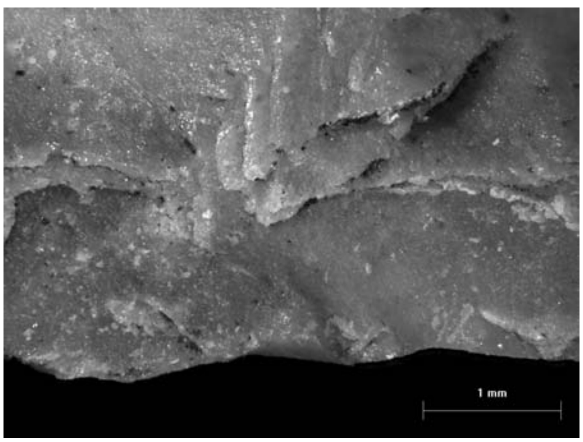



**Figure D-41.05.** Edge rounding observed along lateral margin near midsection of blade.

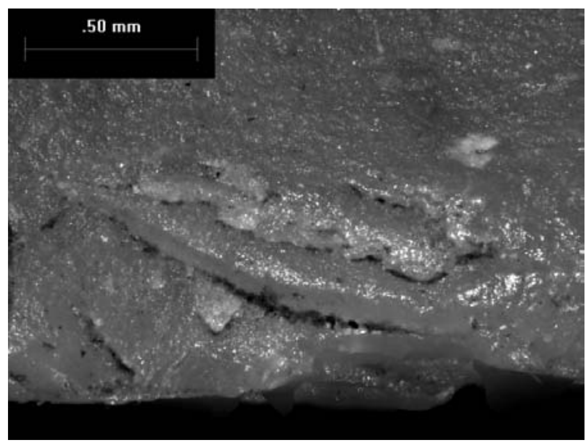



**Figure D-41.06.** Rounded edge, shallow polish, and silica deposits observed along lateral margin near midsection of blade.

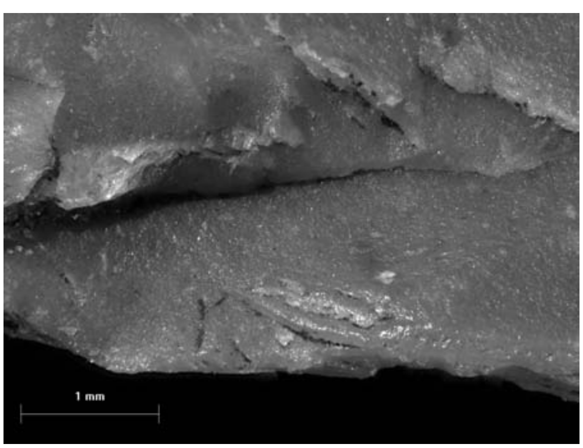



**Figure D-41.07.** Edge rounding and shallow polish observed along lateral margin near midsection of blade.

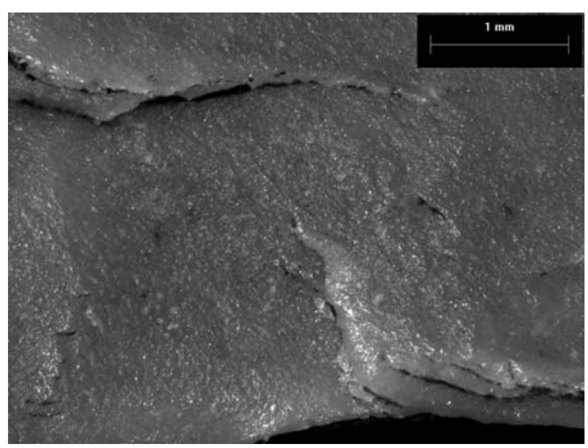



**Figure D-41.08.** Lateral margin at lower midsection of blade exhibits shallow polish and edge rounding.

continued.

***Artifact ID: 1995***
(continued)

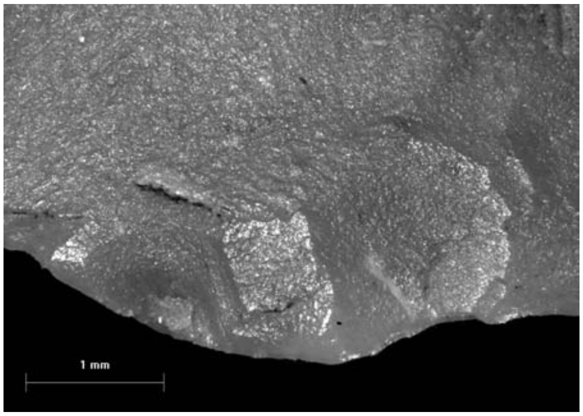



**Figure D-41.09.** Edge rounding and shallow polish observed at proximal extent of lateral margin.

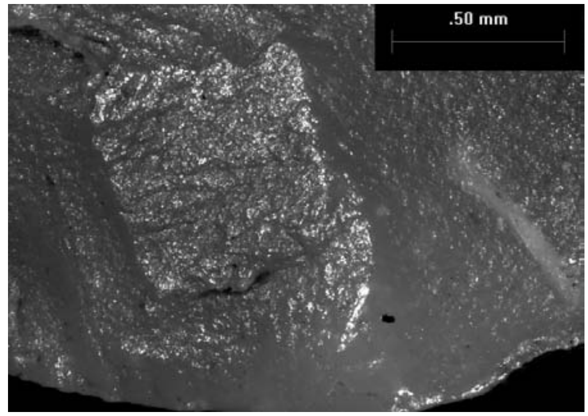



**Figure D-41.10.** Edge rounding and shallow polish observed at proximal extent of lateral margin, shown here at higher magnification.

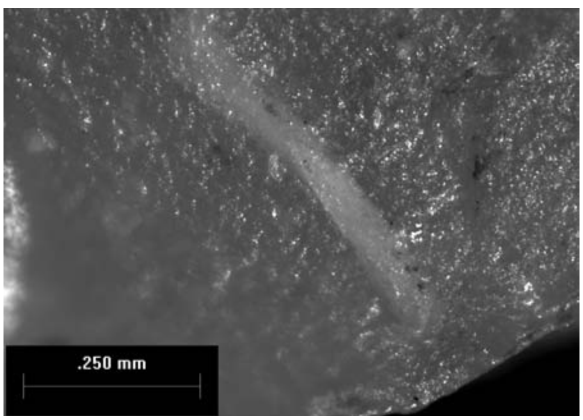



**Figure D-41.11.** Edge rounding, shallow polish, and silica deposit observed at proximal extent of lateral margin at high magnification.

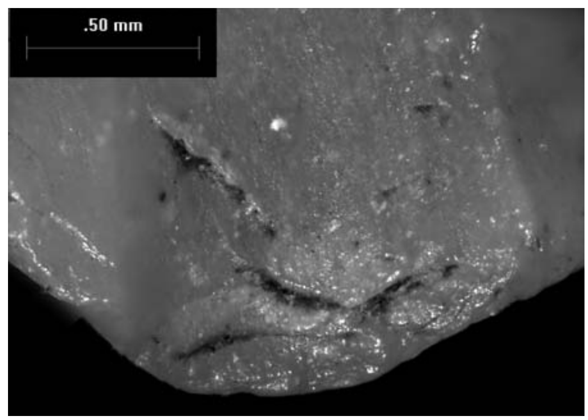



**Figure D-41.12.** The distal point exhibits edge rounding and well-developed polish.

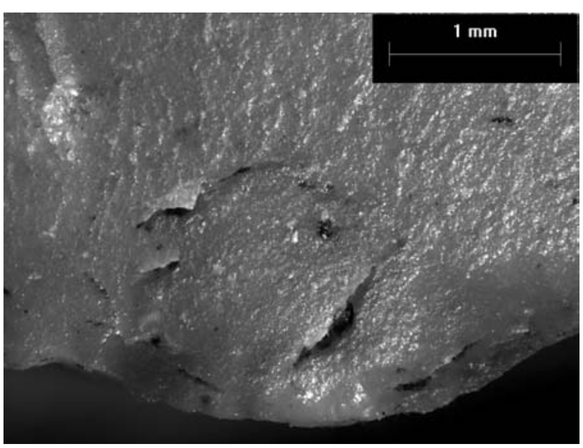



**Figure D-41.13.** Margin near tip exhibits edge rounding and shallow, well-developed polish.

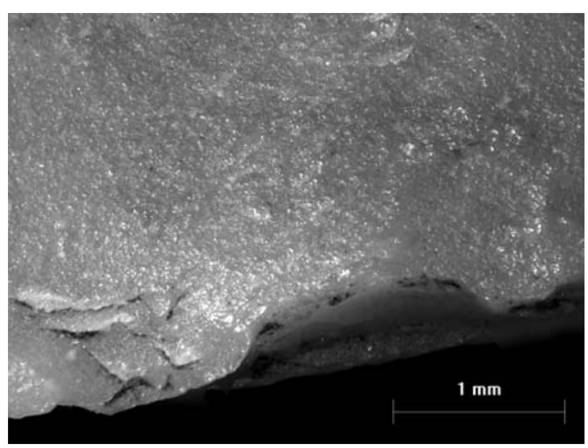



**Figure D-41.14.** Lateral margin at upper midsection of blade exhibits shallow polish and minor edge rounding.

continued.

***Artifact ID: 1995***
(concluded)

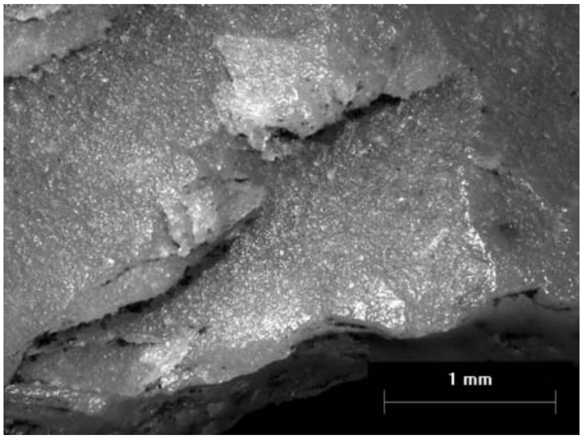



**Figure D-41.15.** Lateral margin at midsection of blade exhibits edge rounding.

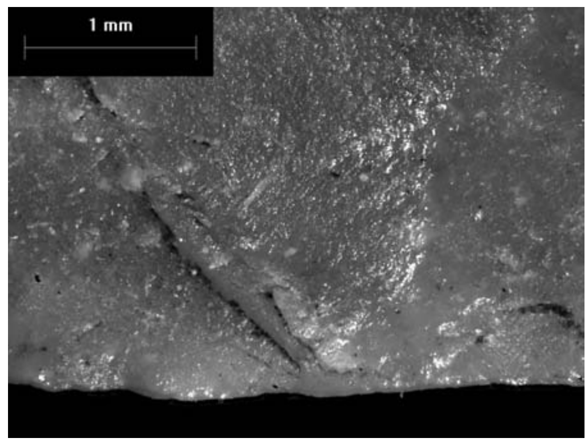



**Figure D-41.16.** Lateral margin at midsection of blade exhibits shallow polish and edge rounding.

*Artifact ID: 2022*

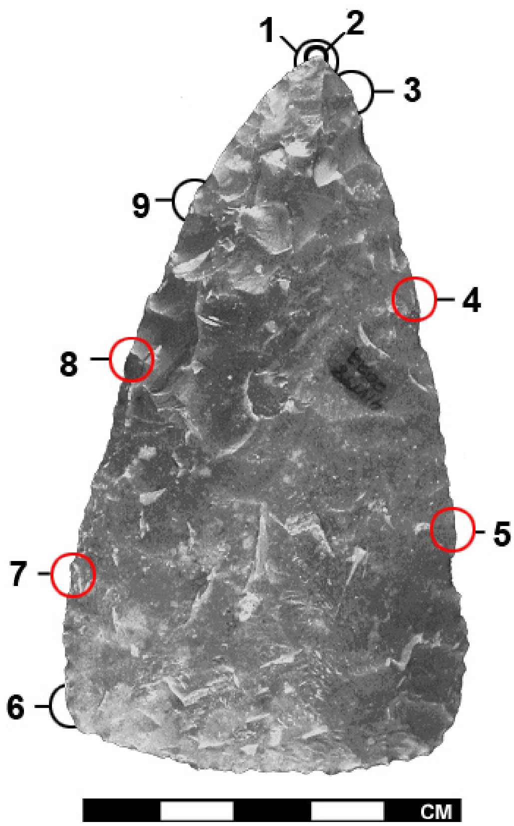



**Figure D-42.** Possible Spear Point or Knife (Catalog/ID# 2022) from S9.61W87.60, Level 13.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** (Possible) Spear Point or Knife.

### *Characteristics*

**Length:** 96 mm; **Width:** 53 mm; **Thickness:** 10 mm; **Weight:** 49.0 g; **Edge Angle:** 40°; **Portion:** complete; **Raw Material Type:** chalcedony (possibly highly translucent chert); **Alteration:** none observed.

### *Use-Wear Pattern*

**Edge Attrition:** circumferential (distinct at tip); **Polish:** circumferential (most pronounced at all corners); **Battering:** none observed; **Etching:** shallow distal; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

### *Comments*

There is not an edge on this tool that doesn't have some dulling (rounding) and polish. The only difference appears to be in the development of the polish. Polish is best developed, and edge rounding is most noted, at (or proximal to) the distal tip and proximal corners. The edge rounding and shallow, poorly developed polish noted on the basal corners may have resulted from hafting.

Striations are noted emanating from the distal tip. The tip is worn (rounded) with shallow, but developed, polish. The attrition pattern noted at the distal tip is distinct from all other areas.

The artifact has been finely pressure flaked around its circumference. What is generally observed to be light attrition circumferentially distributed along the tool's margins may, in fact, be misidentified edge preparation, and thus not directly related to use.

The extensiveness of polish coupled with the lack of strong attrition suggests that the tool was used in association with a soft contact material. However, a soft material would not have produced the striations observed at the distal tip. It is possible that only the tip was brought into contact with harder material during use. If the tool was used in animal processing, for example, the tip may have repeatedly struck bone while the lateral margins remained in contact with flesh. This use cannot be substantiated, but it does not conflict with the pattern of wear observed.

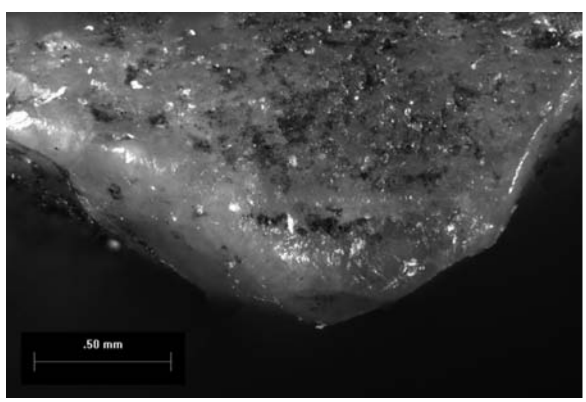



**Figure D-42.01.** Attrition and well-developed polish observed at distal tip. Polish and rounding observed along lateral margins near tip.

continued.

***Artifact ID: 2022***
(continued)

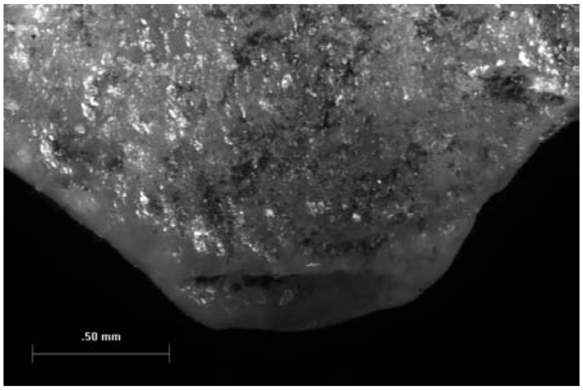



**Figure D-42.02.** Stria observed emanating from distal point. Well-developed polish is observed along distal margin.

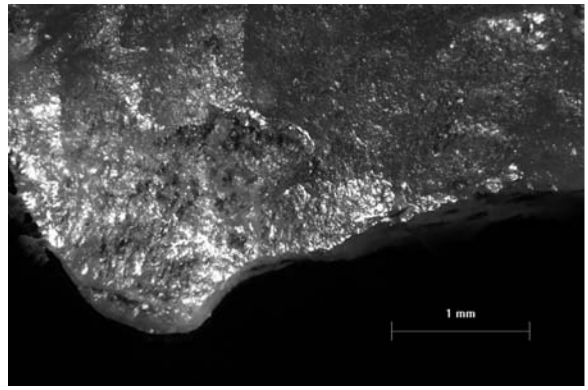



**Figure D-42.03.** Stria observed emanating from distal point. Well-developed polish is observed along distal margin.

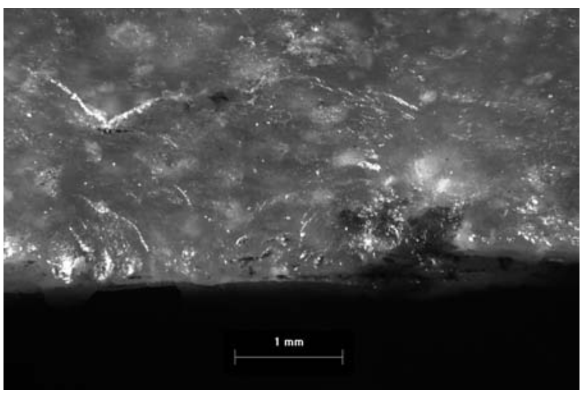



**Figure D-42.04.** Edge rounding and shallow polish recorded on lateral margin at upper midsection of blade.

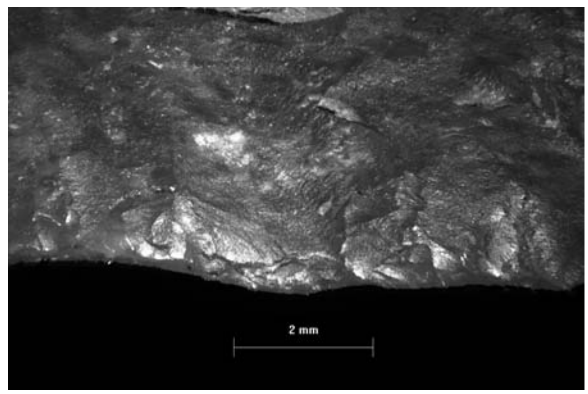



**Figure D-42.05.** Lateral margin at lower midsection of blade does not exhibit any clear evidence of use wear.

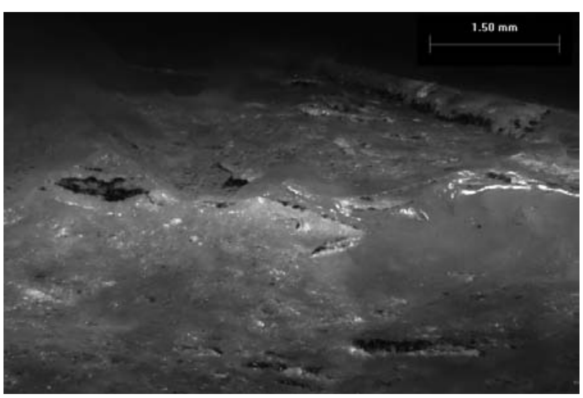



**Figure D-42.06.** Edge rounding and shallow, poorly-developed polish noted at basal corner. Modification may have resulted from hafting.


**Figure D-42.07.** Flake terminations observed along lateral margin at lower quarter of blade are likely remnant from manufacture. No evidence of wear is noted along this section of the blade.

continued.

***Artifact ID: 2022***
(concluded)

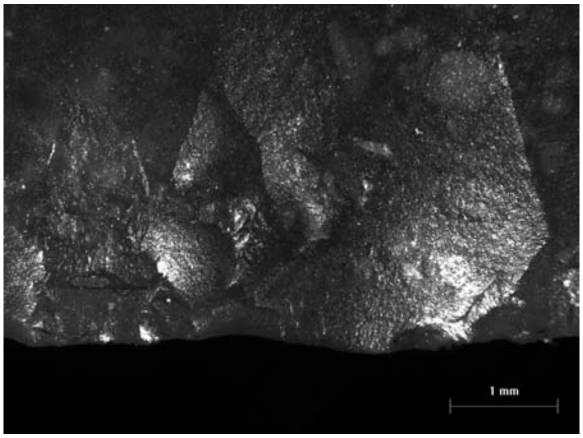
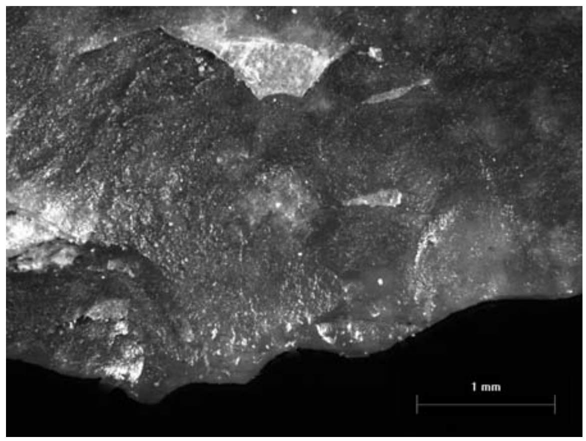



**Figure D-42.08.** Lateral margin at midsection of blade exhibits minor edge rounding, but no clear evidence of use-related attrition or polish.

**Figure D-42.09.** Lateral margin along upper quarter of blade exhibits edge rounding and shallow polish.



***Artifact ID: 2031***

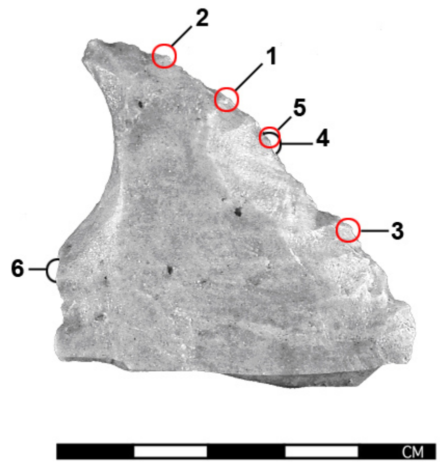



**Figure D-43.** Scraper (Catalog/ID# 2031) from S10W90, Level 15.

***Classification***

**Artifact Class:** Uniface; **Artifact Subclass:** Informal; **Artifact Type:** Scraper.

***Characteristics***

**Length:** 46 mm; **Width:** 48 mm; **Thickness:** 11 mm; **Weight:** 21.2 g; **Edge Angle:** 60°; **Portion:** fragment (?); **Raw Material Type:** fine grained quartzite; **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** unifacial-unilateral; **Polish:** shallow lateral (well developed); **Battering:** none (edges dulled); **Etching:** shallow unilateral (bifacial—favoring dorsal surface); **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

***Comments***

Modified margin exhibits edge rounding and polish along its extent. Feather terminations are also noted along the distal side of modified margin.

Linear striations were observed on each face along the modified margin, but they are more notable (better defined and running deeper) along the dorsal face of the margin. Striations run perpendicular, to slightly diagonal, to the margin.

No obvious or definite signs of hafting are evident. The area of backside polish may indicate wear derived from direct manipulation during use.

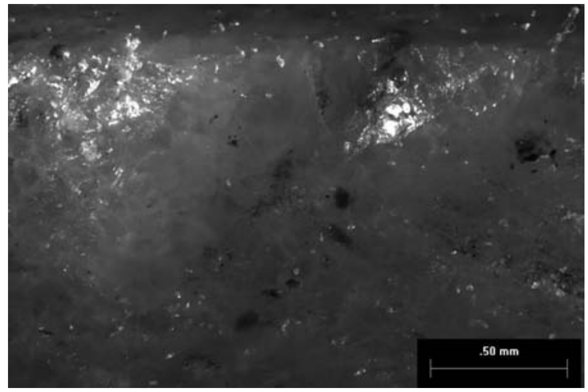



**Figure D-43.01.** Blade margin exhibits edge rounding and shallow polish. Attrition is largely unifacial.

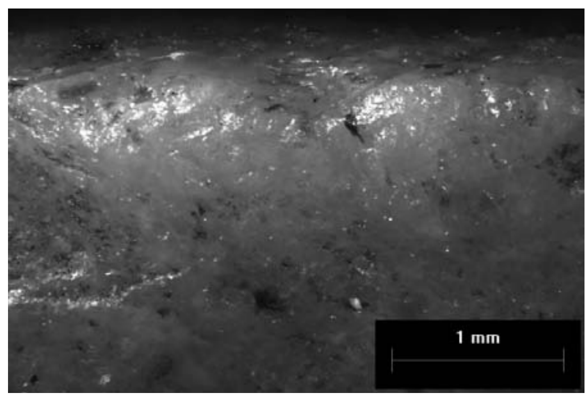



**Figure D-43.02.** Well-developed polish along blade margin.

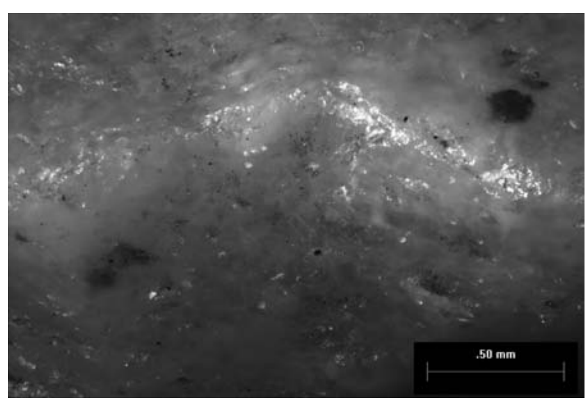



**Figure D-43.03.** Polish along blade margin.

continued.

