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Data Recovery at 41MI96 in Mills County, Texas

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with contributions by
Bruce L. Hardy, Mary E. Malainey, Timothy Figol, and Linda Perry

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MANAGEMENT SUMMARY

Prehistoric site 41MI96 in Mills County, Texas was subjected to archeological data recovery excavations by staff archeologists from the Archeological Studies Program of the Texas Department of Transportation (TxDOT) in May 1999. This work followed an initial environmental review by TxDOT personnel that concluded that a proposed bridge replacement and associated realignment of a county road (CSJ: 0923-23-011) had a high probability to impact previously unrecorded archeological sites. Subsequently, an archeological impact evaluation was conducted by TxDOT staff archeologists, under the direction of Dr. G. Lain Ellis. TxDOT investigations were conducted under Texas Antiquities Committee Permit No. 2193 to perform data recovery efforts at 41MI96 prior to development impacts. In 2012, TRC Environmental Corporation (TRC) of Austin was contracted by the Environmental Affairs Division of TxDOT through Work Authorization 57-109SA003 to conduct analysis on the recovered remains and complete a technical report of TxDOT's field investigations and TRC's laboratory findings in fulfillment of TxDOTs' Antiquities permit.

Data recovery excavations consisted of the excavation of four mechanical trenches across two creek terraces (T_1 and T_2) and hand-excavations in two small blocks (Blocks 1 and 2) within the TxDOT right-of-way on the northwestern side of the project area. Hand-excavations in both blocks were initiated to target newly discovered burned rock concentrations encountered in the bottom of backhoe scrapings. A total 5.5 m^3 of manual-excavation was completed, which was comprised of 16 total 1-by-1 m units, 11 in Block 1, and 5 in Block 2. Cultural materials were dominated by ca. 602 burned rocks and 2,846 pieces of lithic debitage, 89 informal and formal tools, but lacked diagnostic artifacts and faunal material. Six small, intact burned rock features were identified in Block 1 and were the focus of laboratory analyses. The scattered burned rocks and debitage from Block 2 were only tabulated and discussed in a general way, as TxDOT personnel believed they were in mixed context.

The six small burned rock features ranged in size from 33 to 100 cm in diameter and represented four intact heating elements (two with basins and two without), plus two small burned rock discard piles. Radiocarbon dating of organic residues in nine burned rocks from five intact features indicates multiple occupations over a span of roughly 700 years from 820 to 1450 B.P. (cal A.D. 560 to 1270). The lack of recorded depth measurements for cultural materials, combined with limited sediment deposition between the successive occupations, prevented isolation of individual occupational episodes. The lack of discernible vertical separation in the prehistoric occupations reflects slow soil aggregation during this period, likely lengthy surface exposure and possible erosion between events, and soil conditions which may also account for a near absence of charcoal and other organic materials such as vertebrate remains.

Four technical analyses (radiocarbon dating, starch grain, lipid residue, and high-powered use-wear) focused on a limited suite of chipped stone tools, associated lithic debitage, and burned rocks collected from five of the six intact features in Block 1 in the T_2 terrace. Starch grain analysis on fragments of 20 burned rocks from five features and 20 chipped stone tools from around the features in Block 1 yielded positive results from 47.5 percent of the specimens. Of considerable interest is the documentation, in addition to multiple grass species, of grains of the tropical cultigen maize (*Zea mays*) on two burned rocks each, from Features 2 and 3, plus on two edge-modified tools in the vicinity of those two features. One specific burned rock with a gelatinized maize starch grain on it was directly AMS dated to 980 ± 30 B.P. or cal A.D. 1020 to 1150. Some identified maize starch grains had been damaged through grinding, heating, and/or boiling, evidence of processing as a food resource. This indicates use of maize as a food resource in central Texas a number of centuries earlier than previously suspected. Lipid residue analysis on portions of the same 20 burned rocks from those five features yielded residues in 100 percent of the samples. The results indicate that both plant and animal products were present on all the rocks, with large herbivore lipids (likely bison or deer) present on at least one rock, and oily seed lipids present on at least three rocks. Residues from conifer wood products, here likely juniper trees, were present on 60 percent of the rocks, and indicate at least one specific wood species used to heat the rocks. High-powered microscopic use-wear analyses on 15 chert tools (11 edge-modified flakes, 2 biface fragments, and 2 complete choppers) revealed their use in processing wood, plants, bone, and hide as well as unspecified soft and hard materials.