***Artifact ID: 2031***
(concluded)

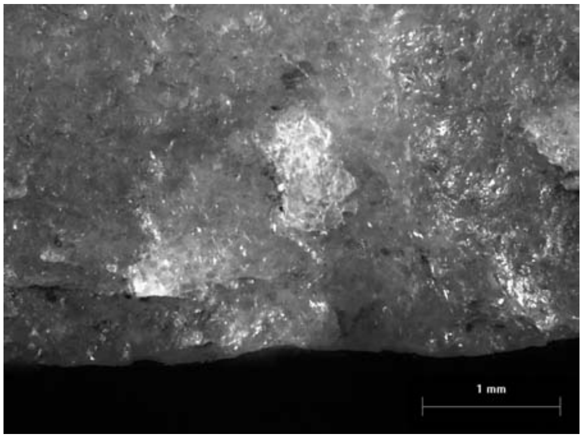



**Figure D-43.04.** Marginal attrition is evenly distributed along margin, suggesting that entire edge was used. This, together with a unifacial attrition pattern, suggests that the tool was used as a scraper.

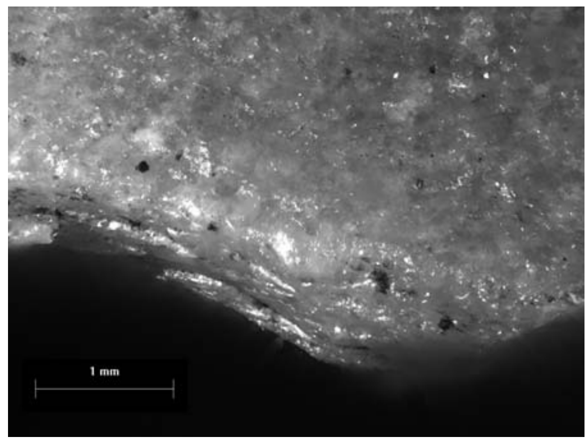



**Figure D-43.05.** Edge rounding and shallow polish located along blade margin. Attrition is largely unifacial.

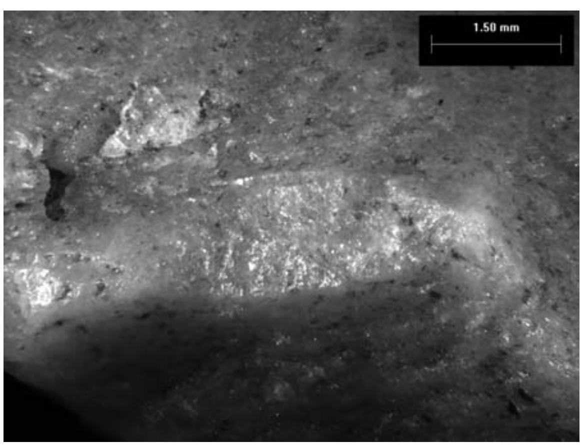



**Figure D-43.06.** Minor polish noted on backside of tool may have resulted from prehensile wear.

## *Artifact ID: 2237*

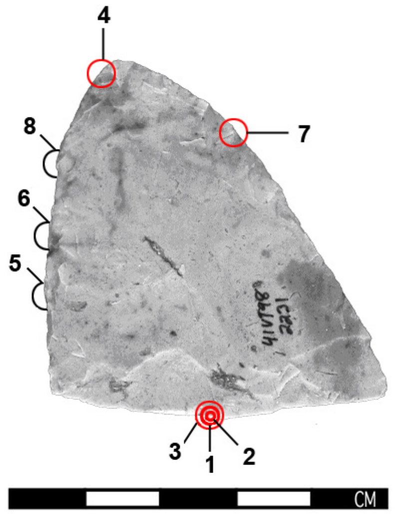



**Figure D-44.** Knife (Catalog/ID# 2237) from S12W86, Level 17.

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

### *Characteristics*

**Length:** 46 mm; **Width:** 46 mm; **Thickness:** 9 mm; **Weight:** 18.9 g; **Edge Angle:** 40°; **Portion:** distal (?); **Raw Material Type:** mottled chert; **Alteration:** minor oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial (heavier along convex edge); **Polish:** circumferential (heavier along convex edge); **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft/medium-hard.

### *Comments*

All margins exhibit polish, including the tip. The distal (?) point displays an attrition pattern that is distinct from an impact fracture, suggesting that the tool was not used as a projectile. However, edge attrition and polish are well developed at the tip, indicating that the tool may have been used for thrusting and/or cutting functions.

Edge attrition on the long margin is consistent, but not severe in terms of the amount of actual edge damage produced. Edge attrition along the shorter of the two margins is much less developed, but removals and polish are present.

A small area along the proximal fracture margin exhibits unifacial attrition and polish. The pattern of wear suggests that this portion of the tool may have been used for a short duration as a scraper.

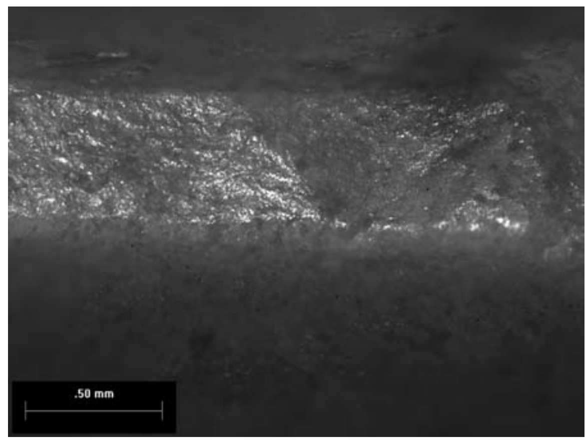



**Figure D-44.01.** Unifacial attrition observed along basal fracture, suggesting that the possibility that the tool was used as an expedient scraper following failure of the original form.

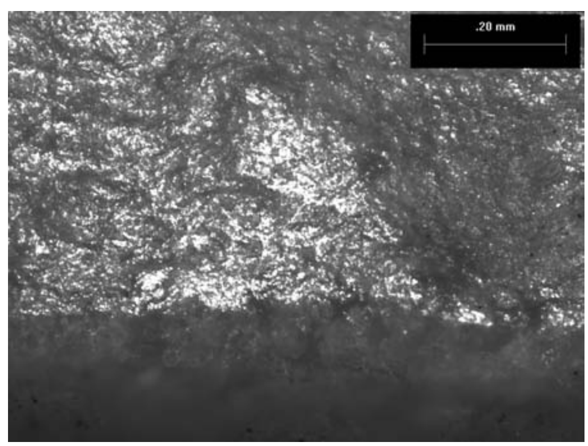



**Figure D-44.02.** Basal margin shown at higher magnification illustrating edge rounding.

continued.

***Artifact ID: 2237***
(concluded)

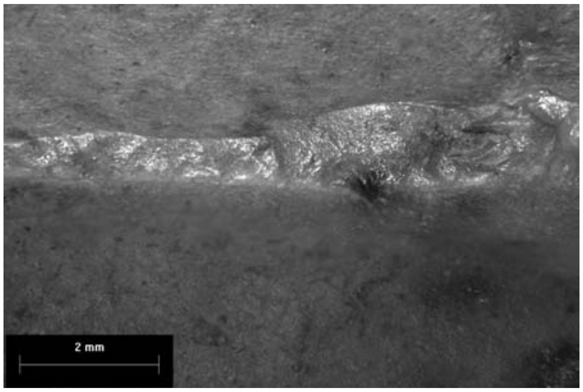



**Figure D-44.03.** Basal edge shown at lower resolution. Unifacial attrition and edge rounding can be observed in the photo.

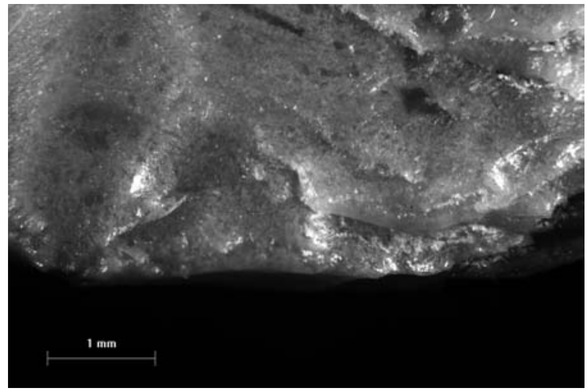



**Figure D-44.04.** Edge rounding, attrition, and shallow polish observed at distal point. Wear pattern suggests that the original tool form may have served as a projectile.

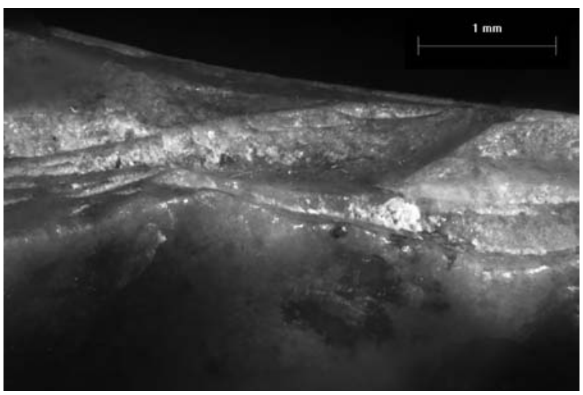



**Figure D-44.05.** Edge rounding recorded along lateral margin.

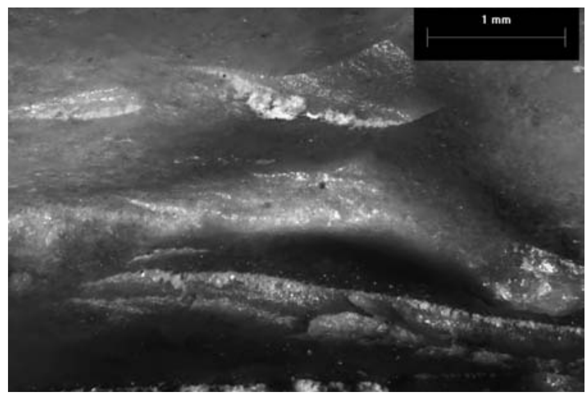



**Figure D-44.06.** Edge rounding recorded along lateral margin.

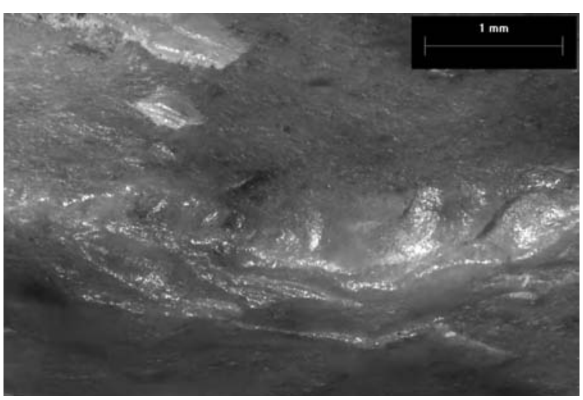



**Figure D-44.07.** Shallow polish and edge rounding observed on upper lateral margin.

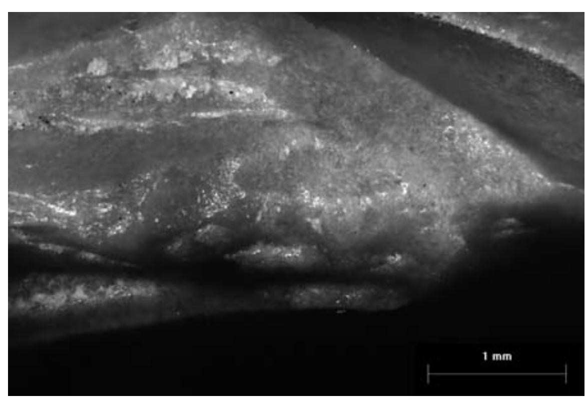



**Figure D-44.08.** Shallow polish, attrition, and edge rounding observed on upper lateral margin.

## Artifact ID: 3015

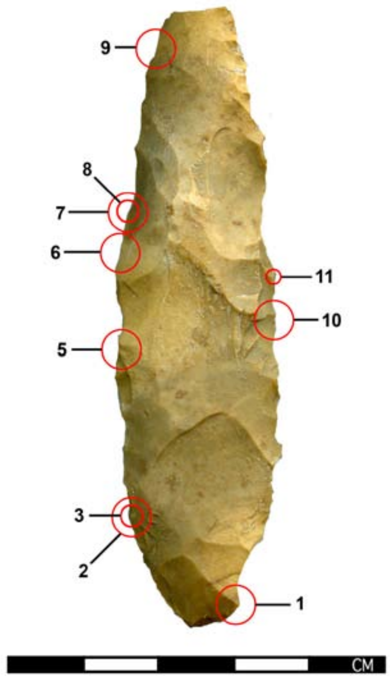



**Figure D-45.** Preform (?) (Catalog/ID# 3015) from S29W116, Level 14.

### Classification

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate (crude); **Artifact Type:** Preform (?).

### Characteristics

**Length:** 83 mm; **Width:** 23 mm; **Thickness:** 15 mm; **Weight:** (unrecorded); **Edge Angle:** edge 55°-65°; distal 60°; **Portion:** complete (95 percent); **Raw Material Type:** chert (coarse grained); **Alteration:** none.

### Use-Wear Pattern

**Edge Attrition:** none (indeterminate); **Polish:** none (indeterminate); **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate; **Contact Material Hardness:** NA.

### Comments

This artifact is crudely flaked and may not have reached the final stage of its production trajectory. Both the base and the tip exhibit fractures. The base displays a bending fracture, while the tip shows a modified removal. It is unclear as to whether the minor attrition noted at the tip represents edge preparation or use-wear, but the attrition apparently followed the removal.

Lateral margins exhibit many soft-hammer removal scars terminating in step fractures. There is no pressure flaking as is characteristic of other similar forms further along in their production trajectory. There is no evidence of use present along the margins. No hafting evidence is present.

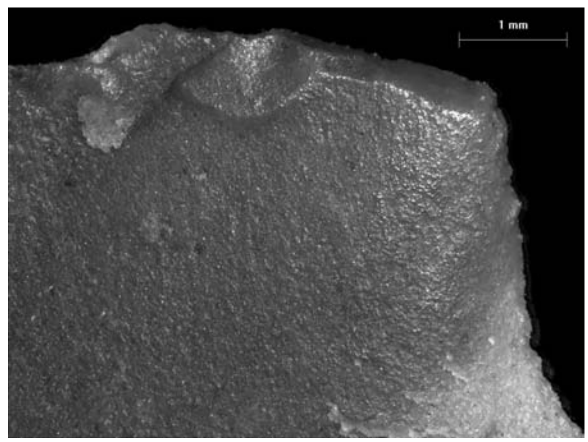



**Figure D-45.01.** Minor edge rounding noted at corner of distal margin.

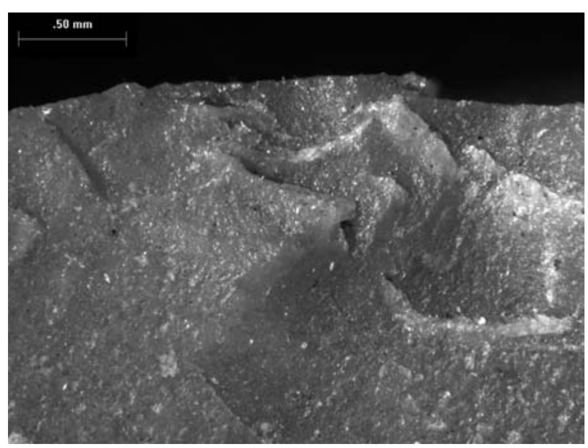



**Figure D-45.02.** Micro-fractures noted along the lateral margin toward the base. No use-related remodeling was recorded.

continued.

***Artifact ID: 3015***
(continued)

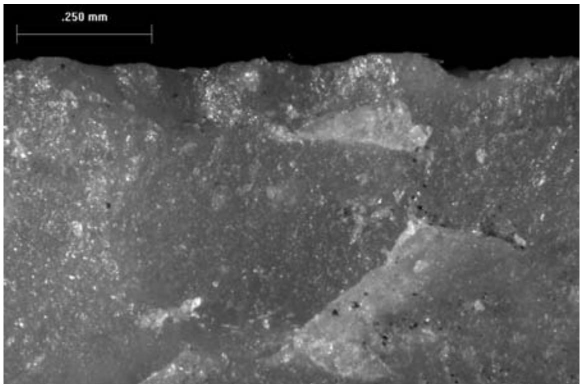



**Figure D-45.03.** Close-up view of lateral margin toward the base showing the lack of distinct edge remodeling.

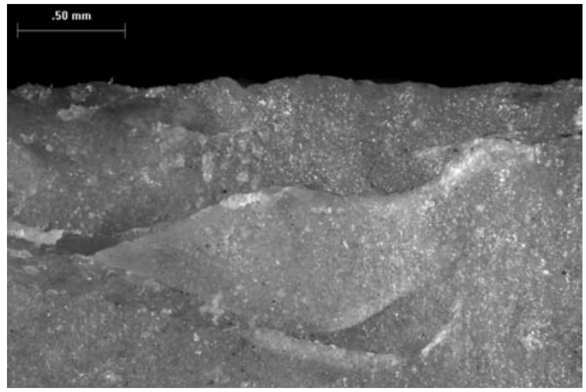



**Figure D-45.04.** The lateral margins toward the midsection of the blade provide no evidence for tool use.

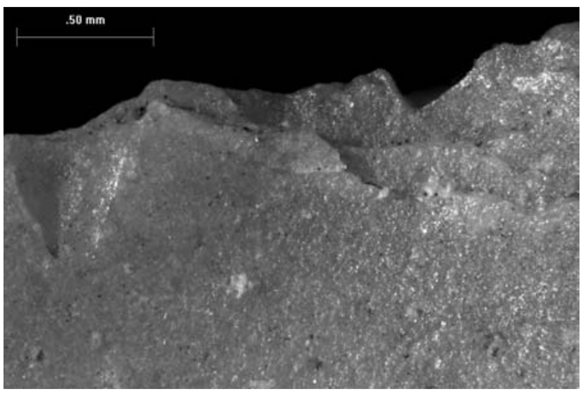



**Figure D-45.05.** Most areas along the lateral margin exhibit sharp, unmodified micro-fractures.

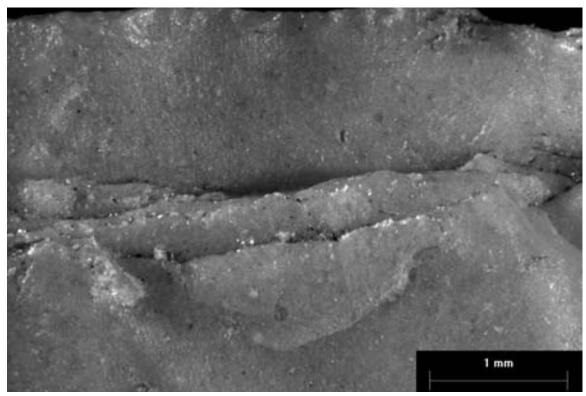



**Figure D-45.06.** Micro-fractures along the lateral margin provide no evidence for use-related modification.

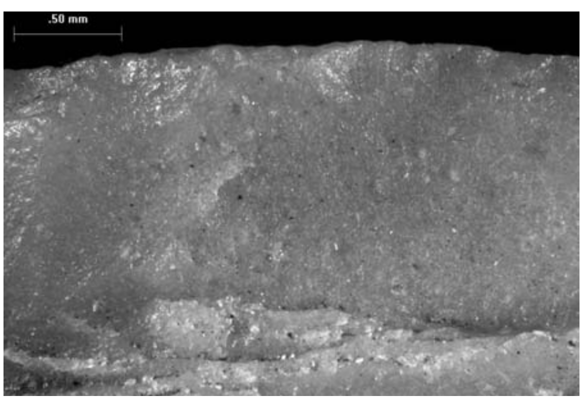



**Figure D-45.07.** Lateral margin near upper mid-section of blade.

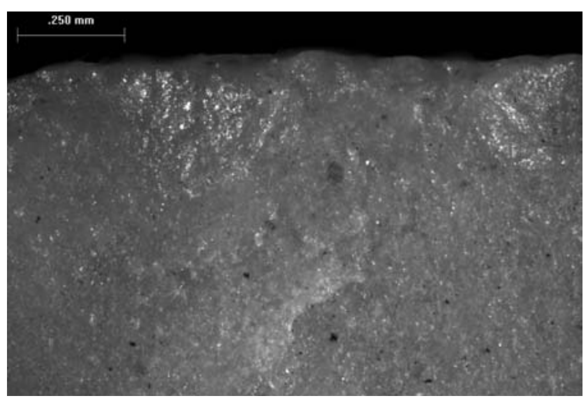



**Figure D-45.08.** This close-up shows that edge rounding along the lateral margin is restricted to the outer 0.25mm of the tool's edge.

continued.

***Artifact ID: 3015***
(concluded)

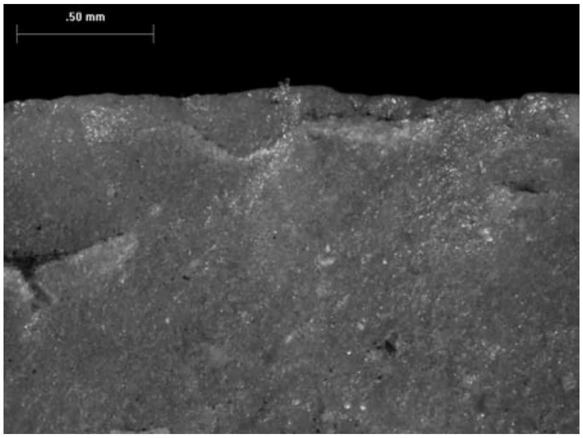



**Figure D-45.09.** This close-up shows that edge rounding along the upper lateral margin near the distal end of the blade is restricted to the outer 0.25mm of the tool's edge.

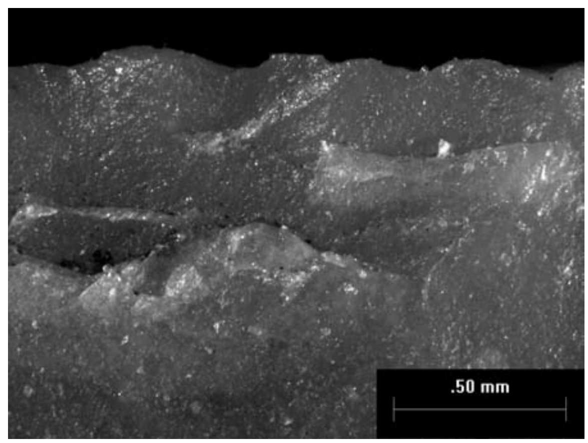



**Figure D-45.10.** Micro-fractures along the blade's margin are largely unmodified.

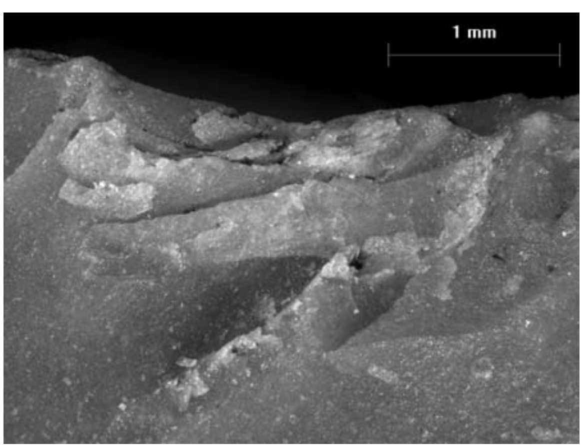



**Figure D-45.11.** Edge fractures are not consistent with use, but rather tool production.

## *Artifact ID: 3326*

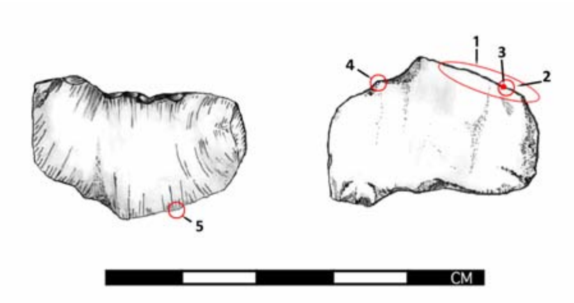



**Figure D-46.** Edge-Modified Flake (Catalog/ID# 3326) from S14W86, Level 2.

### *Classification*

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Unaltered; **Artifact Type:** Expedient Tool.

### *Characteristics*

**Length:** 29 mm; **Width:** 19 mm; **Thickness:** 4 mm; **Weight:** (unrecorded); **Edge Angle:** 30°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** yellow oxide staining.

### *Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium (indeterminate between MS and MH).

### *Comments*

Polish is present on high points, ridges and protrusions. This polish is very shallow and limited to a single edge. Attrition is recorded along the margin on the dorsal side of the flake. The bilateral-bifacial flaking pattern recorded suggests that the implement was used in a slicing action. The shallowness of the polish observed indicates a shallow depth of penetration.

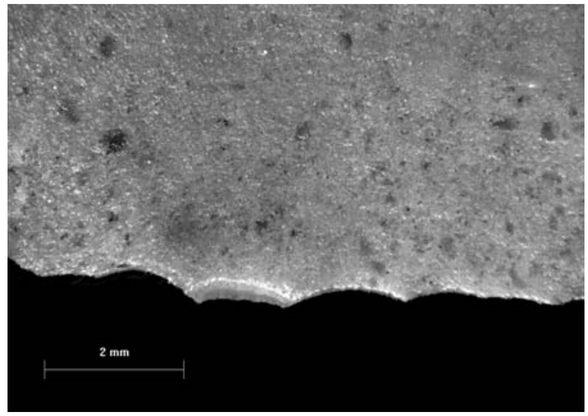



**Figure D-46.01.** Attrition recorded along margin on dorsal side of utilized flake.

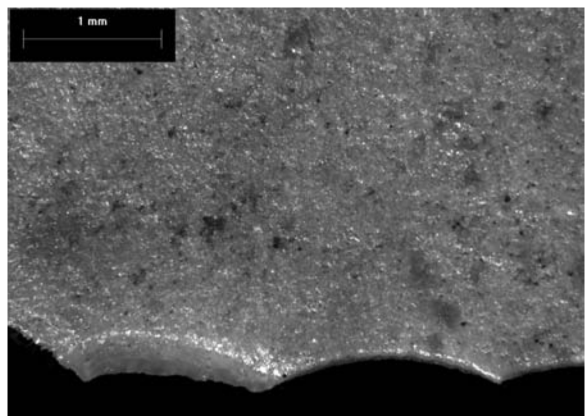



**Figure D-46.02.** Marginal attrition observed along margin on dorsal face at higher magnification. Very shallow polish is observed along modified edge.

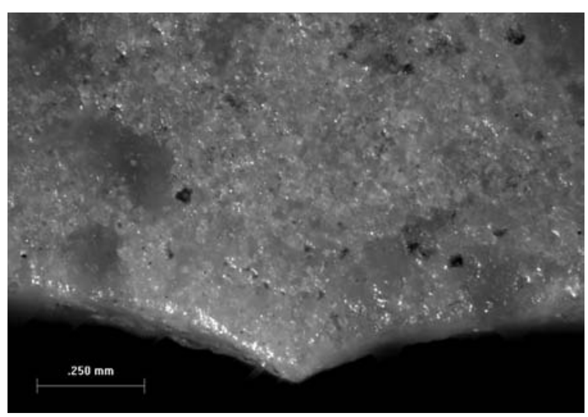



**Figure D-46.03.** Marginal attrition observed at higher magnification.

continued.

***Artifact ID: 3326***
(concluded)

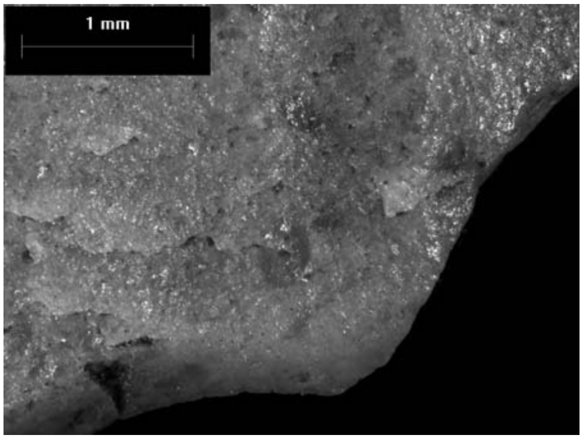



**Figure D-46.04.** Edge rounding observed along modified margin on dorsal face of flake tool.

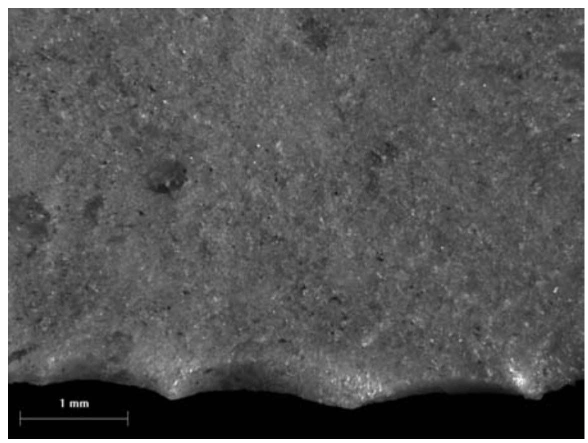



**Figure D-46.05.** Attrition recorded along margin on ventral face of utilized flake. Bifacial attrition suggests that the tool was used for slicing.

***Artifact ID: 3350***

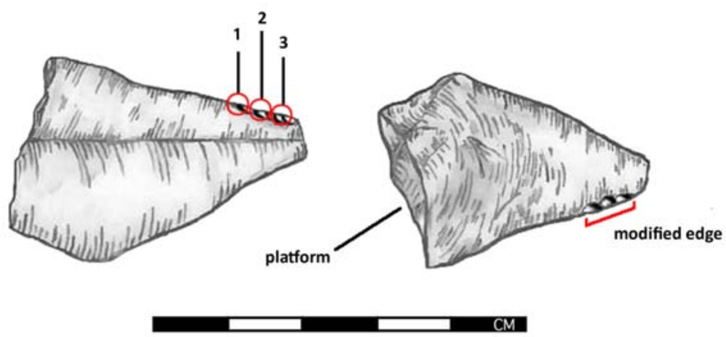



**Figure D-47.** Utilized Recycling Flake (Catalog/ID# 3350) from S14W86, Level 10.

***Classification***

**Artifact Class:** Flake (edge-modified; possibly a rejuvenation flake from a retouched piece); **Artifact Subclass:** Unmodified; **Artifact Type:** Expedient Tool.

***Characteristics***

**Length:** 39 mm; **Width:** 27 mm; **Thickness:** 14 mm; **Weight:** (unrecorded); **Edge Angle:** 45°, 30°; **Portion:** complete flake (core unknown); **Raw Material Type:** chert (coarse grained ? – material burned); **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** unilateral-unifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

***Comments***

The artifact is a utilized flake. The flake was removed from a biface, presumably during rejuvenation efforts. The original bifacial edge measured 80°. The original tool was possibly an adze, based on edge angle and attrition pattern. The raw material had been excessively heated sometime prior to the flake removal. The exterior surface of the initial core (biface) exhibits a heat glaze from silica vitrification.

A small area along one margin at the distal tip of the flake exhibits retouch and modest polish. Flake removals are located along the ventral face. This pattern of wear suggests that the flake tool was used for slicing of a soft contact material. Alternatively, the unifacial pattern of attrition suggests that the tool may have been a scraper.

The outer margin of the flake platform exhibits a bifacially constructed edge. This edge appears to have been dulled from use. Heavy attrition favors one side. While the entire exterior of the piece exhibits a gloss from thermal alteration, the dulled edge appears particularly glossy, suggesting the development of a use polish.

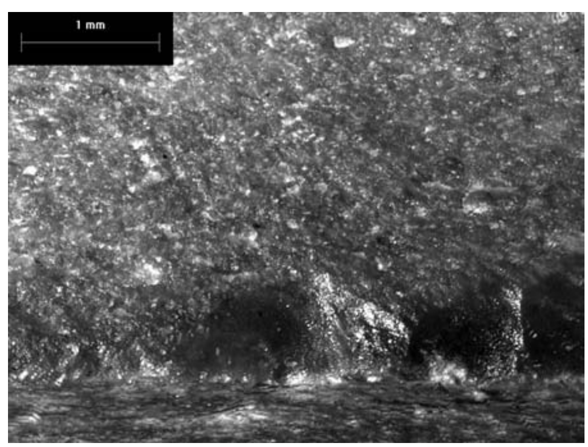



**Figure D-47.01.** Unifacial attrition and shallow polish observed along margin of flake tool. Strong polish may have resulted from thermal alteration.

continued.

***Artifact ID: 3350***
(concluded)

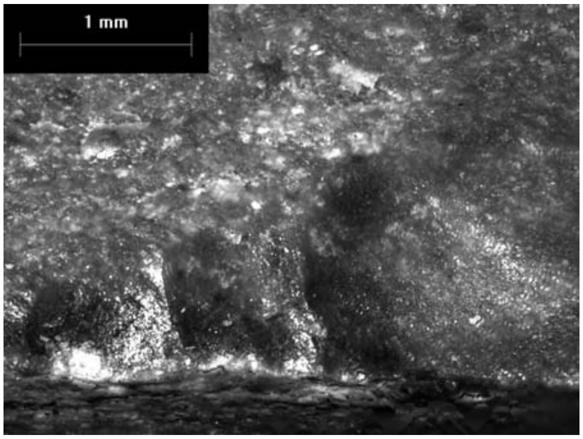
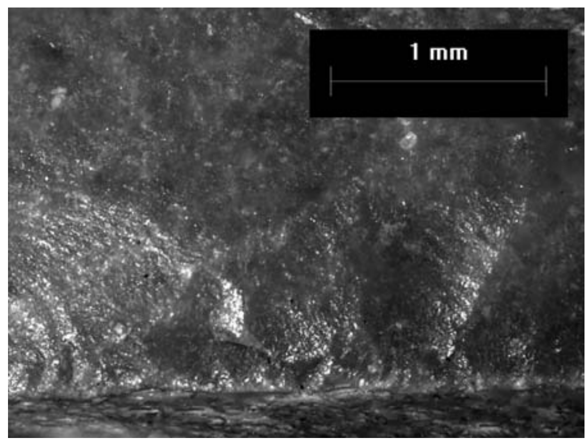



**Figure D-47.02.** Unifacial attrition and shallow polish observed at higher magnification.

**Figure D-47.03.** Unifacial attrition and shallow polish observed at lower magnification.



***Artifact ID: 3351***

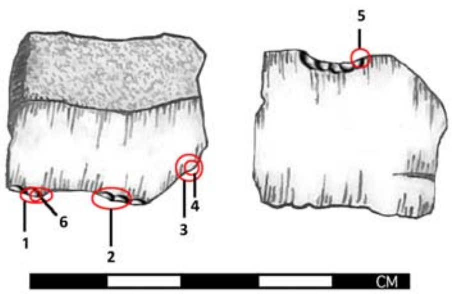



**Figure D-48.** Blade Fragment (Catalog/ID# 3351) from S14W86, Level 10.

*Classification*

**Artifact Class:** Blade fragment; **Artifact Subclass:** Indeterminate (likely unmodified based on presence of cortex); **Artifact Type:** Blade.

*Characteristics*

**Length:** 27 mm; **Width:** 23 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 30°; **Portion:** medial; **Raw Material Type:** chert (fine grain); **Alteration:** none.

*Use-Wear Pattern*

**Edge Attrition:** unilateral (see below); **Polish:** indeterminate; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

*Comments*

This artifact is the medial section of a blade. The blade is primary from the core, as half the dorsal surface is covered by cortex. The remnant cortex present on the dorsal surface of the blade fragment is hard, smooth, and polished. This suggests that the original raw material package was most likely a river cobble.

The attrition pattern of the blade is problematic. A sort of notch exists at the midsection of the blade edge. Flake removals within this notch appear on the ventral surface, whereas flake removals along the remainder of the edge appear on the dorsal surface. Little if any polish is observed and the edges do not appear well-rounded.

The wear pattern observed suggests that the implement experienced limited use on a medium-hard contact material and was possibly employed for scraping or shaving.

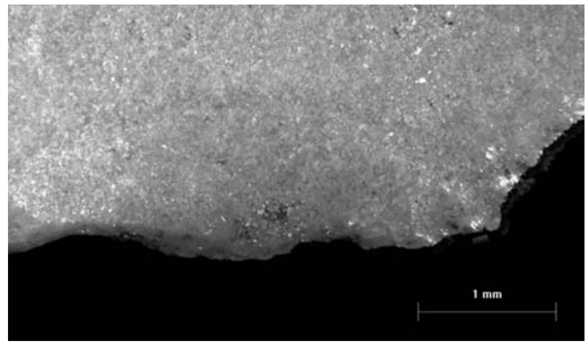



**Figure D-48.01.** Attrition observed along lateral margin of blade fragment. Attrition is unifacial, observed along the dorsal face of the margin.

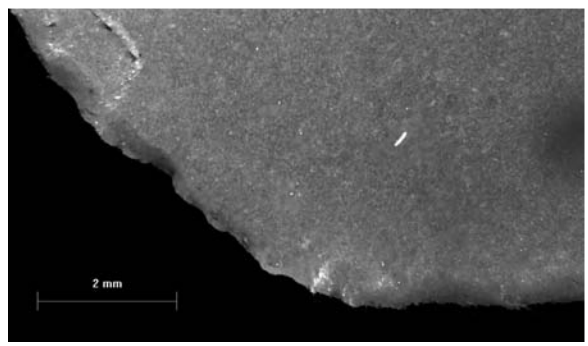



**Figure D-48.02.** Attrition and faint polish observed along lateral margin at corner of notch.

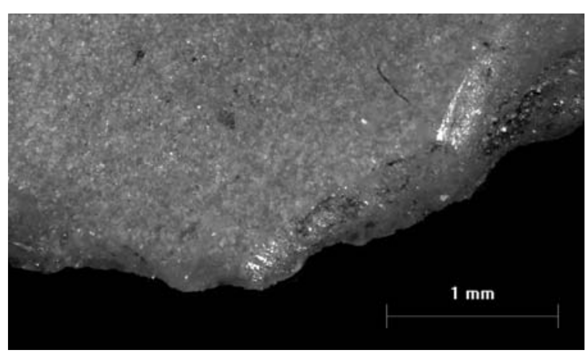



**Figure D-48.03.** Edge rounding and minor attrition shown along margin of blade fragment as seen on dorsal surface.

continued.

***Artifact ID: 3351***
(concluded)

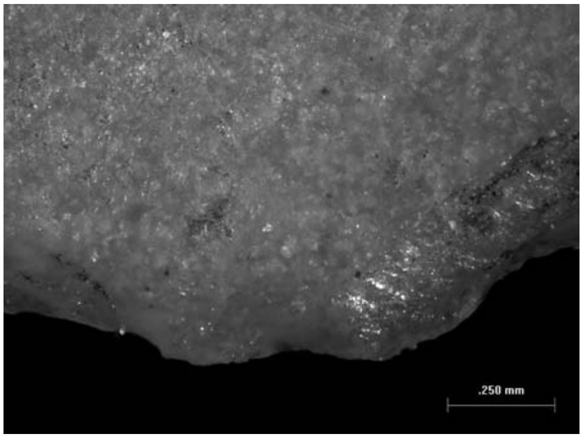



**Figure D-48.04.** Edge rounding and attrition observed at higher magnification.

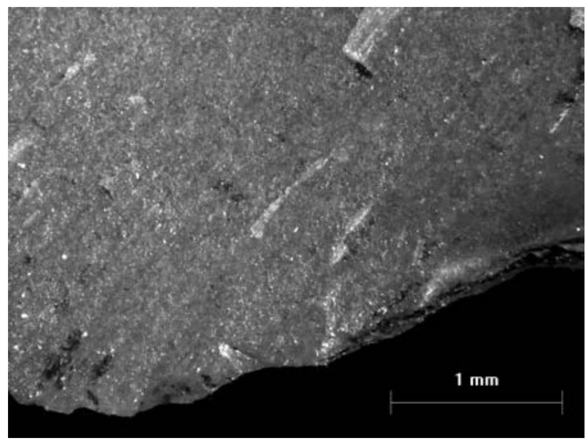



**Figure D-48.05.** Dorsal face of notch margin exhibits some rounding, but no attrition.

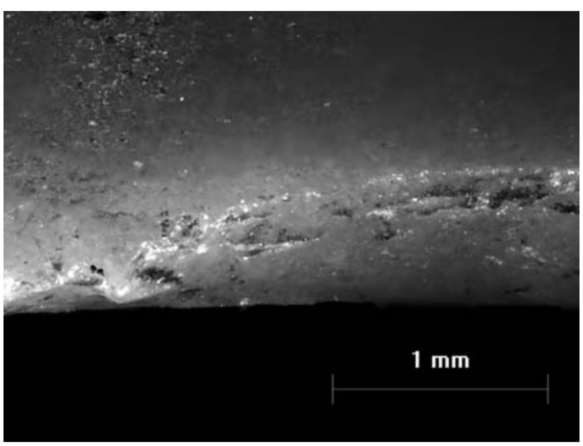



**Figure D-48.06.** Attrition is unifacial along blade edge. Attrition is recorded along the ventral face at the notch margin.

***Artifact ID: 3769***

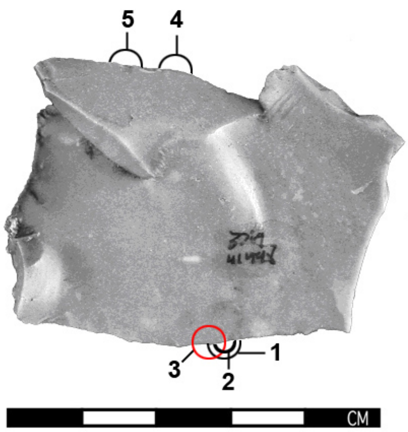



**Figure D-49.** Scraper (Catalog/ID# 3769) from S12W90, Level 12.

***Classification***

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Altered; **Artifact Type:** Scraper ?

***Characteristics***

**Length:** 48 mm; **Width:** 39 mm; **Thickness:** 13 mm; **Weight:** 17.0 g; **Edge Angle:** 25-30°; **Portion:** complete (?) indeterminate; **Raw Material Type:** chert; **Alteration:** oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** bilateral-unifacial; **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft to medium-soft.

***Comments***

The artifact is constructed on an irregular flake. The long margin of the piece, as well as the long segment of the stepped margin, exhibit the strongest evidence for use-wear. The long margin displays a predominantly unifacial attrition pattern with well-developed polish and edge rounding (dulling). The margin shows signs of retouch directed at creating a stronger, steeper bevel. The wear pattern observed along this margin most strongly correlates with a scraping motion.

The long segment of the stepped margin exhibits bifacial attrition and feather terminations. Polish along this margin is less well developed. The wear pattern observed along this margin most strongly correlates with a cutting motion of use.

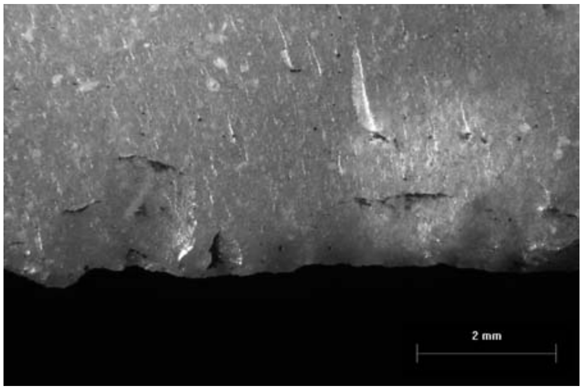



**Figure D-49.01.** Edge rounding and shallow polish observed along flake margin.

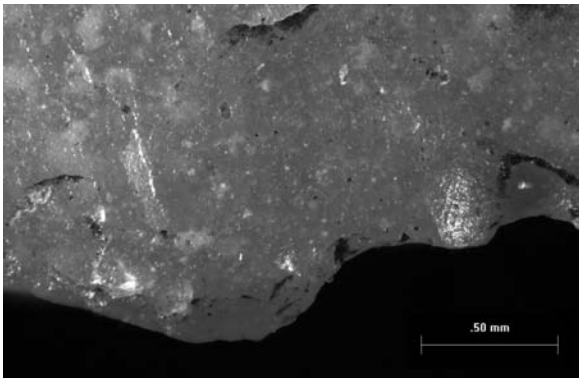



**Figure D-49.02.** Edge rounding and shallow polish observed at higher magnification.

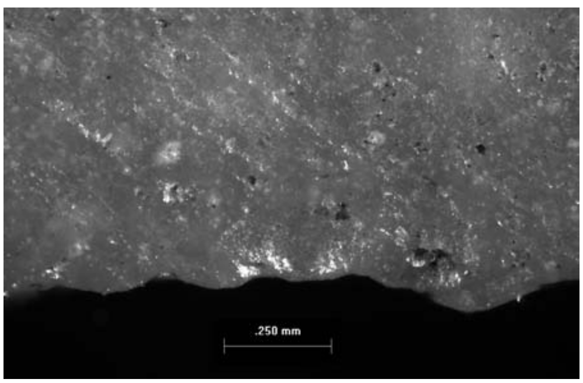



**Figure D-49.03.** Edge rounding and shallow polish observed along flake margin on ventral face.

continued.

***Artifact ID: 3769***
(concluded)

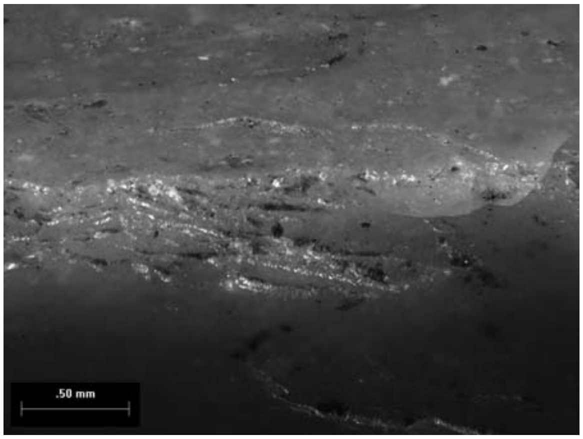



**Figure D-49.04.** Unifacial attrition recoded along flake margin. Edge is slightly rounded and exhibits a shallow polish.

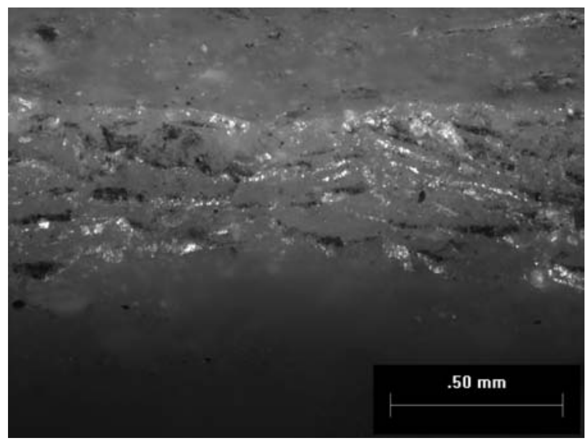



**Figure D-49.05.** Unifacial attrition recorded along the flake edge at higher magnification.

***Artifact ID: 3981***

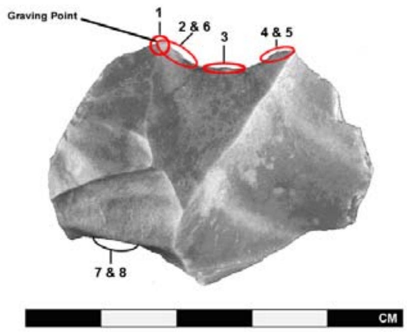



**Figure D-50.** Graver (Catalog/ID# 3981) from S6W84, Level 16.

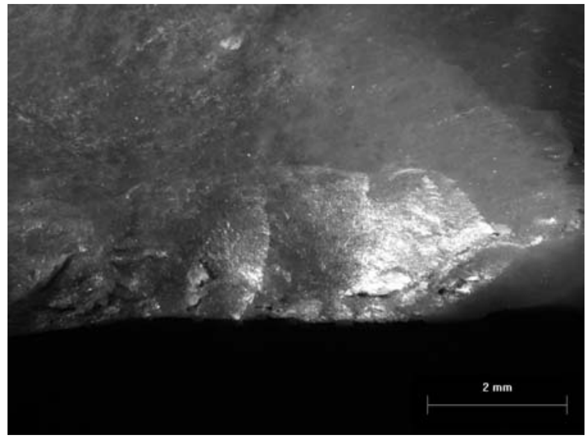



**Figure D-50.01.** Flake was unifacially modified with a notch produced to create a graving point.

### *Classification*

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Altered; **Artifact Type:** Graver.

### *Characteristics*

**Length:** 42 mm; **Width:** 32 mm; **Thickness:** 7 mm; **Weight:** 8.3 g; **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** fine grained chert; **Alteration:** very slight oxide yellowing.

### *Use-Wear Pattern*

**Edge Attrition:** unilateral-unifacial; **Polish:** lateral (very light); **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-hard.

### *Comments*

Multiple edges show signs of modification around the circumference of the tool. The attrition recorded around the notch is unifacial. The margins of the notch exhibit no clear evidence of wear as there is neither dulling attrition nor polish. Apparently, the notch was not the working edge of the tool, but rather was produced to create a graving point.

Attrition in the form of flake removals (spalling) and minor edge rounding are observed on the graving point. The edge attrition related to use significantly favors one face.

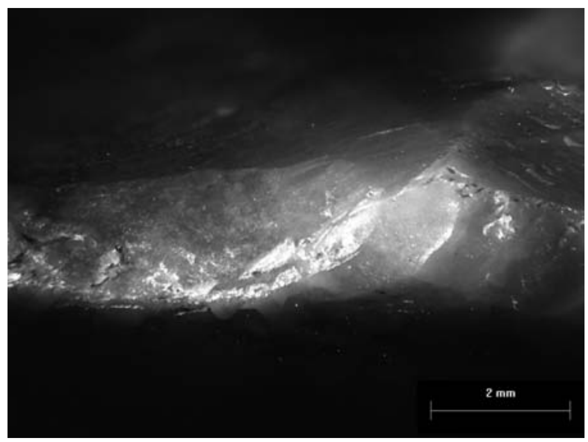



**Figure D-50.02.** Margin at notch is not rounded and exhibits no polish.

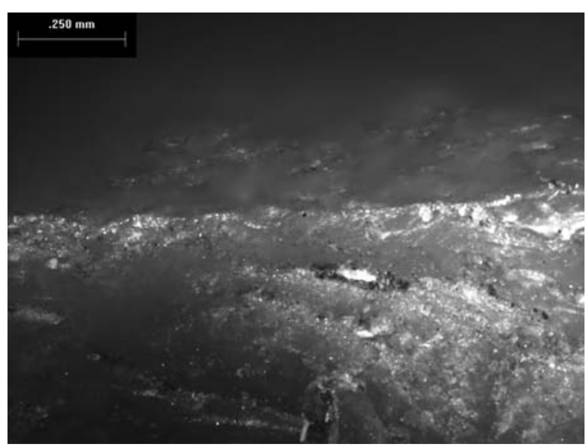



**Figure D-50.03.** Unifacially modified margin at notch shown at higher magnification.

continued.