The sparse frequency of formal chipped stone tools likely reflects the limited area investigated and also the possibility that these occupations reflect low-intensity and short-term camps that focused on preparing and cooking a few food resources in heating facilities and the manipulation of other perishable resources.

The lipid and starch analyses of the burned rocks provides important information concerning the resources cooked by the rocks in these small burned rock features, most significantly the presence of maize and wild native grasses. These resources would have gone unidentified without these specialized analyses. Continued use of these two analytical techniques on suites of burned rocks from other features/sites in and around central Texas will provide an empirical basis for identifying changes in subsistence patterns over time and across geographical space. It is also notable that direct radiocarbon dating of organic residues contained within the porous sandstone burned rocks here has succeeded in providing satisfactory chronological control for the features and site, strongly indicating that this technique can be beneficially employed in the future in cases where other organics such as wood charcoal, charred seeds/nuts, and/or bone are unavailable for absolute dating.

In 1999 the Texas Historical Commission accepted TxDOT's field investigations as sufficient and concurred with TxDOT's recommendation that no further work was necessary under Texas Antiquities Committee Permit No. 2193. Parts of site 41MI96 outside the current TxDOT right-of-way have not been fully evaluated. Based on the present findings and the excavated intact features in Block 1, it appears that potentially eligible deposits may be present beyond the current right-of-way. If TxDOT further expands this county road, it is recommended that those areas at 41MI96 be evaluated prior to surface modifications related to that project.

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Many individuals from the Texas Department of Transportation (TxDOT) participated in this project over the years. At the time of the field investigations (1999), Dr. Nancy Kenmotsu was Supervisor of the Archeological Studies Program in the Environmental (ENV) Affairs Division. Dr. G. Lain Ellis, holder of the original Texas Antiquities Committee Permit (2193), was the staff archeologist in charge of this project. Mike Bevins, TxDOT Environmental Coordinator at the Brownwood District office, helped facilitate communication and coordination of the field investigations. Daymond Crawford of the Archeological Studies Program conducted the initial archeological impact evaluation through a pedestrian inspection of the proposed area of potential impact on January 14, 1999. Following up on Crawford's initial observations of cultural materials within the impact zone and recommendations, TxDOT staff archeologist Pat McLoughlin revisited the project area and executed four shovel tests on April 9, 1999. Following the recommendation that site 41MI96 undergo data recovery made by TxDOT archeologists Nancy Kenmotsu and G. Lain Ellis to the Texas Historical Commission (THC), the THC determined the site was eligible for inclusion in the National Register of Historic Places and designation as a State Archeological Landmark (SAL). Subsequently, TxDOT made immediate plans to conduct data recovery excavations.

TxDOT archeologist G. Lain Ellis served as Principal Investigator and directed the archeological field investigations conducted by TxDOT staff archeologists. The on-site crew included Ellis, Dr. James Abbott, Daymond Crawford, Pat McLoughlin, and Jesus Gonzalez. Dr. Abbott served as project geoarcheologist and examined and documented trench profiles and wrote the geoarcheological chapter of this report in June 1999. Billy Hale, Mills County Historical Commissioner, visited the site during the data recovery excavations.