***Artifact ID: 3981***
(concluded)

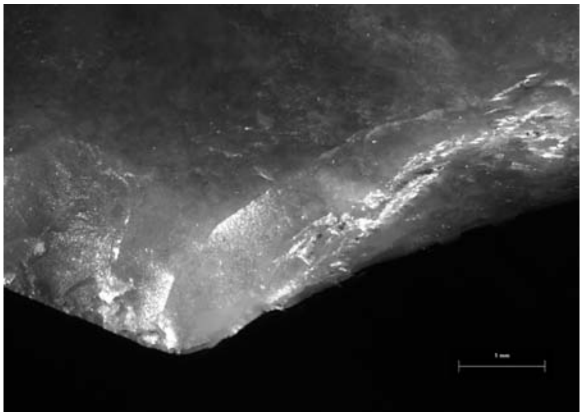


**Figure D-50.04.** Edge at top of notch opposite graving point is sharp and unworn.

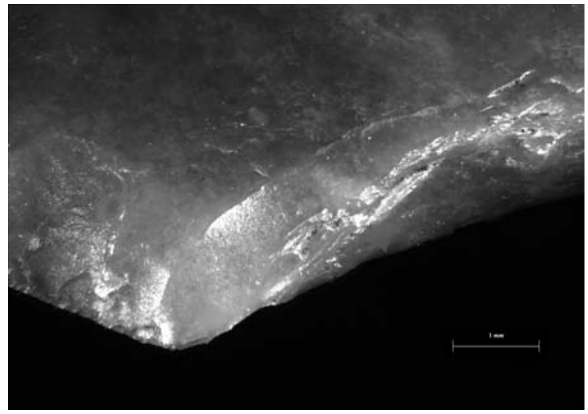


**Figure D-50.05.** Second view of edge at top of notch opposite graving point.

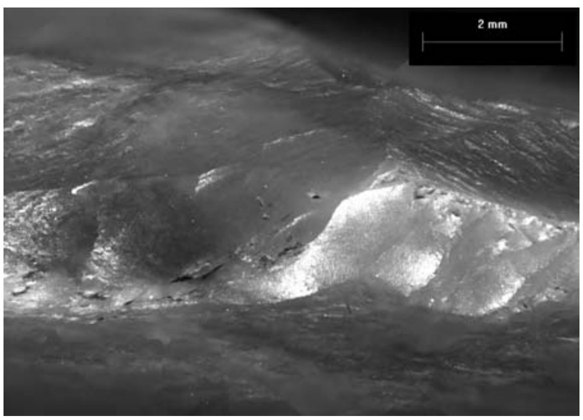



**Figure D-50.06.** Attrition in the form of fractures and minor edge rounding are observed on the graving point.

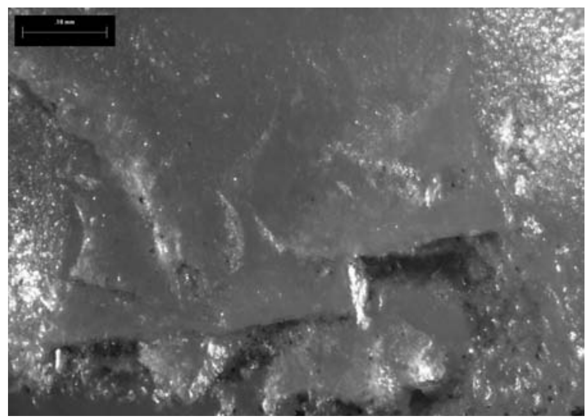


**Figure D-50.07.** Minor rounding and gloss observed along edge and facets at base of flake (below graving point) are likely the result of prehensile wear.

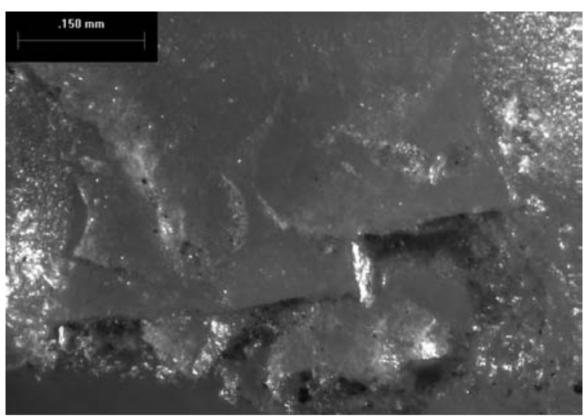



**Figure D-50.08.** Second view of rounding and gloss observed at base of flake.

***Artifact ID: 4178***


**Figure D-51.** Drill (Catalog/ID# 4178) from S16W86, Level 7.

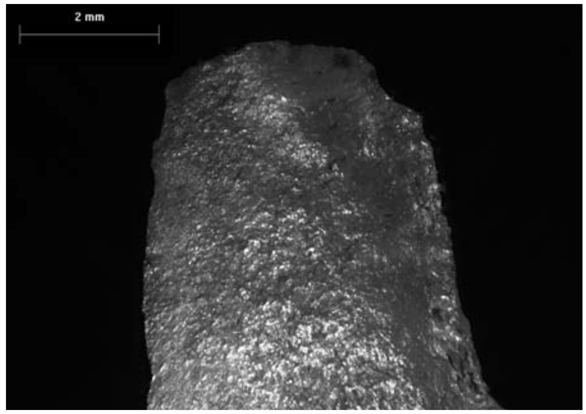



**Figure D-51.01.** Distal tip of drill exhibits diffuse polish and bilateral-unifacial attrition along margins.

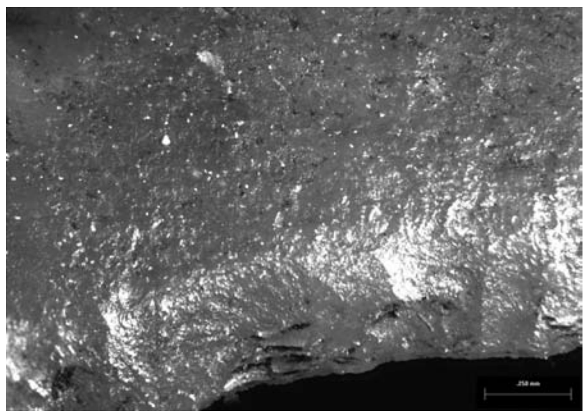


**Figure D-51.02.** Unifacial attrition and deep lateral polish observed along lateral margin of bit.

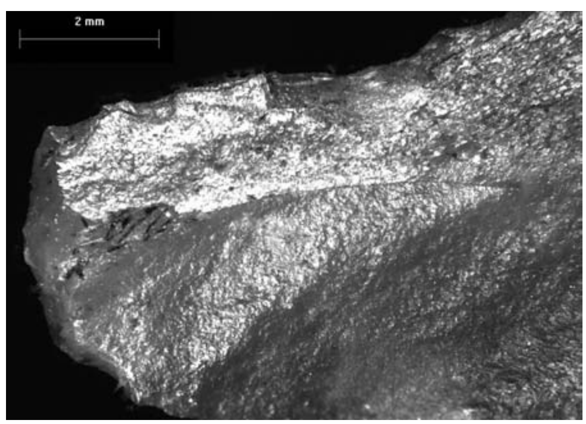



**Figure D-51.03.** Distal bit exhibits attrition and dulling at the tip. Diffuse polish observed across face of bit.

***Classification***

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Altered; **Artifact Type:** Drill.

***Characteristics***

**Length:** 33 mm; **Width:** 25 mm; **Thickness:** 5 mm; **Weight:** 2.6 g; **Edge Angle:** 65°; **Portion:** complete; **Raw Material Type:** chert; **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** bilateral-unifacial; **Polish:** distal-lateral (moderately developed); **Battering:** distal-lateral (dulling); **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

***Comments***

The recorded edge angle is somewhat narrow for a drill, but the wear pattern fully supports a drilling function. The thinness of the blade and the subtlety of edge attrition (flaking) suggest a soft contact material. The distal tip of the drill exhibits diffuse polish across its face and bilateral-unifacial attrition along its margins.

The thermal alteration noted on the piece may be post-depositional in nature. This alteration was not excessive and would not have compromised the structural integrity of the tool form.

continued.

***Artifact ID: 4178***
(concluded)

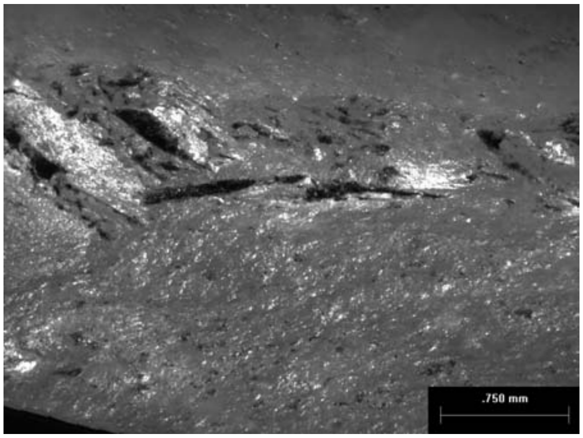



**Figure D-51.04.** Higher magnification view of unilateral attrition observed along lateral margin of distal bit.

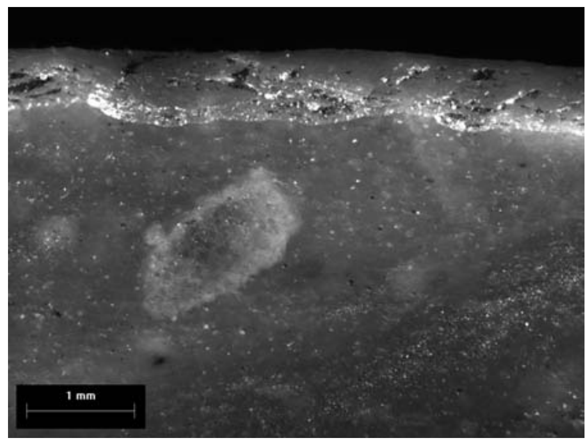



**Figure D-51.05.** Unifacial attrition recorded along lateral margin.

***Artifact ID: 4374A***

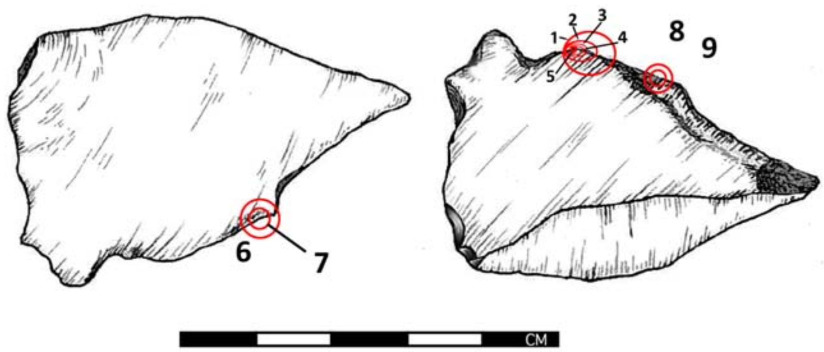



**Figure D-52.** Scraper(?) (Catalog/ID# 4374A) from S10W90, Level 12.

***Classification***

**Artifact Class:** Flake (edge-modified); **Artifact Subclass:** Altered; **Artifact Type:** Scraper (proposed).

***Characteristics***

**Length:** 46 mm; **Width:** 42 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 25°; **Portion:** near complete proximal fragment; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** unilateral-unifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-soft.

***Comments***

Only one small area along the modified edge exhibits rounding and what appears to be polish. Unequivocal evidence for use attrition is present and there is a restricted concentration of polish that is somewhat enigmatic. It is likely that wear continued onto an area of edge that has since been removed.

While not unequivocal, attrition present along the dorsal face of the modified edge could be the result of use. Polish build-up is mainly noted along the ventral face of the edge. The distribution pattern of attrition and polish, along with the straightness of the used edge, suggests that the implement functioned as a scraper. Based on the shallowness of the polish and the overall attrition pattern, the hardness of the contact material was most likely medium-soft.

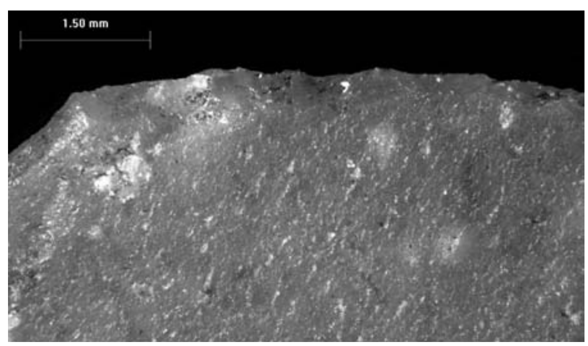



**Figure D-52.01.** Edge attrition shown at the outer margin of the dorsal face.

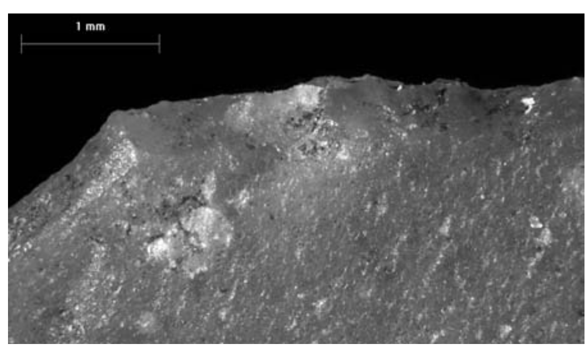



**Figure D-52.02.** Attrition at this location is characterized by a series of parallel scars of approximately the same depth that exhibit modest rounding and shallow polish.

continued.

***Artifact ID: 4374A***
(continued)

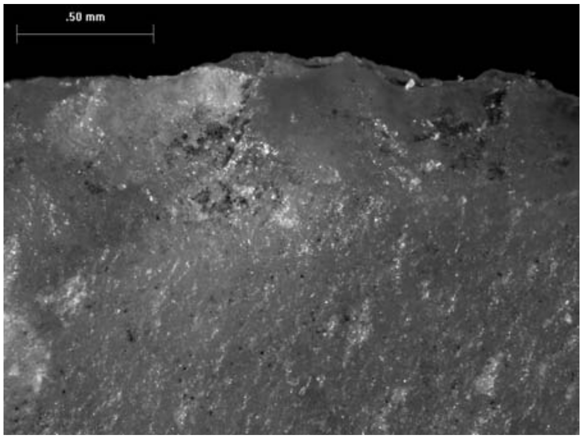



**Figure D-52.03.** (Left) Flake removals form fairly steep edges. This, together with the even depth of the scars and the relatively uniform lateral edge, suggests that the motion of use was consistent with a scraper.

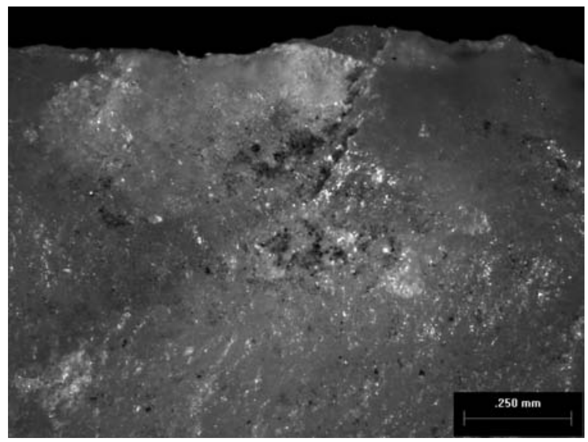



**Figure D-52.04.** (Right) The facets between use-related flake scars exhibit modest rounding and silica accumulation.

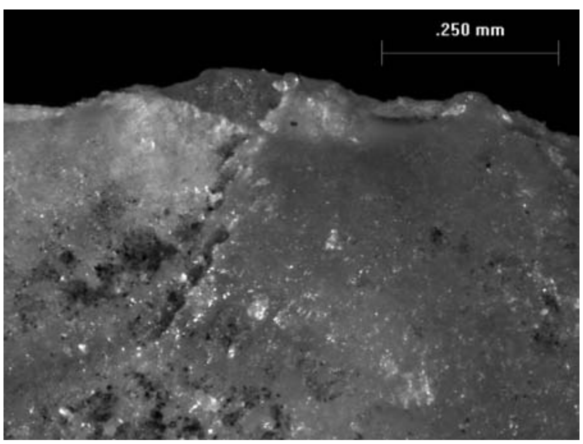



**Figure D-52.05.** (Left) Rounding and silica accumulation are observed here at high magnification at the tool's margin.

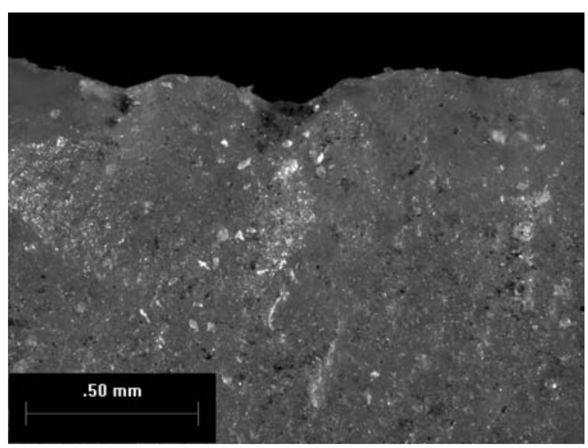



**Figure D-52.06.** (Right) Edge attrition shown at the outer margin of the ventral face. The pattern of parallel flake removals oriented perpendicular to the tool's edge that was observed on the dorsal face is not repeated here. This unifacial pattern of flaking attrition further supports the identification of motion of use as consistent with scraping.

continued.

***Artifact ID: 4374A***
(concluded)

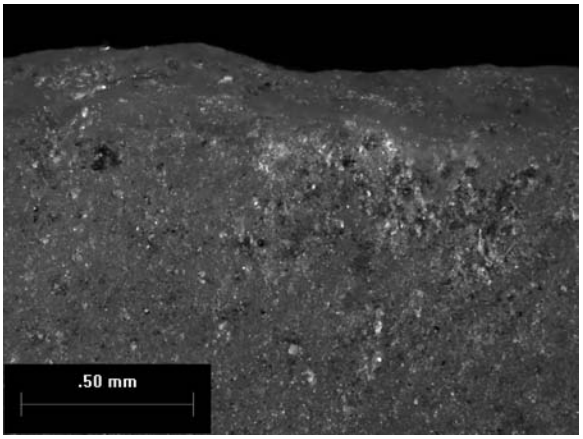



**Figure D-52.07.** (Left) Shallow edge rounding and light silica accumulation can be observed on the ventral face along the tool's lateral margin.

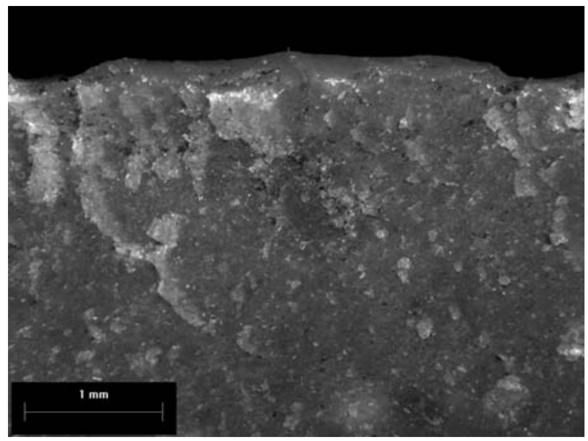



**Figure D-52.08.** (Right) Shallow edge rounding and light silica accumulation are observed on the dorsal face along the tool's lateral margin.

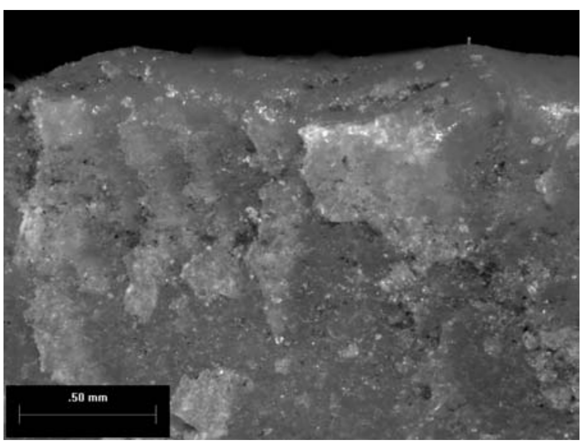



**Figure D-52.09.** (Left) At higher magnification, the remodeling of micro-fractures and flake facets by light silica deposits can be clearly observed along the tool's margin.

## *Artifact ID: 4375*

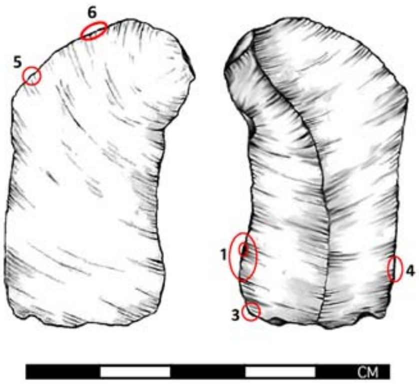



**Figure D-53.** Flake (Abraded Platform) (Catalog/ ID# 4375) from S10W90, Level 13.

### *Classification*

**Artifact Class:** Flake (edge-modified; abraded platform); **Artifact Subclass:** Unaltered; **Artifact Type:** Expedient Tool.

### *Characteristics*

**Length:** 43 mm; **Width:** 36 mm; **Thickness:** 6 mm; **Weight:** (unrecorded); **Edge Angle:** 30°; **Portion:** complete; **Raw Material Type:** chert (fine grain); **Alteration:** indeterminate (thermal possible).

### *Use-Wear Pattern*

**Edge Attrition:** bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

### *Comments*

Multiple edges display somewhat uniform attrition in a bifacial pattern. There is also a very slight gloss and minor rounding present on several edges. Edge attrition appears even and consistent. The edges that exhibit attrition show modest rounding and a faint gloss. In general, the attrition is bifacial and does not favor either side.

The wear pattern is very slight, suggesting that the tool was only used a limited number of times on a relatively soft contact material. The probable motion of use would most likely have been slicing. It is worthwhile mentioning that the evidence of use is so faint on this piece that it seems possible that a natural process (possibly erosion) is mimicking use.

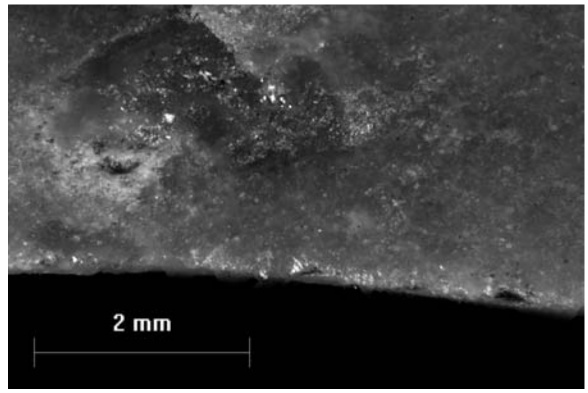



**Figure D-53.01.** Edge rounding observed along margin of flake.

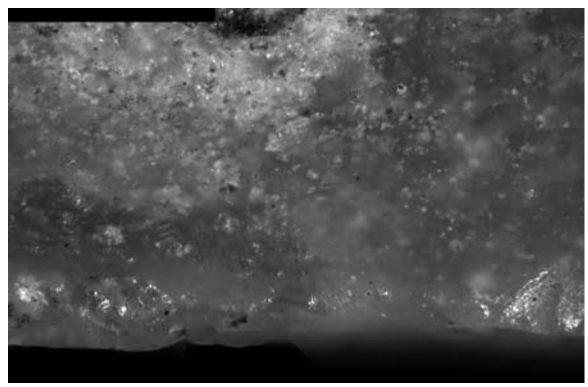


**Figure D-53.02.** Edge rounding observed at higher magnification.

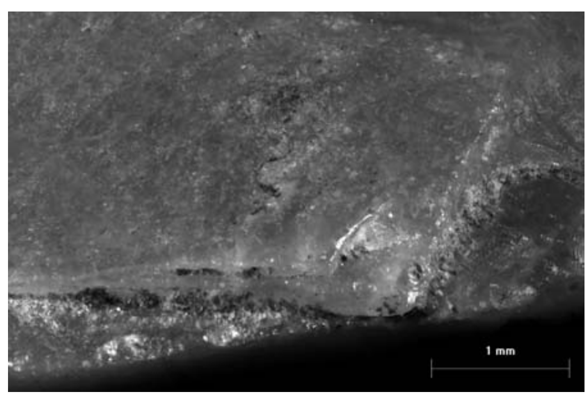



**Figure D-53.03.** Slight marginal attrition and very minor polish recorded along edge of flake.

continued.

***Artifact ID: 4375***
(concluded)

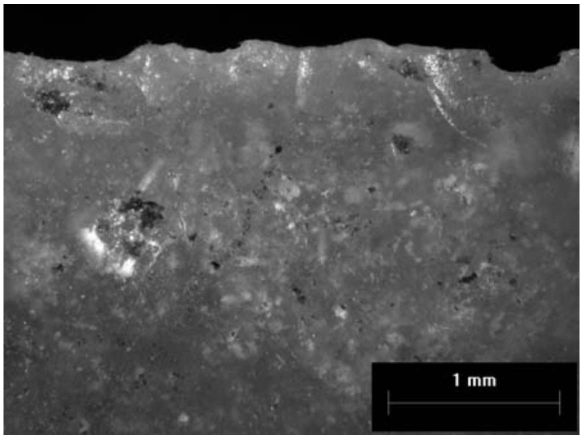



**Figure D-53.04.** Slight marginal attrition recorded along edge of flake. Attrition is not clearly associated with a developed polish, and may have derived from some activity other than use.

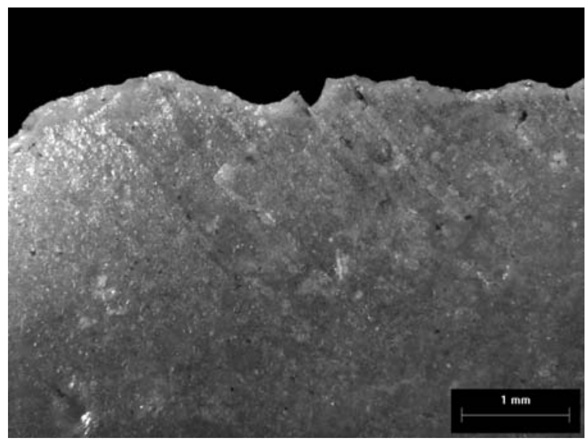



**Figure D-53.05.** Edge shown in this photo exhibits very slight rounding. The flake may have been used over a short duration with a soft contact material.

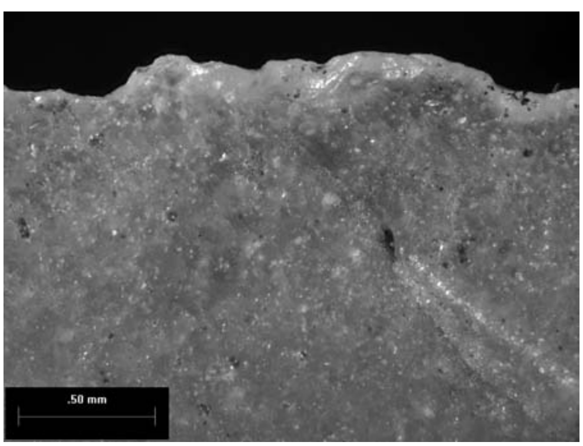



**Figure D-53.06.** Slight edge rounding observed at higher magnification.

***Burial Artifact ID: 1038***

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife or Point.

***Characteristics***

**Length:** 134 mm; **Width:** 36 mm; **Thickness:** 13 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert/quartzite; **Alteration:** minor oxide yellowing.

***Use-Wear Pattern***

**Edge Attrition:** distal, bilateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate (probable); **Contact Material Hardness:** medium-soft.

***Comments***

Distal tip is rounded and polished from wear. The lateral margins show modest attrition and rounding from the tip to slightly past the mid-point. Attrition is in the form of feather terminations. All polish observed is very shallow and restricted to the extreme margin at the distal tip and along the lateral margins on the upper half of the blade. The basal one-third of the blade shows edge abrasion, but no clear polish. This abrasion may be an indication of hafting. As the tip shows no impact fracture and only shallow polish, it appears more likely that this tool was used as a knife, but a piercing function cannot be definitely ruled out.

The contact material is believed to have been medium-soft based on the subtle attrition observed at the tip and margins and the shallowness of the polish.

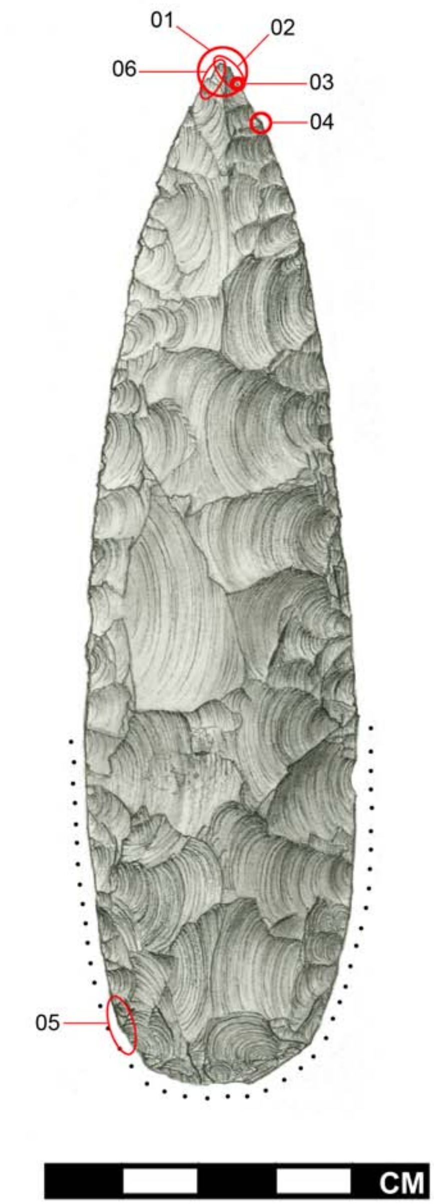



**Figure D-54.** Projectile Point or Knife (Catalog/ID# 1038) from Burial 1B.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 1151***

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile (knife ? – less likely).

***Characteristics***

**Length:** 118 mm; **Width:** 36 mm; **Thickness:** 13 mm; **Weight:** (unrecorded); **Edge Angle:** 55°; **Portion:** complete; **Raw Material Type:** chert (coarse grained; **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** distal-lateral/bifacial; **Polish:** deep lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate; **Contact Material Hardness:** medium-soft.

***Comments***

Artifact exhibits a glossy sheen on the high points on each face. This may be the result of thermally altering a late-stage preform. Fine pressure retouch is present along each lateral margin, generally removing the sheen where present.

The distal tip exhibits attrition indicative of light impact and is consistent with use for thrusting and piercing. Some edge rounding and polish are also observed at the tip.

Lateral edges are most heavily polished and rounded along the distal one-third of the blade. Edges along the proximal one-third of the blade exhibit some abrasion and rounding. Hafting polish cannot be substantiated because of the ubiquitously distributed gloss (which almost certainly resulted from vitrification caused by thermal alteration).

The wear pattern observed more clearly fits the expectations of a thrusting weapon rather than a knife. The minor attrition observed around the distal margin suggests that the contact material was of medium-soft hardness.

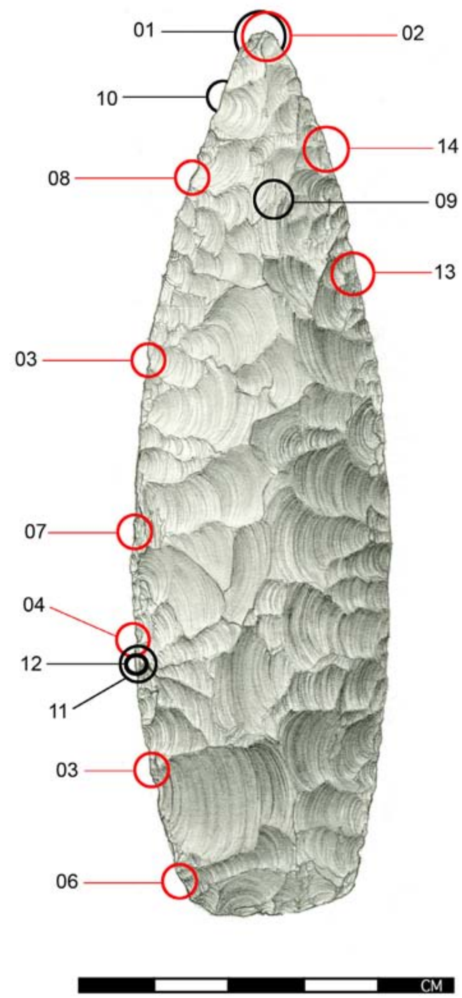



**Figure D-55.** Projectile Point or Knife(?) (Catalog/ID# 1151) from Burial 1B.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 1152***

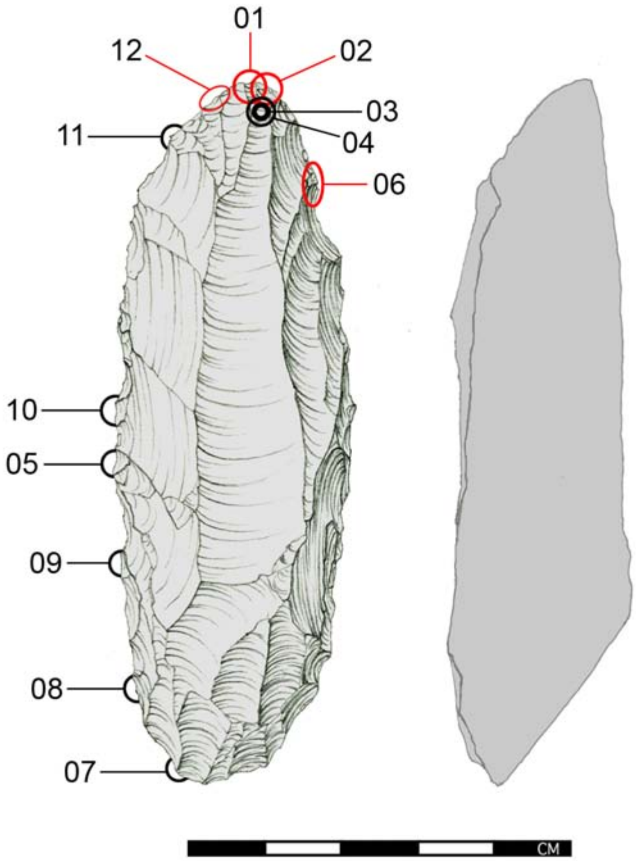



**Figure D-56.** Guadalupe Biface (Gouge?) (Catalog/ID# 1152) from Burial 58.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Gouge (?), Guadalupe Biface.

***Characteristics***

**Length:** 92 mm; **Width:** 32 mm; **Thickness:** 22 mm; **Weight:** (unrecorded); **Edge Angle:** 70°-80°; **Portion:** complete; **Raw Material Type:** chert (medium grain, banded); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** distal; **Battering:** none; **Etching:** none observed; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

***Comments***

The artifact matches the description of a Guadalupe Biface as provided in Turner and Hester (1985:216). Formal study of this tool type was prepared by Black and McGraw (1984). The artifact's cross-section is plano-convex and roughly keel-shaped.

The lateral margins of the tool are abraded and rounded with traces of light polish. The wear and polish observed are most likely related to hafting or, perhaps more likely, wrapping for manipulation during use. Only minor rounding was observed along proximal margin.

The tool was possibly constructed on a macroflake, and was formed with steep-angled percussion

continued.

***Burial Artifact ID: 1152***
(concluded)

along the margins initiated on the ventral surface. The dorsal surface has been flattened by a long, blade-like removal emanating from the distal margin of the tool.

The distal margin shows very strong polish on both the dorsal and ventral faces. This suggests that only the tip was the working/functional portion of the tool. There are no observable striations to inform motion of use, though I suspect either a forward pushing or lateral pulling movement was undertaken.

The general lack of observed flaking attrition, coupled with the absence of striations and the extent of edge-rounding, suggest that the tool was used against a soft to medium-soft contact material.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 1671***

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

***Characteristics***

**Length:** 103 mm; **Width:** 35 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 45°-50°; **Portion:** complete; **Raw Material Type:** chert (fine grain); **Alteration:** indeterminate (possible thermal alteration).

.

***Use-Wear Pattern***

**Edge Attrition:** unilateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** possible; **Contact Material Hardness:** soft/medium-soft

***Comments***

Slight polish and edge rounding are concentrated along one lateral margin. While no unambiguous hafting polish is discernable, the lateral margins near the proximal point of the blade exhibit minor edge rounding that may have resulted from hafting. Some fine pressure retouch noted along margins.

A flake removal at the distal tip is not consistent with impact. The flake emanates from the side of the point rather than straight on. The angle of removal is more consistent with a cutting motion.

The artifact was most likely subjected to only light, brief use – possibly on a single occasion. The edges remain notably sharp and unaltered.

Based on the pattern or edge modification observed, the motion of use is believed to have been cutting and/or slicing.

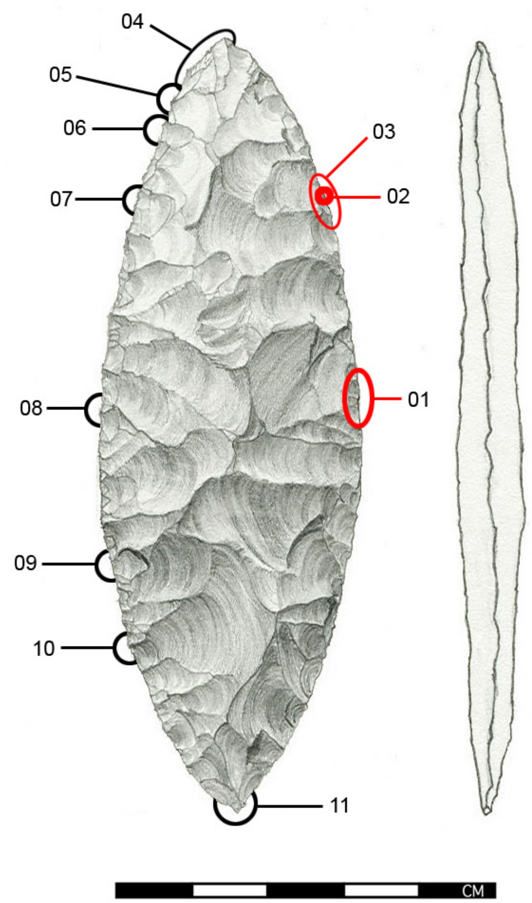



**Figure D-57.** Knife (Catalog/ID# 1671) from Burial 21.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 1685***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

*Characteristics*

**Length:** 89 mm; **Width:** 43 mm; **Thickness:** 17 mm; **Weight:** (unrecorded); **Edge Angle:** 70°; **Portion:** complete; **Raw Material Type:** Chert (fine grain); **Alteration:** none.

*Use-Wear Pattern*

**Edge Attrition:** none; **Polish:** prehensile; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

*Comments*

There is no evidence of use observed on this tool form. Some minor, poorly developed polish (glossy areas) is observed sporadically on raised ridges and protrusions, and this seems to be almost certainly attributable to prehensile abrasion during manufacture.

Multiple step fractures are observed around the tool's circumference, favoring a unifacial distribution. Soft-hammer and pressure techniques are evident, suggesting that the form had reached later production stages. The artifact is best described as a mid-stage preform. The cortex has been completely removed and the form has been primarily thinned, but there is no clear final orientation determinable. This piece may never have been intended to reach completion given its context; it was discovered in a burial along with several other preforms. This would be interesting, as many other burials contained complete and even used tool forms.

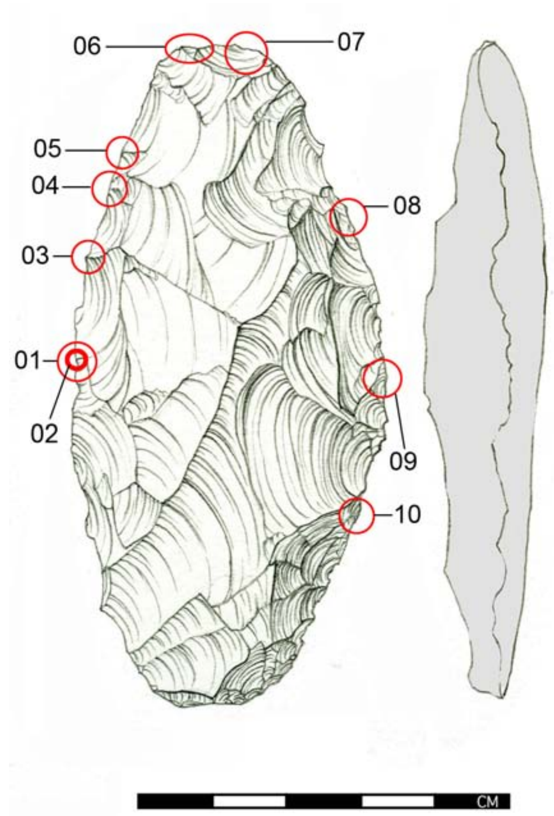



**Figure D-58.** Preform (Catalog/ID# 1685) from Burial 6.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2035***

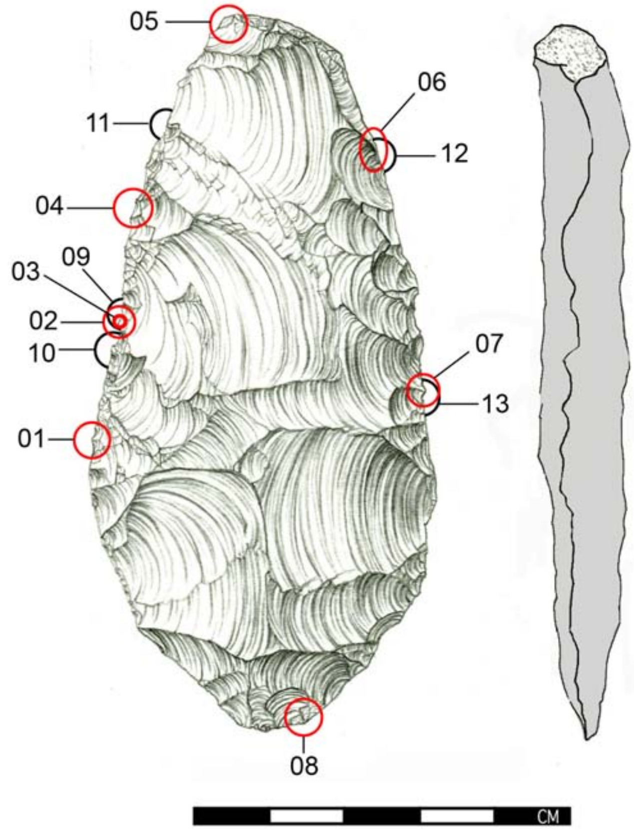



**Figure D-59.** Preform (Catalog/ID# 2035) from Burial 6.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

***Characteristics***

**Length:** 94 mm; **Width:** 45 mm; **Thickness:** 12 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** thermal (?).

***Use-Wear Pattern***

**Edge Attrition:** none; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

***Comments***

Artifact is a late-stage preform. Some step fractures are observable along the lateral margins. Substantial cortex remains at the distal tip. The lateral margins are generally sharp and well-defined without rounding. There is no clear evidence that this artifact was ever used.

Some gloss is noted sporadically along the tool's margins, but it is only topical and very shallow. In appearance, the gloss is not inconsistent with what would be expected to be produced through prehensile manipulation during manufacture.

Soft-hammer and pressure techniques are evident, suggesting that the artifact was in its later manufacturing stages.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2036***

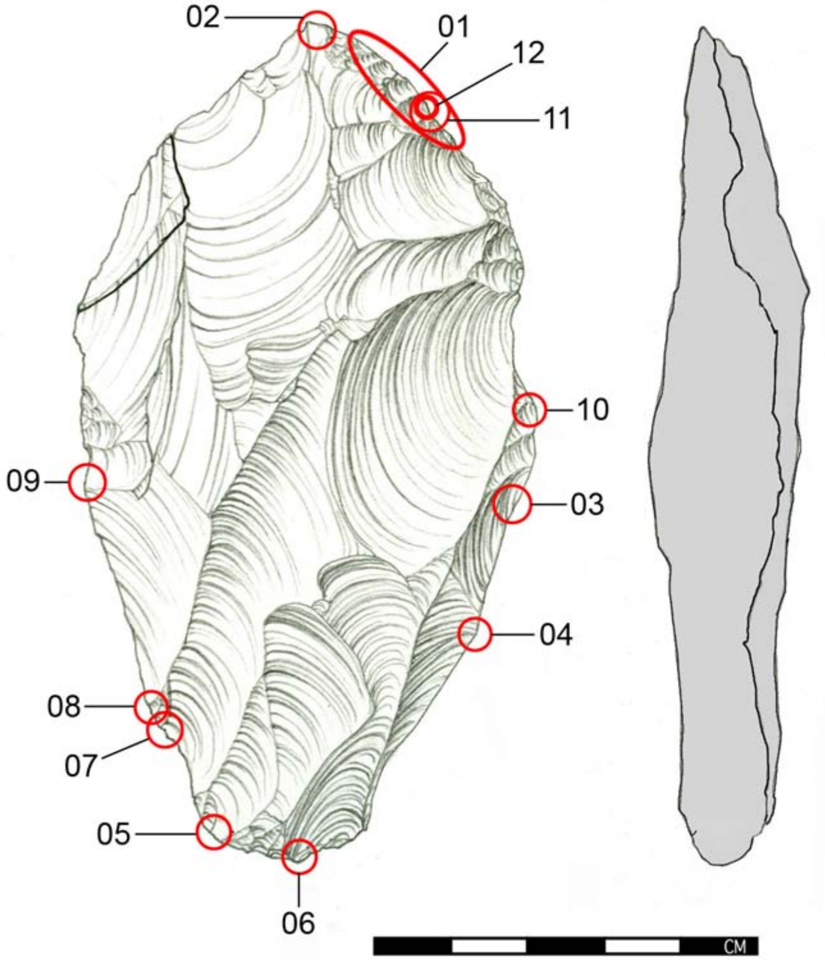



**Figure D-60.** Preform (Catalog/ID# 2036) from Burial 6.

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

***Characteristics***

**Length:** 109 mm; **Width:** 61 mm; **Thickness:** 17 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (fine grain); **Alteration:** thermal (likely).

***Use-Wear Pattern***

**Edge Attrition:** abrasion; **Polish:** light, shallow circumferential; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

***Comments***

The artifact is an early- to middle-stage preform. All cortex has been removed, but the final trajectory of the tool form remains indeterminate. In general, the artifact is poorly designed. Flake removals are not well executed. Several significant step and hinge fractures are noted.

Several edges appear abraded. One edge area appears unifacially retouched (proximal), but it does not display evidence of wear. Reduction at this stage in the tool's trajectory is dominated by soft-hammer techniques.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2037***

***Classification***

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

***Characteristics***

**Length:** 105 mm; **Width:** 44 mm; **Thickness:** 19 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (coarse grained); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** none; **Polish:** none; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

***Comments***

Artifact is a mid-stage preform. Cortex has been removed, but a final trajectory is not evident. A combination of hard-hammer and soft-hammer techniques appear to have been employed at this stage of the tool's manufacture.

Multiple step fractures are noted circumferentially along margins on both dorsal and ventral faces. Step fracturing may be the result of using soft-hammer techniques on such a coarse, dense chert. Several areas along the margin show abrasion from edge preparation.

Some medial mass remains for which there is no available platform from which to initiate a removal. Platform loss would be the noted motive for discard if this tool were not part of a special burial assemblage.

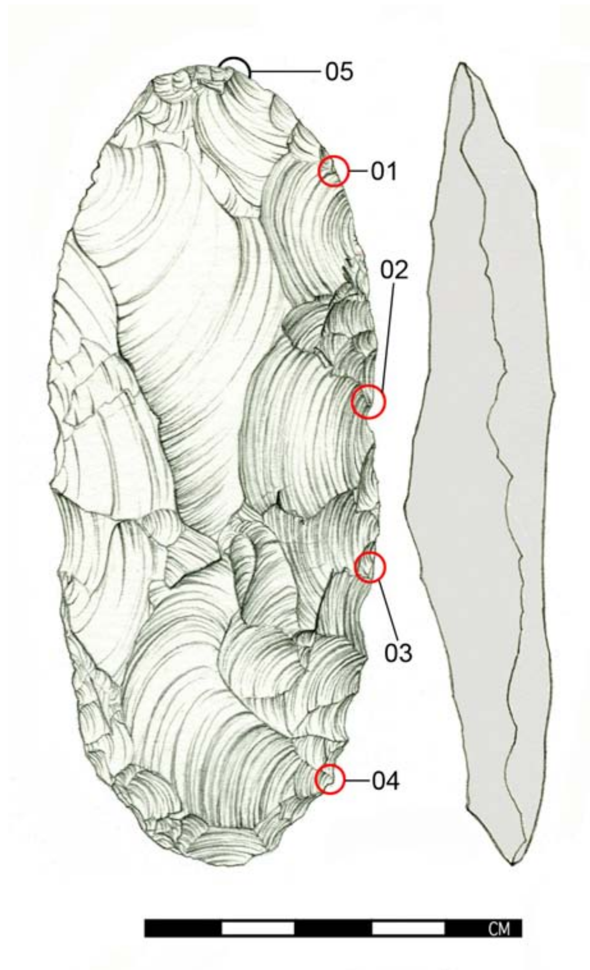



**Figure D-61.** Preform (Catalog/ID# 2037) from Burial 6.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2038***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

*Characteristics*

**Length:** 111 mm; **Width:** 45 mm; **Thickness:** 19 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** thermal.

*Use-Wear Pattern*

**Edge Attrition:** none; **Polish:** none; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

*Comments*

This artifact is a mid-stage preform. All cortex has been removed, but the final trajectory does not appear to have been established. Manufacture has not been well executed up to this point. Multiple hinge fractures are noted bifacially along the margins. Soft-hammer removals dominate at this stage of production.

Further thinning of the medial mass is impossible due to multiple hinge fractures and platform loss. Little effort appears to have been put into edge preparation during the manufacturing process. The integrity of the lateral margin has been compromised due to striking failures in at least two areas.

One area of possible unifacial retouch is noted along the margin, but it is not associated with wear. All edges and facets are sharp and well defined, further supporting the assessment that this tool was never engaged in use.