Over the years since this project was initiated, the leadership of the Archeological Studies Program and staff archeologists changed. Dr. Scott Pletka, is the current Supervisor of the Archeological Studies Program. Staff archeologist Allen Bettis, currently holds Texas Antiquities Permit 2193, and is now responsible for this project. Dr. Pletka, Dr. James Abbott and Allen Bettis worked closely with TRC Environmental Corporation's (TRC's) archeological staff over the last couple of years to facilitate the individual work authorizations, supplemental agreements, and other paperwork necessary to move this project forward and complete the analyses and report the previous TxDOT investigations at 41MI96. We thank Dr. Abbott for facilitating the submission of the samples for radiocarbon dating. We especially thank Allen Bettis for directing and helping with the many meetings to move this work authorization forward. We at TRC express our gratitude to the many TxDOT personnel for their support and guidance through the analysis and reporting of the findings from the 1999 investigation.

The TRC archeological staff is thanked for their efforts to process the cultural materials, facilitate the various analyses and produce this technical document. Trisha Ann Gonzales rewashed and cataloged the artifacts, organized the different data sets, prepared the samples and tables to send to the various technical analysts, conducted lithic artifact analysis under the guidance of Paul Matchen, produced many tables and contributed to the preparation of the materials and records for curation. Thank you, Trisha, for your attention to detail and willingness to complete the many different tasks requested of you. Shannon Gray, Laboratory Supervisor, established and constantly updated and proofed the electronic database, checked all TxDOT records, and provided quality assessment and control over the materials during the various analyses and curation. Shannon also produced the drawings used in the methods and results chapters. She also provided the direction of the preparation of the materials for analyses and curation, completed technical editing tasks of sections and chapters, and helped in many different ways. Thank you, Shannon, for your management of the database and creation of tables, plus your illustration and editing skills. Dr. Robert A. Ricklis was the primary author of the Environmental and Cultural Background chapters, the principal author of the research design, as well as a contributor in addressing the research questions. Dr. Ricklis also edited and provided comments to various draft sections. Paul Matchen directed and conducted most of the formal artifact and debitage analyses and was the primary author of those sections. Thank you, Paul, for your interest and efforts directed to the lithic assemblage. Marissa Stewart produced the draft and final document, and coordinated the printing of this report. Thank you, Marissa, for your excellent production skills and attention to detail in the production of this report.

A group of highly trained and skilled technical analysts made significant contributions to the findings during specific analyses. Each is thanked for their contributions.

Dr. Bruce Hardy, Professor in the Department of Anthropology at Kenyon College in Gambier, Ohio, is thanked for his identifications of microfossils and excellent high-powered microscopic use-wear analyses on the diverse stone artifacts. His insights into tool functions has furthered our understanding of those tools and contributed to identifying human behaviors at this site.

Dr. Linda Perry, Executive Director of The Foundation for Archaeobotanical Research in Microfossils, conducted the starch grain analysis on a broad suite of samples. I want to especially thank Linda for her scientific approach to handling the artifacts, her attention to detail, in-depth identification procedures, and continuous communication and interest in working with us and her willingness to conduct starch analysis on diverse and multiple artifact classes.

Dr. Mary Malainey, Professor at Brandon University in Manitoba, Canada, with assistance from Timothy Figol, performed the lipid residue analysis on the burned rocks. Thank you, Mary and Tim, for your continued interest and improvement in this analytical technique over time and the work performed here.

The professional staff at Beta Analytic Inc. in Florida, under the watchful eye of Ron Hatfield, is thanked for their careful handling of the burned rocks, following specific extraction procedures, and processing the radiocarbon samples and explaining their procedures. The extra care in the extraction of the outer layer of the burned rocks was especially helpful and much appreciated.

As a group, these highly skilled individuals contributed significant expertise, information and interpretations of diverse data sets to this technical report. Their combined efforts allowed greater insight, understanding, and interpretations of the prehistoric human behaviors at 41MI96. To the above scientists, we are grateful, and appreciate their expert contributions. Thanks to all for helping preserve a part of Texas prehistory and contributing to our understanding of the past. Any problems in the presentation, or errors in content, are the responsibility of the project manager.