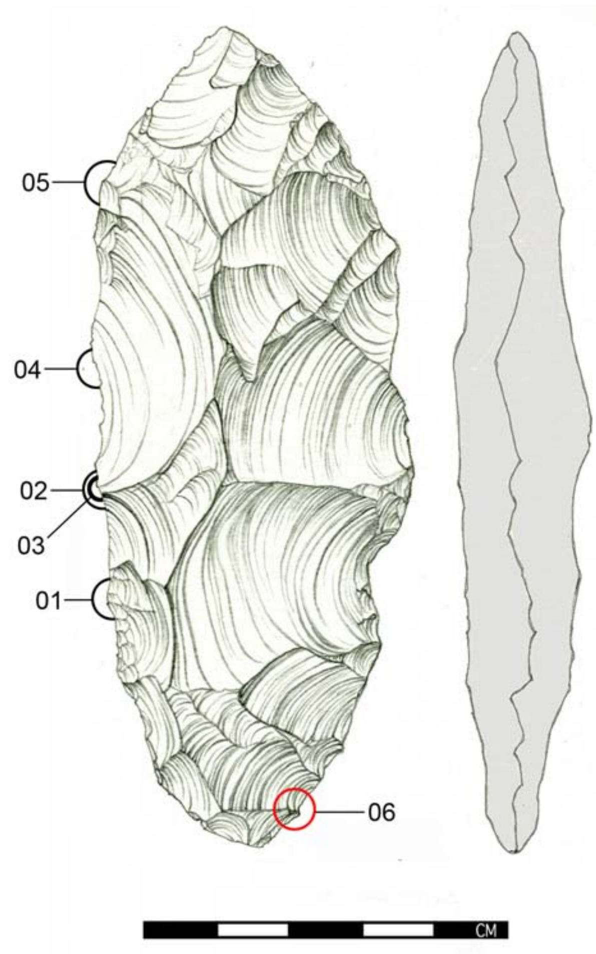



**Figure D-62.** Preform (Catalog/ID# 2038) from Burial 6.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2039***

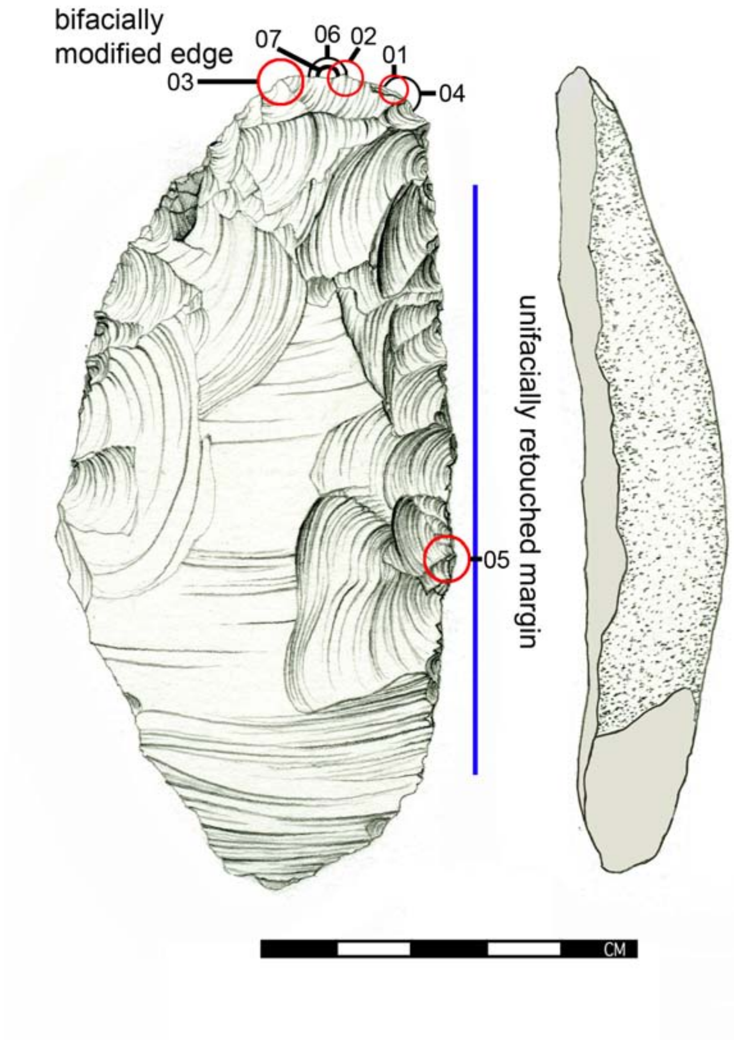



**Figure D-63.** Expedient Adze (Catalog/ID# 2039) from Burial 6.

***Classification***

**Artifact Class:** Flake (edge-modified; macro flake); **Artifact Subclass:** Informal; **Artifact Type:** Expedient Adze.

***Characteristics***

**Length:** 107 mm; **Width:** 52 mm; **Thickness:** 19 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal; **Polish:** shallow distal; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** medium-hard.

***Comments***

Artifact is a modified flake. The flake was removed early in the reduction sequence of primary cobble modification. Characteristics of the cortex

continued.

***Burial Artifact ID: 2039***
(concluded)

(hard, dark, worn smooth) suggest that the cobble was procured from a riverine source (channel gravels).

Some unifacially focused flake removals—likely for platform preparation—can be observed along the straight lateral margin, but the edge remains largely unmodified. There is no clear evidence of use along this edge. Minor rounding and faint gloss are present on the ventral surface at the extreme edge of the straight lateral margin. The gloss is likely to have derived from handling during tool use.

The proximal platform and bulb of the flake are bifacially modified. Multiple step fractures can be observed along the edge, mainly along the dorsal face. Facets along this edge appear to be moderately rounded with shallow polish. The ventral face of the bifacially modified margin shows attrition and edge rounding. The attrition is predominantly unifacially focused. The wear pattern observed suggests that the tool was used in a limited capacity as an expedient adze against a medium-hard contact material.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2042***

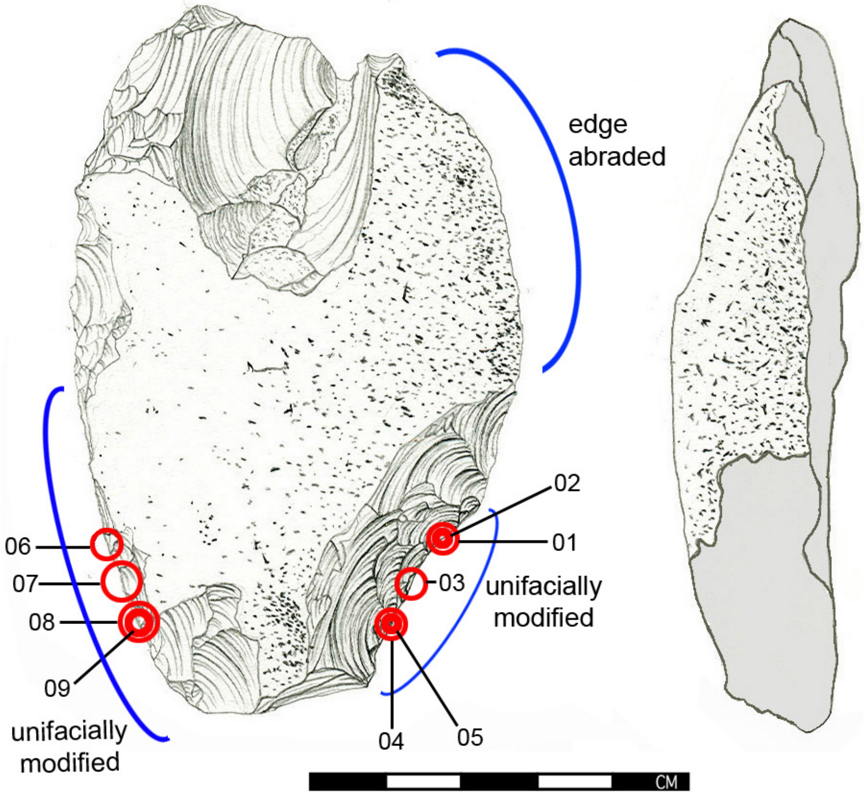



**Figure D-64.** Expedient Tool (Catalog/ ID# 2042) from Burial 6.

***Classification***

**Artifact Class:** Flake (edge-modified; macro flake); **Artifact Subclass:** Informal; **Artifact Type:** Expedient/Informal tool.

***Characteristics***

**Length:** 94 mm; **Width:** 62 mm; **Thickness:** 25 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain, mottled); **Alteration:** thermal.

***Use-Wear Pattern***

**Edge Attrition:** none from use specifically; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** soft.

***Comments***

Cortex is white, smooth, and hard. Material likely procured as a cobble from a riverine source. A fracture pattern that is consistent with thermal alteration is observed on the ventral face.

Edge rounding is observed along the unifacially modified lateral margin. A faint gloss is observed, but it appears more likely to have resulted from thermal alteration than from actual use. Flaking attrition cannot be distinguished from edge-preparation scars. Polish is shallow and just moderately well developed in most places, and is bifacial in distribution. The wear pattern observed on the modified edges suggests the tool was used in a limited capacity on soft contact materials. The motion of use is not determinable based on available data. No hafting or prehensile wear/polish is present.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2045***

### *Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

### *Characteristics*

**Length:** 117 mm; **Width:** 38 mm; **Thickness:** 10 mm; **Weight:** (unrecorded); **Edge Angle**: 60°; **Portion:** complete; **Raw Material Type:** chert (fine grained); **Alteration:** none.

### *Use-Wear Pattern*

**Edge Attrition:** distal (twisting); **Polish:** shallow distal-lateral (may not be from use); **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft (if used)

### *Comments*

The lateral margins exhibit multiple step fractures and are not finely finished in general, although some pressure flaking is observed. The margins show faint and somewhat sporadic rounding and very light polish. This pattern does not clearly indicate use.

Edge rounding and faint, shallow polish are noted along the lateral margin and medial areas of the stem. This pattern of wear suggests that the tool was hafted.

Minor edge and facet rounding are located along the lateral margin on the upper quarter of the blade. Attrition observed is likely related to edge preparation and not the result of use. However, it seems more likely that the flaking pattern noted at the tip was produced through edge preparation. The distal tip exhibits a spiraling fracture that could suggest a twisting motion in use, but the general form of the tool and other traces of wear along the tool's margins do not directly support this assertion.

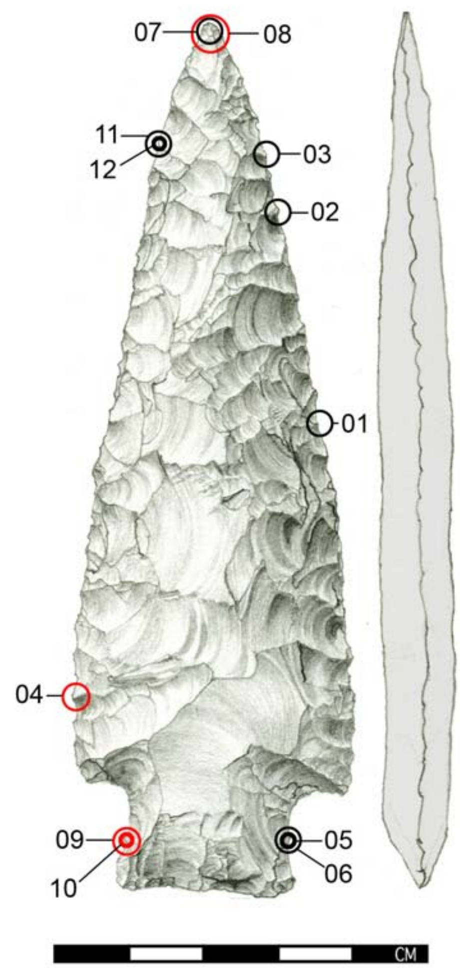



**Figure D-65.** Projectile Point (Catalog/ID# 2045) from Burial 23.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2046***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

*Characteristics*

**Length:** 89 mm; **Width:** 28 mm; **Thickness:** 8 mm; **Weight:** (unrecorded); **Edge Angle:** 50°; **Portion:** complete; **Raw Material Type:** chert (fine-to-medium grain); **Alteration:** none.

*Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial; **Polish:** shallow lateral; **Battering:** none; **Etching:** shallow lateral; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

.

*Comments*

Lateral margins (distal two-thirds of blade) show clear edge rounding and polish. Subtle striations are present on the margins running perpendicular to the edge. Edge attrition tends to favor one side (unifacial), though not exclusively. The wear pattern generally indicates that the tool was used in a motion transverse to the working edge (such as carving or whittling).

Edge attrition and very shallow polish were recorded near the distal tip. The pattern of attrition at the tip is not consistent with impact fracturing, indicating that the tool was not used as a projectile.

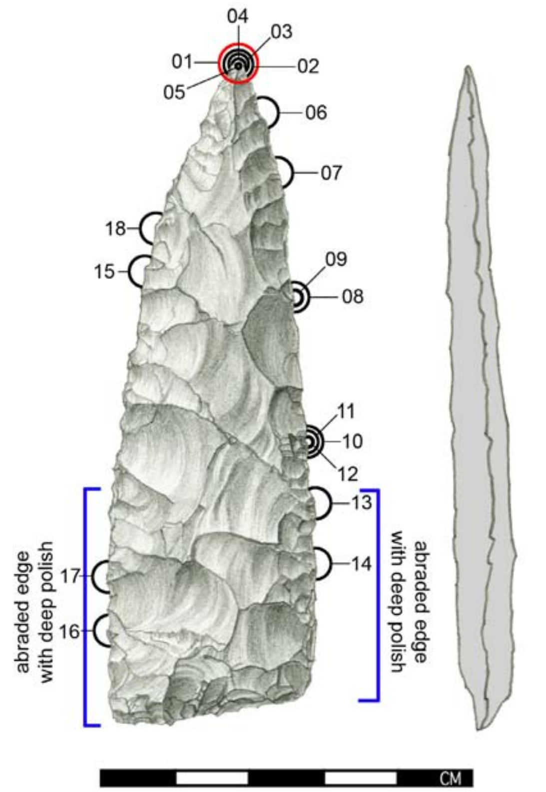



**Figure D-66.** Knife (Catalog/ID# 2046) from Burial 23.

The lateral margins along the proximal quarter of the blade exhibit frequent instances of edge abrasion and deeper polish that almost certainly resulted from hafting. The contrast observed on this area of the blade, as compared to more distal areas on the blade, may be due to the basal quarter being covered by hafting.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2047***

***Classification***

**Artifact Class:** Biface; **Artifact Subclass**: Formal; **Artifact Type:** Knife.

***Characteristics***

**Length:** 73 mm; **Width:** 29 mm; **Thickness:** 7 mm; **Weight:** (unrecorded); **Edge Angle:** 40°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** indeterminate.

***Use-Wear Pattern***

**Edge Attrition:** distal-lateral; **Polish:** distal, medial-shallow/mid; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

***Comments***

Attrition recorded at the distal tip is characterized by step and hinge terminations emanating at the point. These are subtle and do not match the severity of impact fractures. A shallow polish extends approximately 2 mm from the tip.

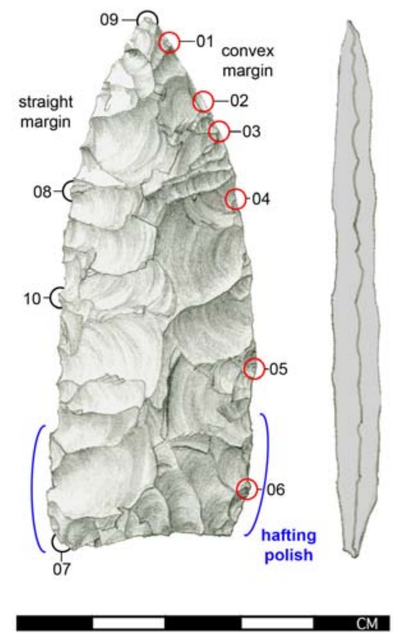



**Figure D-67.** Knife (Catalog/ID# 2047) from Burial 23.

Only slight polish and rounding are observed along the margin on the straighter of the two sides. Step fractures are also observed along the edge. These are more likely remnants of the manufacturing processes than signs of use-derived wear. The facets of flake removals are well defined. In general, however, modification to the tool's straight margin is not as well developed as it is along the more convex margin.

Edges along the more convex margin appear worn with well-developed silica polish. Fracture scars along the margin have been worn and are generally poorly defined. Attrition is bifacial and all use-wear (attrition and polish) is generally more developed toward the midsection of the tool than it is toward the distal point. The wear pattern observed along the tool's margins suggests that the tool was likely used as a knife rather than a projectile

The lateral margin near the base of the blade does not exhibit either the well-developed polish or the edge rounding that is observed on more distal portions of the blade. The modifications recorded on the lateral margins near the proximal end of the tool are more characteristic of hafting than of use. The basal corners show some rounding and are well-polished.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2048***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

*Characteristics*

**Length:** 73 mm; **Width:** 32 mm; **Thickness:** 8 mm; **Weight:** (unrecorded); **Edge Angle:** 40°; **Portion:** complete; **Raw Material Type:** chert (medium grain, mottled); **Alteration:** minor yellowing.

*Use-Wear Pattern*

**Edge Attrition:** distal; **Polish:** distal-lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

*Comments*

Remnant traces of a mastic—likely asphaltum—are present on the medial face near the midpoint of the blade. This would certainly have been the farthest that hafting would have extended toward the distal point.

The distal tip appears worn and polished. Attrition noted at the tip resulted in a slightly constricted width. Small step fractures can be observed along the margins at the tip. These emanate from the tip and are consistent with soft impact. Resharpening removals are also noted at the tip on one face. Resharpening is likely to have removed evidence of functionality.

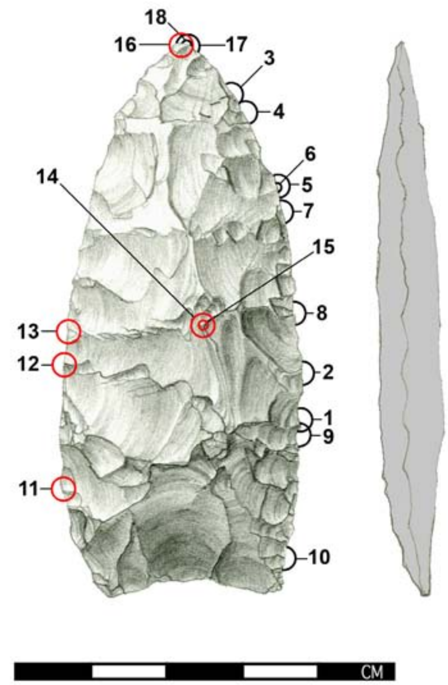



**Figure D-68.** Projectile Point (Catalog/ID# 2048) from Burial 23.

Lateral margins have been dulled (rounded) through abrasion during use. Flake facets along the margin appear well-worn along the edge. All polish observed along the blade's edges is relatively shallow, although polish is also occasionally observed on high points interior from the edge. In contrast, the basal margin shows no attrition or polish.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2049***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Knife.

*Characteristics*

**Length:** 101 mm; **Width:** 36 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 50°; **Portion:** complete; **Raw Material Type:** chalcedony; **Alteration:** indeterminate (possibly thermal).

*Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial; **Polish:** shallow distal-lateral; **Battering:** none; **Etching:** basal: perpendicular to basal margin; lateral none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** complete.

*Comments*

The distal point of the tool exhibits flake removals more consistent with edge preparation than with use-derived wear. There is some polish at the point, but very little rounding or attrition is observed. The tool's point does not appear to have been the primary contact area in use.

Polish recorded along the tool's lateral margins is well developed, but shallow. Flaking attrition is not well represented along the tool's margins, and polish has rounded or obliterated most flake facets. A faint siliceous sheen is observed in most areas that may indicate that the raw material was heat treated.

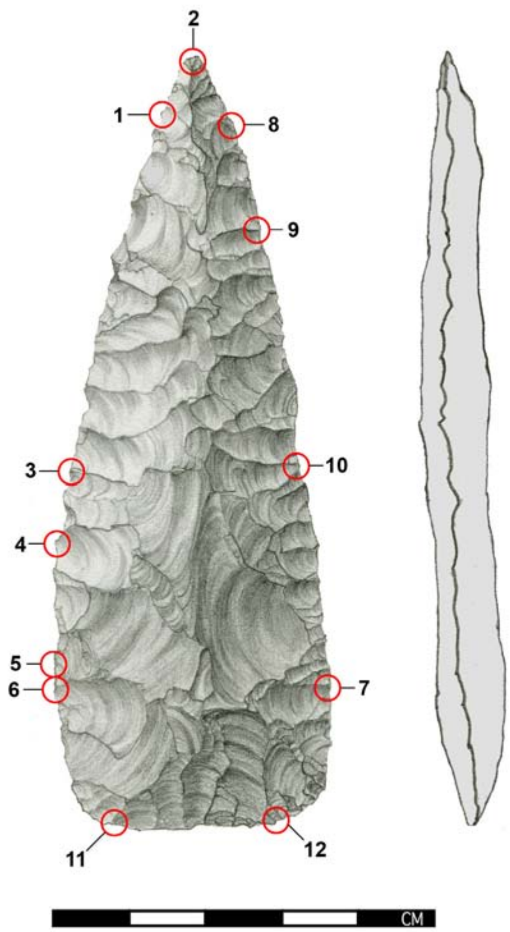



**Figure D-69.** Knife (Catalog/ID# 2049) from Burial 23.

The basal margin shows some poorly developed polish and slight rounding. This pattern of wear is consistent with hafting-derived modifications. In general, the area along the basal and lateral margins, which would likely have been hafted, exhibits sporadic areas of abrasion and poorly developed polish. Striations running perpendicular to the lateral margin are noted near the blade edge along the proximal quarter of the blade. However, it is quite possible that these striations represent hackles rather than use-derived etching. It is interesting that these striations would have been located below the hafting rather than on an area of the blade that would have received wear through the course of use.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

### *Burial Artifact ID: 2050*

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Projectile.

*Characteristics*

**Length:** 79 mm; **Width:** 29 mm; **Thickness:** 8 mm; **Weight:** (unrecorded); **Edge Angle:** 45°-55°; **Portion:** complete; Raw Material Type: chalcedony; Alteration: thermal.

*Use-Wear Pattern*

**Edge Attrition:** distal-lateral; **Polish:** distal, shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate; **Contact Material Hardness:** medium-soft.

*Comments*

Margins at the base exhibit highly developed polish. The distal point exhibits several flake removals emanating from the tip. The tip is rounded with bifacial flaking attrition, and a slight polish can be observed across the face of the point. This pattern of wear is consistent with a tool that was used in a piercing function and which suffered impact fractures. This suggests that the tool functioned as a projectile. In general, the edge rounding and polish development observed at the tip exceeds that noted along lateral margins.

A shallow, well-developed polish and minor edge and facet rounding are observed along the lateral margins on the upper quarter of blade. Minor bilateral-bifacial attrition is also present. The remodeled fractures and facets and the nature of the polish recorded along the sides of the blade suggest that the contact material was of medium-soft hardness.

A faint polish is developed along the basal margin, but only minor and sporadic edge rounding is observed. This pattern appears to be consistent with what has been described as hafting-derived modification throughout the collection.

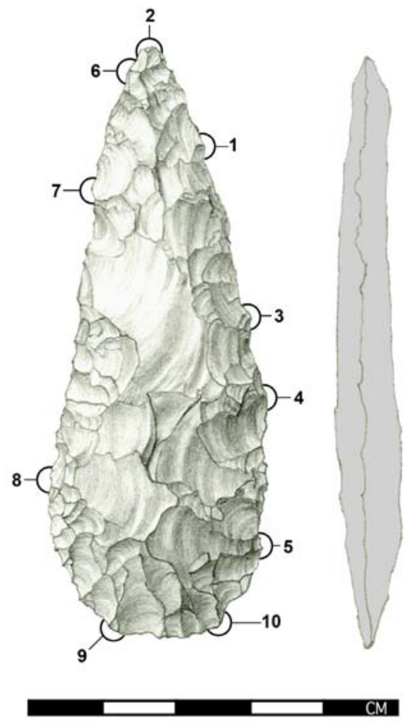



**Figure D-70.** Projectile Point (Catalog/ID# 2050) from Burial 23.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2219***

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Informal; **Artifact Type:** Multifunctional form.

*Characteristics*

**Length:** 45 mm; **Width:** 32 mm; **Thickness:** 9 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** minor oxide yellowing.

*Use-wear pattern*

**Edge Attrition:** circumferential; **Polish:** deep lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** indeterminate (unlikely); **Contact Material Hardness:** soft.

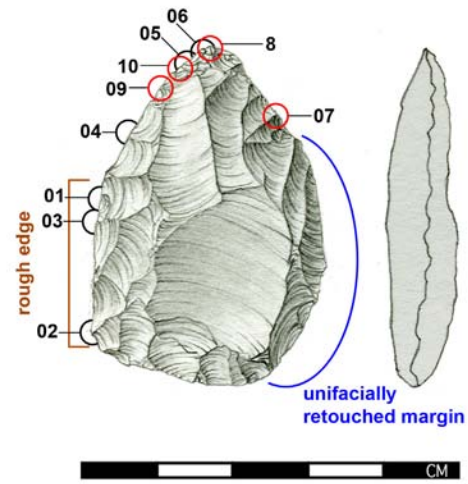



**Figure D-71.** Multifunctional Tool (Catalog/ID# 2219) from Burial 58.

*Comments*

This artifact has been recycled from a previous tool form. The form of the original tool cannot be determined based on the evidence available. The artifact is not a preform, as it was labeled in the field.

The edges of the tool have been resharpened as part of the recycling process, obscuring any trace of the tool's original function. The lateral margins of the implement appear rounded and polished. The margins exhibit a primarily bifacial attrition pattern that would be consistent with a cutting function. However, in contrast to the lateral margins, the basal margin exhibits unifacial wear similar to what could be caused by scraping. Improbably, the distal margin shows multiple step fractures emanating from the tip that resemble impact fractures. However, it is considerably more likely that this attrition was the result of contact with a material of at least medium hardness during use.

The widely varying wear patterns observed strongly suggest that this tool was multifunctional in nature. There is no evidence to suggest that the tool was ever hafted and it seems most likely that the implement was hand-held in its final use phase.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

### *Burial Artifact ID: 2227*

***Classification***

Artifact Class: Biface; Artifact Subclass: Formal; Artifact Type: Multifunctional tool.

***Characteristics***

**Length:** 78 mm; **Width:** 33 mm; **Thickness:** 11 mm; **Weight:** (unrecorded); **Edge Angle:** 60°; **Portion:** complete; **Raw Material Type:** chert (medium grain); **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** bilateral (varied); **Polish:** shallow lateral; **Battering:** none observed; **Etching:** none observed; **Hafting Polish Observed:** yes; **Contact Material Hardness:** medium-soft.

***Comments***

Flaking attrition, slight rounding, and shallow polish are observed at distal point. Unifacial attrition and slight edge rounding are present along the lateral margin near the distal tip. This attrition may be the result of edge preparation. Scarring on either immediate side of the tip suggests a twisting use motion as they are oppositional-unifacial. However, this style of use is not consistent with the general form of the tool.

Flake removals are present along the straighter of the two edges. This attrition is bifacial and suggests that the tool was used for slicing or cutting. In contrast, scarring observed along the more convex edge is primarily unifacial, suggesting a whittling or shaving motion of use. Given the contrasting patterns of wear observed along either edge and at the distal point, it seems reasonable to assume the tool was multifunctional.

Minor polish and edge abrasion observed along the proximal half of the blade are consistent with modifications derived from hafting.

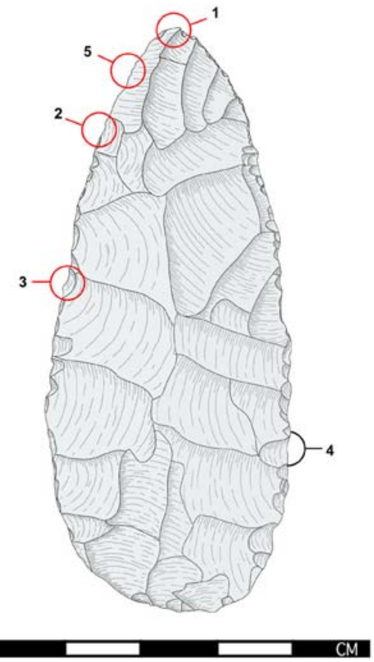



**Figure D-72.** Multifunctional Tool (Catalog/ID# 2227) from Burial 26.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 2298a***

***Classification***

Artifact Class: Biface; Artifact Subclass: Formal; Artifact Type: Projectile Point.

***Characteristics***

**Length:** 51 mm; **Width:** 21 mm; **Thickness:** 8 mm; **Weight:** (unrecorded); **Edge Angle:** 55°; **Portion:** complete; **Raw Material Type:** Chert-chalcedony blend; **Alteration:** none.

***Use-Wear Pattern***

**Edge Attrition:** distal-lateral; **Polish:** shallow lateral; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes; **Contact Material Hardness:** soft.

***Comments***

The distal tip is burinated (spalling), likely due to an impact fracture. Lateral margins show rounding and shallow polish on high points and protrusions, particularly on the upper half of the blade. Modest bilateral-bifacial attrition is present along the lateral margins.

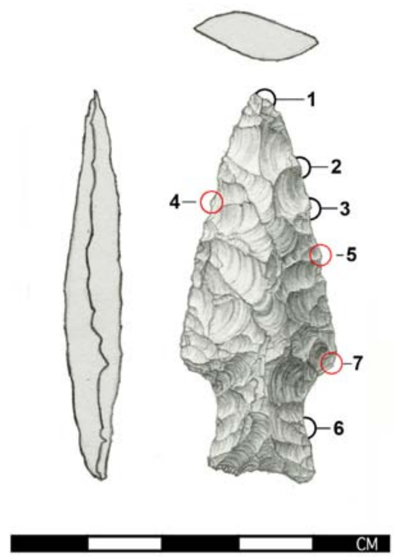



**Figure D-73**. Projectile Point (Catalog/ID# 2298A) from Burial 52.

Lateral margins along the stem and at the base are well rounded and smooth/polished. This wear appears to have derived from hafting. The wear pattern observed is consistent with repeated use.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

**Burial Artifact ID: 3049**

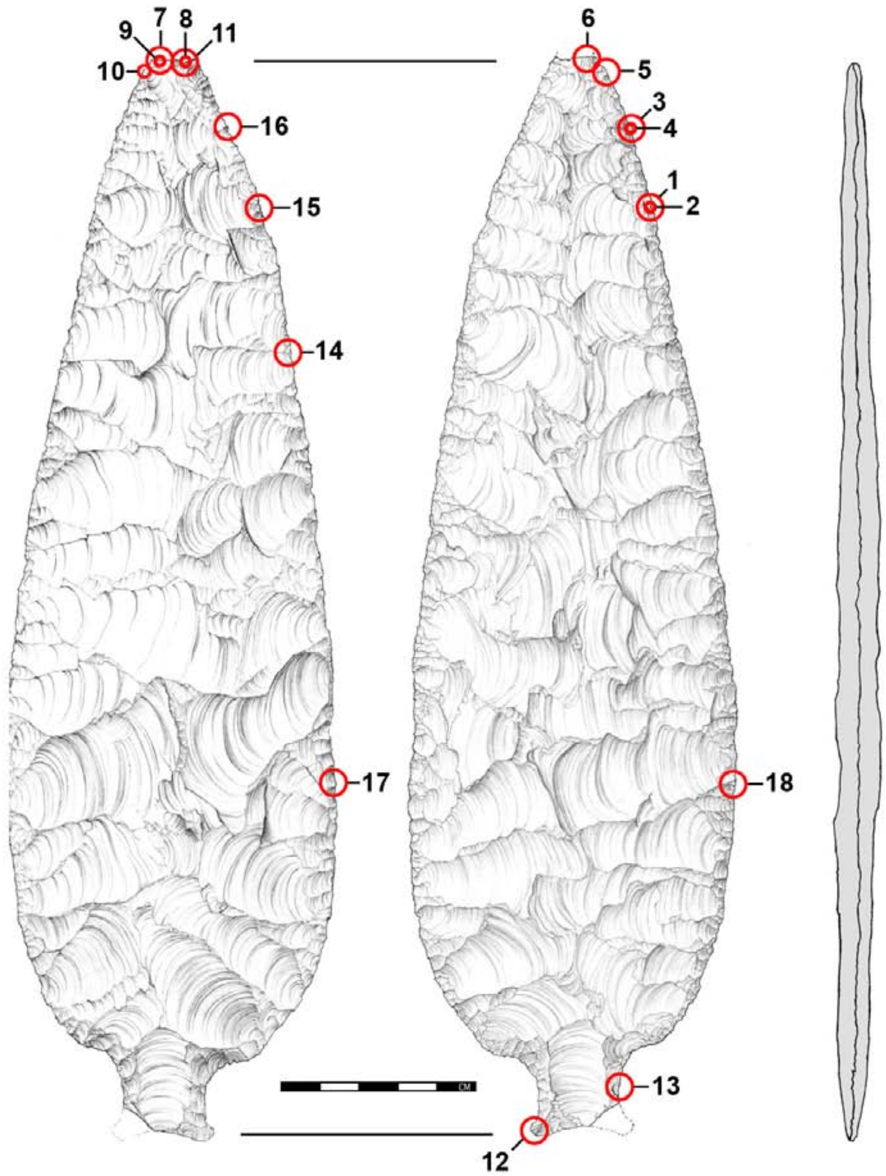



**Figure D-74.** Ceremonial Oversize Fish-Tail Biface (Catalog/ID# 3049) from Burial 74. (Note: Image is reproduced at approximately one-half actual size.)

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Formal; **Artifact Type:** Ceremonial oversized fish-tail biface.

*Characteristics*

**Length:** 275 mm; **Width:** 84 mm; **Thickness:** 10 mm; **Weight:** 252.36 g; **Edge Angle:** (variable); **Portion:** 95 percent complete (missing portion of tip and one basal tang); **Raw Material Type:** Unique brecciated, fine-grained chert (mottled with transverse fissure); **Alteration:** undetermined.

*Use-Wear Pattern*

**Edge Attrition:** bilateral-bifacial (facets smoothed, actual attrition is questionable); **Polish:** very faint, nearly ubiquitous (prehensile?); **Battering:** none; **Etching:** none; **Hafting Polish Observed:** yes,

continued.

***Burial Artifact ID: 3049***
(concluded)

on lateral margins and both faces at stem; **Contact Material Hardness:** soft (likely used infrequently in ceremonial fashion).

***Comments***

Edge rounding is observed along the lateral margin near the distal tip of the blade. The polish recorded this area of the observed margin is very faint, restricted to the extreme margin, and is unassociated with marginal attrition. The character and distribution of polish are not consistent with use-derived wear. Fractures (generally feather terminations) observed along margin are likely the product of edge preparation. The shallow polish appears to have formed over the fracture margins resulting in the minor edge and facet rounding observed.

The distal point exhibits attrition caused by a snap fracture, resulting in the removal of a portion of the tip. Attributes of the fracture indicate that the removal initiated from a strike to the side of the tip on the face of the blade. The fracture does not appear to be related to use-related impact.

Most areas along the lateral margins exhibit minor edge rounding and very faint, shallow polish. The polish is restricted to the extreme margin and is unassociated with marginal attrition. Given the form of the object and the nature of the wear along its margins, it is likely that the polish developed along the tool's edges as a result of prehensile manipulation over a long duration rather than from use.

Some edge rounding/grinding and a shallow polish are observed along margin of preserved barb at base of stem. No observable wear was recorded along lateral margin of the stem itself, suggesting that the implement was likely never hafted. It is worth noting that from a mechanical standpoint, it is unlikely that the stem would have allowed the tool to function in a utilitarian manner without subsequently fracturing given its width and thickness in relation to the blade, as well as the tensile strength of the raw material

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

***Burial Artifact ID: 3072B***

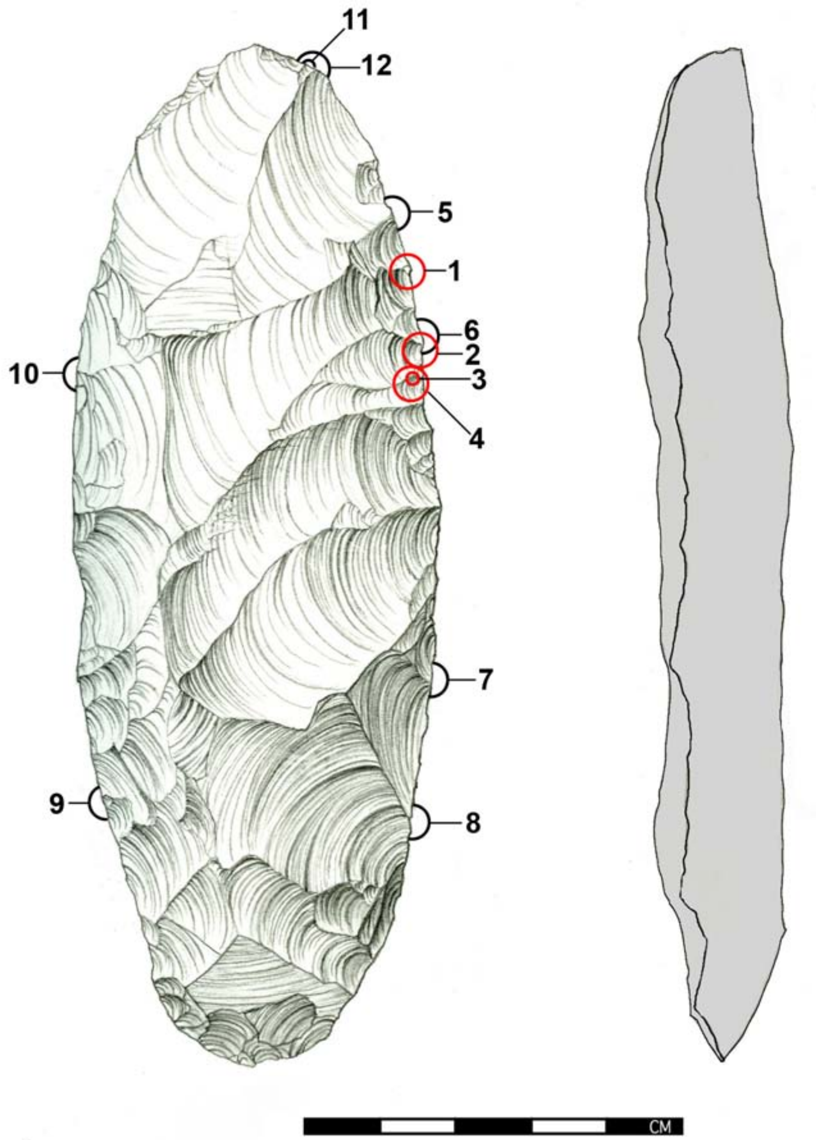



**Figure D-75.** Preform (Catalog/ID# 3072B) from Burial 6.

*Classification*

**Artifact Class:** Biface; **Artifact Subclass:** Indeterminate; **Artifact Type:** Preform.

*Characteristics*

**Length:** 135 mm; **Width:** 50 mm; **Thickness:** 18 mm; **Weight:** (unrecorded); **Edge Angle:** 60°-70°; **Portion:** complete; **Raw Material Type:** chert (mottled, fine-to-coarse grained); **Alteration:** thermal (likely).

*Use-Wear Pattern*

**Edge Attrition:** none; **Polish:** none; **Battering:** none; **Etching:** none; **Hafting Polish Observed:** no; **Contact Material Hardness:** NA.

*Comments*

No evidence of use-wear was detected along the margins of the tool. In general, all edges are characterized by abrasion and hang flakes. These

continued.

***Burial Artifact ID: 3072B***
(concluded)

hang flake fractures are the result of edge preparation during preform production. No edges exhibit pressure-flaking retouch or any other form of detailed, late-stage preparation. Slight edge rounding can be observed along the upper margin of the blade. This gloss may be from prehensile abrasion acquired during production, as there is no clear indication that it was use-derived. An organic residue is near the lateral margin at the upper midsection of the blade.

Note: Microscopic photographs of use-wear patterns on mortuary artifacts are not shown here under terms negotiated between INVISTA and the U.S. Army Corps of Engineers. These are, however, on file at the Texas Archeological Research Laboratory (TARL).

### *Summary of Findings and Conclusions*

#### *General*

A sample of 75 stone tools from Buckeye Knoll were analyzed for the presence of use-wear and use-related residues. The contexts from which these artifacts were recovered date to the Early Archaic (ca. 7000-6200 B.P.), Middle Archaic (6000-4000 B.P.), and Late Archaic (4000-1200 B.P.) periods. Twenty-two of the artifacts recovered in Early Archaic deposits were discovered in mortuary contexts. Middle and Late Archaic artifacts were discovered in association with midden deposits. Typologically, the assemblage included gouges, scrapers, knives, spokeshaves, choppers, adzes, projectile points, drills, axes, awls, gravers, and blades, as well as multifunctional implements, flake tools, and preforms.

All evidence of use-related modification or remnant residues located on specimens within the analysis sample were recorded using ESEM and low power (12.8 to 160) microscopy. This evidence was compared with experimental material, published illustrations, and published descriptions to assist in correlating patterns of wear with the activities that are likely to have produced them and the likely attributes of contact materials.

Twenty-one artifacts from the Middle Archaic deposit were analyzed using ESEM. The goal of ESEM analysis was to detect residues present on the edges of tools and to better discern the context in which a particular tool was used. Residues that may be identified through ESEM analysis include pollen, phytoliths, starches, plant fibers and tissues, hair, and other such detritus resulting from use (Anderson 1980; Anderson-Gerfaud 1986; Barton et al. 1998; Briuer 1976; Gorski 1997; Hardy and Garufi 1998; Jahren et al. 1997; Kealhofer et al. 1999; Loy et al. 1992; Sobolik 1996). The first goal of this analysis was to identify any residues present on the tool margins. To the extent possible, the second goal was to determine whether the residue was related to the tool's use context or to post-depositional contamination. Of the 20-tool study sample, only four tools were identified as having residues. The nature of residues as either use-related or post-depositional could not be determined. The results of the residue analysis preformed by Tim Riley at Texas A&M University are presented in Appendix E.

#### *Procurement*

The focus of this study was not on raw material procurement, although insights were provided when possible. No chemical characterization analyses were performed in the course of this study. Nevertheless, based on cortex characteristics and material properties, many of the artifacts appear to have been crafted from locally available river cobbles. However, several artifacts were crafted from fine-grained materials that may have been procured through migration or trade from inland source areas. One artifact (3049) was crafted from a mottled, brecciated chert that was almost certainly exotic to the area, and may well have come from an extraordinary distance.

Insights into the use of raw materials foreign to the local area can be attained by measuring the incidence of occurrence in the assemblage of particular materials. Tools crafted from exotic materials are expected to be represented less frequently in the artifact assemblage. Also, the absence of debitage of a particular raw material type may provide useful information as to the local availability of a given resource. Such an analysis was beyond the scope of this study, as debitage was not included in the study sample. In some instances, raw materials may be either chemically or visually identified as originating at specific, previously identified resource areas.

#### *Production Technology*

The strategies and stages of production are not discussed here as this analysis focused only on tools and excluded a spatial analysis of all lithic materials including debitage and hammerstones. Specifically, the reduction process was not the focus of this study. Still, insights were provided when possible, especially with regard to preforms and recycled tools.

A combination of hard- and soft-hammer techniques were observable throughout the collection. Most preforms expressed only hard-hammer percussion, with soft-hammer techniques employed toward the later phases of the production trajectory. An assessment of the presence of thermal alteration was based on color and luster changes expressed by the raw material, as well as through the presence of fracturing., crenulated fractures, and spalling. Heat treating, when performed, appears to have been done when the tool was a mid- to late-stage preform. Thermally altering raw materials at this stage would have enabled greater precision in soft-hammer and pressure flaking when the preform is reduced sufficiently in size for thermal alteration to have affected the material uniformly.

***Use Context***

Use-actions were determined based on the location, degree of development, and distribution pattern of use-derived edge attrition, edge rounding, polish, and striations. Descriptions of use-actions generally follow those provided in Odell and Odell-Vereecken (1980). These include chopping, axing, adzing, cutting, slicing, whittling, carving, shaving, gouging, awling, drilling, and scraping. The pattern of use-wear was used to distinguish the area on the artifact that was used, the motion of use, and the probable hardness of the contact material. Contact materials were described as soft, medium-soft, medium-hard, or hard (after Odell and Odell-Vereecken1980).

Individual typological classes within the collection appear to exhibit a variety of functions. Thus, function cannot be definitively assumed based on design morphology. However, the majority of tools do not exhibit a variety of overlapping use signatures, suggesting that they were employed in the completion of like tasks throughout their use-life. To be clear, there is strong and consistent evidence within the study sample that tools were not commonly multifunctional, but rather appear to have been used in a singular activity.

In general, expedient forms appear more likely to have been used for multiple purposes while formal tools were less often employed in more than one type of activity. For example, projectiles do not appear to have functioned alternatively as knives. Nevertheless, several formal tools were certainly used as multifunctional implements. Multifunctional use appears to increase where tools failed (broke) during use in their original function. Several of the tools in this collection appear to have been recycled into alternative uses following their initial failure.

In several instances, the assumed function of the tool, based on attributes of its design, did not correlate with the use-wear evident on the piece. This underscores the importance of performing an analysis of use-wear in the study of lithic assemblages.

Few of the artifacts in this collection appear to have been used extensively. The vast majority of the artifacts were not used to exhaustion. In fact, only informal, flake tools appear to have reached their end trajectory. Many of the preforms included with Burial 6 (Feature 18) were effectively exhausted due to poorly executed manufacture. The preforms could not have been further reduced due to severe step fractures, edge removal, and platform loss. Given the number of preforms included in this deposit, as well as the ceremonial nature of the context, it seems plausible that the bifaces were strictly symbolic in nature and were never intended to reach actual functionality.

The inclusion of numerous bifacial preforms in Burial 6 is anomalous to the sample as a whole. There exists no clear correlation between tool use and inclusion within a mortuary context. Specifically, the majority of mortuary artifacts exhibit clear evidence of use. It seems plausible to suggest that individuals were interred with the tools they used or owned in life. It does not appear as though burial artifacts were expressly ceremonial in nature with the exception of the biface preforms discovered in Burial 6 and the oversize, stemmed biface included in Burial 74.

***Hafting***

Many of the artifacts displayed faint polish and edge abrasion along their proximal margins, probably indicative of hafting. In most cases the pattern of wear ascribed to hafting was distinct from the edge modifications observed along distal margins that were ascribed to use. The pattern of edge attrition, marginal rounding, and faint polish on margins and interior facets and ridges that has been described as evidence for hafting was, however, remarkably similar from artifact to artifact. Several artifacts retained trace amounts of asphaltum on their hafting elements, generally embedded in step fractures when present.

Other artifacts were likely directly manipulated in the course of use rather than being hafted. Possible evidence for this exists in focal areas of polish that are located in places where the tool would have needed to be gripped during use.

***Recycling***

In general, most artifacts do not appear to have been extensively recycled given that the majority of the chipped stone tools included in this study appear to be in their initially finished form. However, edge-resharpening was noted on several specimens suggesting a utilitarian use-life rather than a purely ceremonial function. In other words, most artifacts were not crafted specifically for burial inclusion. A smaller number of the tools studied appear to have entered a secondary use life following failure in their original use context. Failures resulted from stress and impact fractures, as well as from knapping errors and the mechanical inability to further reduce the objective piece any further while retaining its original design characteristics. In such instances, the piece was most often recycled into expedient cutting implements and scrapers. The evidence for secondary use, together with the presence of several utilized flake tools, suggests that the ancient population at the Buckeye Knoll site actively conserved raw materials to the extent possible.

### *Acknowledgements*

I would like to thank Robert Ricklis and Coastal Environments, Inc., for inviting me to participate in this project. The late Robson Bonnichsen and the Center for the Study of the First American at Texas A&M University made their Leica light microscopes and vast literature collection available for this study; their generosity was critical in completing this research. Jim Wiederhold lent his experience and insight in the field of microscopic use-wear to this study and provided a comparative experimental-tool sample. Rick Littleton at the Microscopy and Imaging Center at Texas A&M University provided me with training and guidance in the use of the Environmental Scanning Electron Microscope. Tim Riley analyzed the ESEM images for identifiable pollen, phytoliths, and other residues. Donny Hamilton and the Conservation Research Laboratory at Texas A&M University were immeasurably generous in providing laboratory space, materials, and equipment necessary for casting the stone mortuary artifacts from Buckeye Knoll, providing a permanent record of the collection. C. Wayne Smith and the Archaeological Preservation Research Laboratory at Texas A&M University provided guidance and support in artifact replication and in generating images used in this report.

## *References*

Anderson, P. C.
1980 A Testimony of Prehistoric Tasks: Diagnostic Residues on Stone Tool Working Edges. *World Archaeology* 12(2):181-194.

Anderson-Gerfaud, P.
1986 A Few Comments Concerning Residue Analysis of Stone Plant-Processing Tools. In *Technical Aspects of Microwear Studies on Stone Tools*, *Part II*, edited by L. Owen and G. Unrath, pp. 69-81. *Early Man News* 9-11.

Andrefsky, W.
1998 *Lithics: Macroscopic Approaches to Analysis*. Cambridge Manuals in Archeology. Cambridge University Press, Cambridge, England.

Aoyama, K.
1999 *Ancient Maya State, Urbanism, Exchange, and Craft Specialization: Chipped Stone Evidence from the Copán Valley and the La Entrada Region, Honduras*. University of Pittsburgh Memoirs in Latin American Archaeology No. 12. Department of Anthropology, University of Pittsburgh, Pittsburgh.

Barton, H., R. Torrence, and R. Fullagar
1998 Clues to Stone Tool Function Re-examined: Comparing Starch Grain Frequencies on Used and Unused Obsidian Artifacts. *Journal of Archaeological Science* 25:1231-1238.

Black, S. L., and A. J. McGraw
1984 *The Panther Springs Creek Site: Culture Change and Continuity Within the Upper Salado Creek Drainage, South Central Texas*. Archaeological Survey Report No. 10. Center for Archaeological Research, University of Texas at San Antonio.

Briuer, F.
1976 New Clues to Stone Tool Function: Plant and Animal Residues. *American Antiquity* 41:478-484.

Clark, J. E.
1988 *The Lithic Artifacts of La Libertad, Chiapas, Mexico: An Economic Perspective*. Papers of the New World Archaeological Foundation No. 52. Brigham Young University, Provo, Utah.

Fullagar, R. L. K.
1991 The Role of Silica in Polish Formation. *Journal of Archaeological Science* 18:1-24.

Gorski, A.
1997 Material Residues on Stone Tool Edges: Is Optical Microscopy Missing an Opportunity? *Microscope* 45:89-92.

Grace, R.
1996 Use-Wear Analysis: The State of the Art. *Archaeometry* 38:209-229.

Hardy, B. L., and G. T. Garufi
1998 Identification of Woodworking on Stone Tools Through Residue and Use-Wear Analyses: Experimental Results. *Journal of Archaeological Science* 25:177-184.

Jahren, A. H., N. Toth, K. Schick, J. D. Clark, and R. G. Amundson
1997 Determining Stone Tool Use: Chemical and Morphological Analyses of Residues on Experimentally Manufactured Stone Tools. *Journal of Archaeological Science* 24:245-250.

Kealhofer, L., R. Torrence, and R. Fullagar
1999 Integrating Phytoliths Within Use-Wear/Residue Studies of Stone Tools. *Journal of Archaeological Science* 26:527-546.

Keeley, L. H.
1977 An Experimental Study of Microwear Traces on Selected British Palaeolithic Implements. Unpublished Ph.D. dissertation, Oxford University.

________
1980 *Experimental Determination of Stone Tool Uses: A Microwear Analysis*. Prehistoric Archeology and Ecology. University of Chicago Press, Chicago.

Keeley, L. H., and M. H. Newcomer
1977 Microwear Analysis of Experimental Flint Tools: A Test Case. *Journal of Archaeological Science* 4:29-62.

Lewenstein, S. M.
1987 *Stone Tool Use at Cerros: The Ethnoarchaeological and Use-Wear Evidence*. 1st ed. University of Texas Press, Austin.

Lewenstein, S. M., and J. Walker
1984 Obsidian Chip/Manioc Grating Hypothesis. *Journal of New World Archaeology* 6(2):25-38.

Loy, T. H., M. Spriggs, and S. Wickler
1992 Direct Evidence for Human Use of Plants 28,000 Years Ago: Starch Residues on Stone Artifacts from the Northern Solomon Islands. *Antiquity* 66:898-912.

McBrearty, S., L. Bishop, T. Plummer, R. Dewar, and N. Conard
1998 Tools Underfoot: Human Trampling as an Agent of Lithic Artifact Edge Modification. *American Antiquity* 63:108-129.

Morse, D. F.
1997 Description of the Artifacts. In *Sloan: A Paleo Indian Dalton Cemetery in Arkansas*, edited by D. F. Morse, pp.14-52. Smithsonian Institution Press, Washington, D.C.

Odell, G. H.
2001 Stone Tool Research at the End of the Millennium: Classification, Function, and Behavior. *Journal of Archaeological Research* 9(1):45-100.

Odell, G. H., and F. Odell-Vereecken
1980 Verifying the Reliability of Lithic Use-Wear Assessments by 'Blind Tests': The Low-Power Approach. *Journal of Field Archaeology* 7(1):87-120.

Semenov, S. A.
1964 *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. Translated by M. W. Thompson. Harper & Row Publishers, New York.

Shafer, Harry J., and Richard G. Holloway
1979 Organic Residue Analysis in Determining Stone Tool Function. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 385-399. Academic Press, New York.

Shea, J. J., and J. D. Klenck
1993 An Experimental Investigation of the Effects of Trampling on the Results of Lithic Microwear Analysis. *Journal of Archaeological Science* 20:175-194.

Sobolik, K. D.
1996 Lithic Organic Residue Analysis: An Example from the Southwestern Archaic. *Journal of Field Archaeology* 23:461-469.

Tringham, R., G. Cooper, G. H. Odell, B. Voytek, and A. Witman
1974 Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.

Turner, E. S., and T. R. Hester
1985 *A Field Guide to Stone Artifacts of Texas Indians*. Texas Monthly Press, Inc., Austin.

**Appendix E**

# Stone Tool Residue Analysis

**Tim Riley**

### *Introduction*

This report presents the results of an organic residue study of selected stone tools recovered from the Buckeye Knoll site (41VT98). These tools were inspected by Jason Barrett using an Environmental Scanning Electron Microscope (ESEM). The resultant micrographs were examined by the author with the stated goal of identifying any observed microbotanical components, specifically phytoliths, pollen grains and/or starch granules. The limitations of this divided approach will be discussed below. Very little evidence for any of these categories of microbotanicals was observed in the micrographs. However, there were some other organic components noted in the micrographs that will be discussed.

### *Background*

Organic residue analysis of stone tools has become a common component of lithic analyses since the 1970s (Barton et al. 1998; Haslam 2006; Jahren et al. 1997; Kealhofer et al. 1999; Lombard and Wadley n.d.; Perry 2004; Piperno and Holst 1998; Shafer and Holloway 1977; Sobolik 1996). Many of these studies focus on the botanical component of the record, due to the greater potential for preservation and the compatibility of these types of studies with previously established research in archaeology, such as palynology. Recently, studies have started to incorporate chemical analyses of organic residues along with the more established morphological analyses (Jahren et al. 1997).

### *Limitations*

While some important information can be gleaned from the current study, there are a number of ways in which the approach is limited. First, like any organic residue study, there is a limitation in the potential interpretation. Most microbotanical studies are interpreted at the level of the assemblage (Piperno 2006). This is not possible in most organic residue studies, where identifiable components are frequently observed in isolation. This limits the interpretation to either broad categories such as grass phytoliths vs. arboreal phytoliths, or microbotanical components that are morphologically unique to species. There is little that can be done to correct this limitation. Second, there are no reference assemblages from the site with which to compare the organic residues on the tools (Kealhofer et al. 1999). This limits the potential interpretation, as there is no way to distinguish microbotanical components deposited on the tool by use from those components deposited through natural taphonomic factors. This could easily be corrected in future studies by collecting onsite samples, specifically from sediment in direct contact with the artifacts and from sediment from the same context as the artifact (Kealhofer et al. 1999). Third, many microbotanical components can only be properly identified by examining the three-dimensional morphology of the structure. This has limited the usefulness of scanning electron microscopy (SEM) in the analysis of mixed microbotanical assemblages, since specimens must be coated with a conductive material and are, effectively, fixed in position. ESEM may provide a solution to this, since the method relies upon water vapor to generate the image and does not require any specimen coating. Since this report relied exclusively on the resultant micrographs of the original study by Jason Barrett, the author is limited to the views presented in the micrographs. This limitation could be avoided by incorporating the paleoethnobotanist into the original research design and the subsequent microscopic analysis. Fourth, while the ESEM allows an incredible amount of resolution in the resultant image, many of the diagnostic features of microbotanical components, such as starch, require specialized features of light microscopy such as polarized light or the ability to perceive color differences due to dyes (Lamb and Loy 2005; Perry 2004). While the ESEM may result in much greater resolution of morphological detail, it may also limit the ability to identify microbotanical components when used singularly. One way to avoid this limitation would be to use both ESEM and light microscopy to examine organic residues. This combined method would take advantage of the strengths of both approaches.

### *Materials and Methods*

A total of 423 micrographs from 20 stone tools was examined with the goal of identifying the microbotanical evidence on each tool. The original focus of the study was on the identification of the phytolith, pollen, and starch components of the record. It was hoped that these components of the microbotanical record could inform on the functional uses of the artifacts analyzed. Other botanical components of the record were also observed and identified where possible.

Identifications were made through comparison with both atlases of microbotanical components (Bock et al. 1988; Piperno 2006; Rovner 2004; Wrenn and Tedford 2004) and references slides available to the author. Most of the microbotanical material encountered in the micrographs was not readily identifiable beyond large morphological groups.

### *Results by Tool*

#### *Artifact 0474—Adze*

There were no identifiable phytoliths, pollen, or starch grains encountered in the seven micrographs available for this tool. A number of the micrographs contain some flat, smooth structures that could be thin walled plant cells at first glance (Bock et al. 1988) or possibly fat cells (Lombard and Wadley n.d.). There is also a larger structure in that looks superficially similar to sheet collagen as shown in Lombard and Wadley (n.d.). It seems more likely that these "plate-like" structures are non-biological in origin, perhaps very small micro flakes of the tool itself.

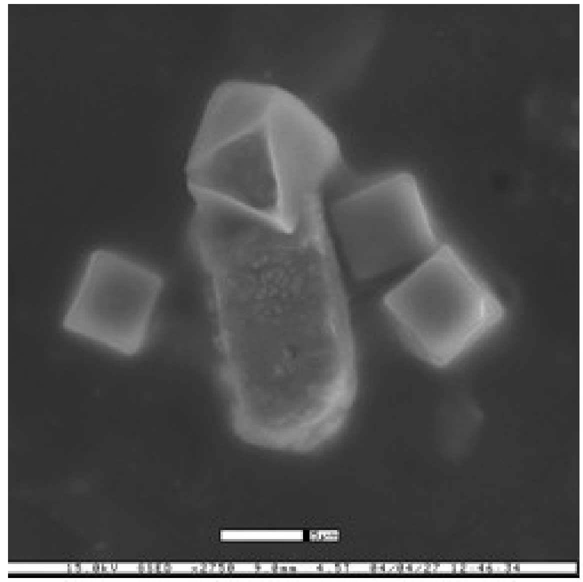


**Figure E-1.** Representative example of the types of crystal structures encountered in some of the micrographs.

#### *Artifact 0556—Scraper*

There were no identifiable phytoliths, pollen, or starch grains encountered in the 18 micrographs available for this tool. The same "plate-like" structures observed in the micrographs of 0474 are visible in most of the micrographs of this tool, as well. With the more detailed micrographs available for this tool, it is clear that the structures are micro flakes of the parent material.

#### *Artifact 0743—Spokeshave*

There were no identifiable phytoliths, pollen, or starch grains encountered in the 21 micrographs available for this tool. Many of the micrographs contain images of the micro flakes observed in other tools. There are also a number of very small crystal structures observed in many of these micrographs (Figure E-1). The rectangular nature of these structures suggests a mineralogical origin. They are clearly not biological.

#### *Artifact 0753—End Scraper*

There were no identifiable phytoliths, pollen, or starch grains encountered in the 24 micrographs

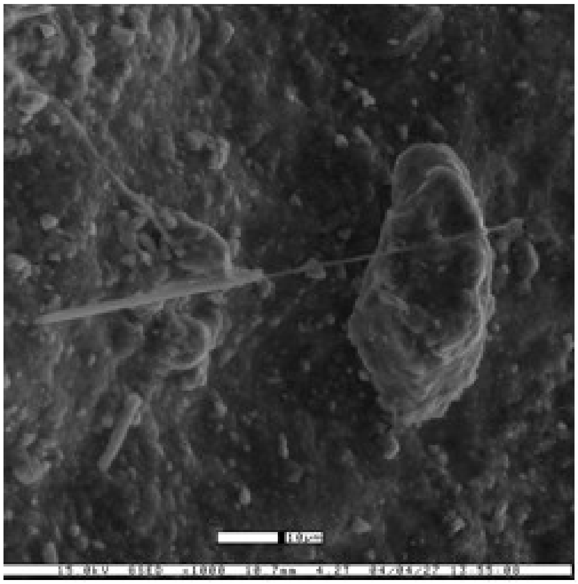


**Figure E-2.** A small rod-like structure on Artifact 0961 (Clear Fork Tool).

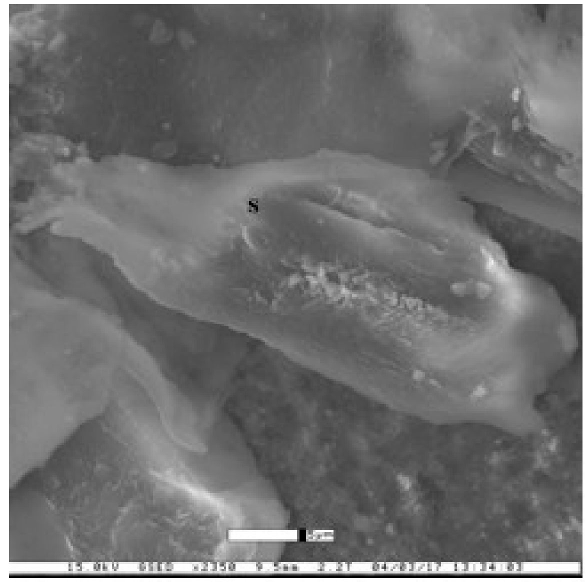


**Figure E-3.** An epidermal cell with a stoma, probably a silicified cell (phytolith) (S).

available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 0822—Clear Fork Tool***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 24 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. There are also several micrographs that detail imperfections in the raw material of the tool itself.

***Artifact 0832—Multifunctional Tool***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 23 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 0961—Clear Fork Tool***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 13 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. Figure E-2 shows several small rod-like structures on the tool. They do not appear to be phytoliths based upon morphology and size. They may be sponge spicules, but this author does not have the expertise or reference collections to verify this statement.

***Artifact 1046—Projectile (Possibly an Awl)***

There were no identifiable pollen or starch grains encountered in the 14 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. There were two micrographs taken of this tool that do show evidence of microbotanical components. Figure E-3 shows an epidermal cell with a stoma. This is probably a silicified cell (phytolith). The author is unable to identify the phytolith beyond this broad class other than to indicate that this is probably a dicotyledonous plant, as most monocotyledons do not have silicified epidermal cells. Figure E-4 appears to be a trichome (plant hair) phytolith. The author is not entirely sure of this identification, since the three-dimensional morphology is not available. This phytolith is also from a dicotyledonous plant.

***Artifact 1115—Knife***

There were no identifiable pollen or starch grains encountered in the 35 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. There were two micrographs taken of this tool that do show evidence of microbotanical components and a third that may contain an animal hair. Figure E-5 shows a bilobate-type phytolith, commonly found in many members of the grass family (Poaceae). Figure E-6 shows an elongate phytolith, also a com-

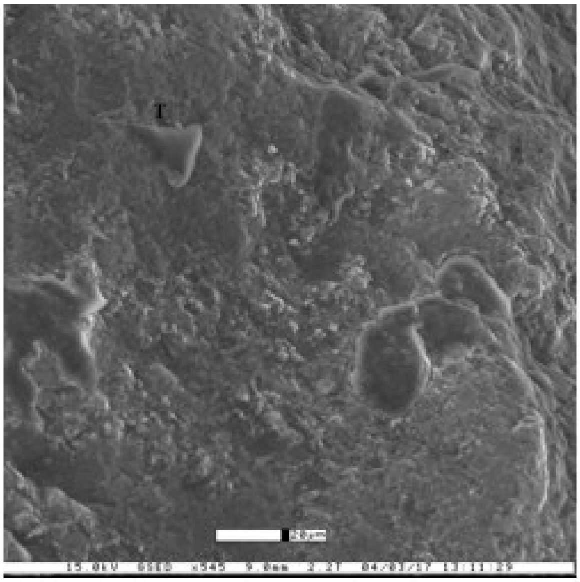



**Figure E-4.** A trichome (plant hair) phytolith (T).

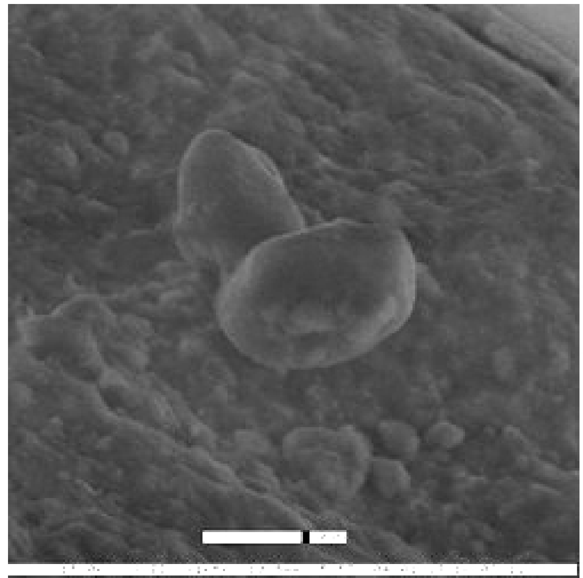


**Figure E-5.** A bilobate-type phytolith, commonly found in many members of the grass family (Poaceae).

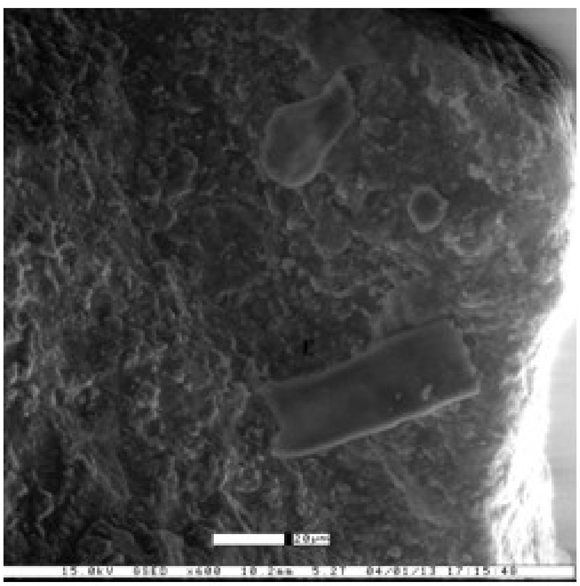


**Figure E-6.** An elongate phytolith, also a common phytolith type found in members of the grass family (Poaceae).

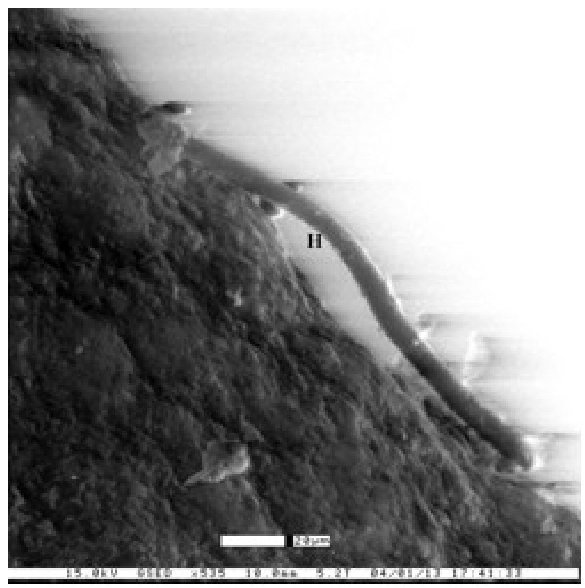



**Figure E-7.** H indicates a possible animal hair.

mon phytolith type found in members of the grass family (Poaceae). Figure E-7 may show some sort of animal hair.

***Artifact 1158—***
***Recycled Projectile Point***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 18 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 1716—Awl***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 18 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 1723—Scraper***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 31 micrographs avail-

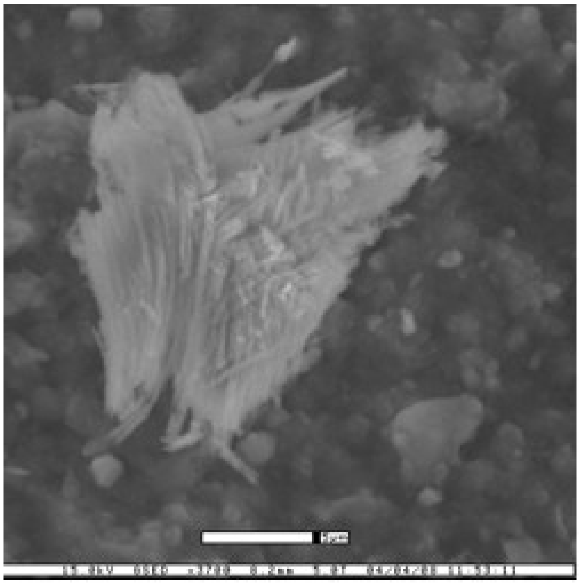


**Figure E-8.** Plant-fiber elements indicative of secondary growth.

able for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 1919—Adze or Gouge***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 17 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 1940—Adze (Secondary Use)***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 22 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 2022—Possible Spear Point or Knife***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 23 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. Figure E-8 shows plant-fiber elements indicative of secondary growth. This type of material is present only in woody species.

***Artifact 2031—Scraper***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 13 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 2237—Preform***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 15 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 3769—Scraper***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 12 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 3981—Graver***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 24 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes.

***Artifact 4178—Drill***

There were no identifiable phytoliths, pollen, or starch grains encountered in the 23 micrographs available for this tool. Most of the micrographs show evidence of partially detached micro flakes. Figure E-9 shows an unidentified cellular structure. The cells appear to have a thickened cell wall, indicating a plant origin. The cells look superficially similar to parenchymous tissue, used by plants for energy storage. There are a number of holes in the unknown sample that may correspond to the vessel elements (pores) of a woody plant.

### *Interpretation*

Only four of the 21 samples had microbotanical evidence observable in the micrographs. Of these four tools, two (2022 and 4178) appear to have microbotanical components from woody plants. Tool 1046 appears to have microbotanical components related to an herbaceous plant and Tool 1115 has microbotanical components from a member of the grass family. Unfortunately, there is no way in the present study to determine if these residues are related to tool use or post-depositional processes.

### *Future Research and Recommendations*

Future studies of microbotanical residues associated with stone tool use-wear studies could be improved by taking three steps. First, collection of adequate background samples from the sediment adhering to the tools

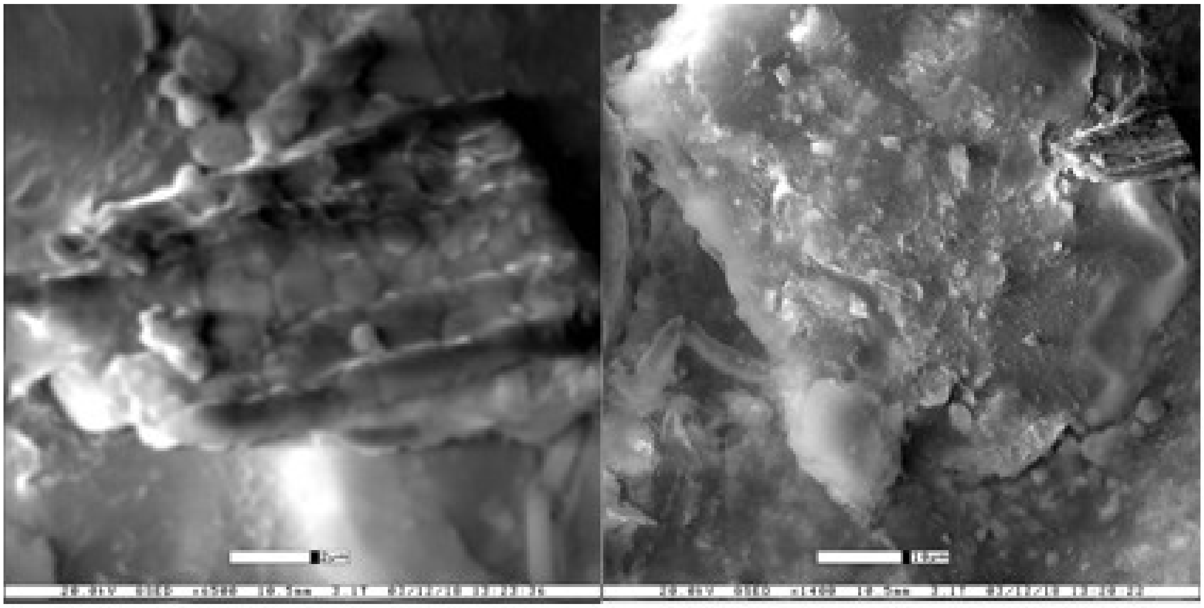


**Figure E-9.** An unidentified cellular structure with thickened cell wall, indicating a plant origin.

as well as unassociated sediments from the same context, would allow researchers to determine the association of residue components with tool use. General surface samples from the site and surrounding environment would also be helpful. Second, once tools with promising residue have been identified microscopically, sonication techniques could be used to remove the residue from the tool and mount the residue on slides, allowing for a more thorough examination of the three-dimensional morphology of the microbotanical components. Third, a chemical analysis of the residue could be conducted in combination with the morphological analysis, both to expand the potential identification as well as corroborate interpretations between the two methods.

***References***

Barton, H., R. Torrence, and R. Fullagar
1998 Clues to Stone Tool Function Re-Examined: Comparing Starch Grain Frequencies on Used and Unused Obsidian Artefacts. *Journal of Archaeological Science* 25(12):1231-1238.

Bock, J. H., M. A. Lane, and D. O. Norris
1988 *Identifying Plant Food Cells in Gastric Contents for Use in Forensic Investigations: A Laboratory Manual*. National Institute of Justice Research Report. U.S. Department of Justice, Washington, D.C. .

Haslam, M.
2006 Potential Misidentification of in Situ Archaeological Tool-Residues: Starch and Conidia. *Journal of Archaeological Science* 33:114-121.

Jahren, A. H., N. Toth, K. Schick, J. D. Clark and R. G. Amundson
1997 Determining Stone Tool Use: Chemical and Morphological Analyses of Residues on Experimentally Manufactured Stone Tools. *Journal of Archaeological Science* 24:245-250.

Kealhofer, L., R. Torrence, and R. Fullagar
1999 Integrating Phytoliths within Use-Wear/Residue Studies of Stone Tools. *Journal of Archaeological Science* 26:527-546.

Lamb, J., and T. Loy
2005 Seeing Red: The Use of Congo Red Dye to Identify Cooked and Damaged Starch Grains in Archaeological Residues. *Journal of Archaeological Science* 32(10):1433-1440.

Lombard, M., and L. Wadley
n.d. The Morphological Identification of Micro-Residues on Stone Tooles Using Light Microscopy: Progress and Difficulties Based on Blind Tests. *Journal of Archaeological Science*, in press.

Perry, L.
2004 Starch Analyses Reveal the Relationship Between Tool Type and Function: An Example from the Orinoco Valley of Venezuela. *Journal of Archaeological Science* 31(8):1069-1081.

Piperno, D. R., and I. Holst
1998 The Presence of Starch Grains on Prehistoric Stone Tools from the Humid Neotropics: Indications of Early Tuber Use and Agriculture in Panama. *Journal of Archaeological Science* 25(8):765-776.

Piperno, D. R.
2006 *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*. Altamira Press, New York.

Rovner, I.
2004 Appendix F: Phytolith Analysis of Selected Soil Samples from the Puncheon Run Site. In *Archaeology of the Puncheon Run Site (7K-C-51)* by C. LeeDecker, J. Bedell, R. Jacoby, and S. Fiedel, pp. F1-F50. Louis Berger Group, Inc. Report submitted to Delaware Department of Transportation, Dover.

Shafer, H. J., and R. G. Holloway
1977 Organic Residue Analysis and Stone Tool Function from Hinds Cave, Val Verde County, Texas: A Progress Statement. In *Archaeological and Botantical Studies at Hinds Cave, Val Verde County, Texas*, edited by H. J. Shafer and V. M. Bryant, pp. 103-125. Anthropology Laboratory Special Series 1. Texas A&M University Anthropology Laboratory, College Station, TX.

Sobolik, K. D.
1996 Lithic Organic Residue Analysis: An Example from the Southwestern Archaic. *Journal of Field Archaeology* 23(4):461-469.

Wrenn, J. H., and R. A. Tedford
2004 Phytolith Atlas: Catahoula Lake, Louisiana. Prepared for the Faculty Research Grant Program, Louisiana State University, Baton Rouge.