Mike Quigg
Project Manager

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1.0 INTRODUCTION

J. Michael Quigg

1.1 PROCEDURAL BACKGROUND

This report presents the archeological methods, analyses and interpretations from the discovery and subsequent excavations at prehistoric site 41MI96 in May and June 1999. The fieldwork was conducted by Texas Department of Transportation (TxDOT) archeologists along a county road in Mills County in the Brownwood District prior to a proposed bridge replacement (CSJ: 0923-23-011) by TxDOT. The proposed bridge replacement was to be undertaken with federal funding. This project was conducted in accord with the Programmatic Agreement between TxDOT, the Federal Highways Administration (FHA), the Advisory Council on Historic Preservation (ACHP), and the Texas Historical Commission (THC), and under a Memorandum of Understanding (MOU) between TxDOT and the THC, and with Section 106 consultation. The fieldwork was conducted under TxDOT's Texas Antiquities Committee (TAC) Permit No. 2193, issued to G. Lain Ellis, and subsequently transferred to TxDOT staff archeologist Allen Bettis.

TxDOT issued a Work Authorization (No. 57-109SA003) to the Cultural Resources Section of TRC Environmental Corporation (TRC), Austin office under TxDOT Scientific Services Contract No. 57-1XXSA003 to conduct the analyses, report the findings of the 1999 TxDOT fieldwork at 41MI96 and analyses, and curate the materials. A number of meetings were held between TxDOT and TRC personnel to develop these plans and decide on analyses. TxDOT paper records include field level records, field and project maps, color photographs, general correspondence, plus three boxes of artifacts: one predominately of lithic debitage, and two of burned rocks. These materials were transferred to TRC for analyses and preparation of the materials for permanent curation at the Center for Archaeological Studies, Texas State University in San Marcos.

1.2 PROJECT LOCATION

This bridge replacement project lies in central Texas, roughly 17.5 kilometers (km) west of Goldthwaite in west-central Mills County, on the northern side of the Colorado River valley, and west of a major bend in the Colorado River (Figure 1-1). The surrounding environment is rural and the terrain exhibits undulating relief. Vegetation cover consists of scattered oak (*Quercus* sp.), pecan (*Carya* sp.), and mesquite (*Prosopis* sp.) trees and grasses (Figure 1-2). The prehistoric site discovered and investigated, 41MI96, lies within two adjoining alluvial terraces (T_1 and T_2) on the western side of Crooked Run Creek, a short, 4 km long tributary of the Colorado River. The alluvial deposits are underlain and surrounded by sandstones of the undivided Pennsylvanian Strawn Group (Barnes 1976). These fine- to coarse-grained sandstones, brown to red in color, lie in thin to massive beds that are cross-bedded and form rugged rocky scarps.

The area northeast of the bridge contained a man-made pond that lay partially in the area of proposed right-of-way. The northeast bridge abutment consisted of an approximately 1 meter (m) wide area of fill.

The southeastern abutment consisted of a 2 m wide fill section. South and east of the abutment is an eroded or deflated area that appeared cleared and through which ran a two-track road. The southwest bridge abutment exhibited a 2 m wide fill section as well. South of the bridge abutment, next to the channel, a gravel bar is present. Adjacent to and north of the gravel bar, and almost parallel to the existing drainage, is a 1 m tall sand levee. North of the levee, and between the levee and the edge of the fill section, is a depression that is believed to be an old creek channel. To the west, some 12 m from the existing bridge, the point bar grades upward onto the T_1 terrace, which had been transected by the low water crossing. The northwest abutment also exhibited a substantial fill section at least 2 m wide and nearly 2 m long.

1.3 DEPARTMENT OF TRANSPORTATION PROPOSED DEVELOPMENT

The department is planning to rehabilitate the existing steel stringer bridge on an east-west rural County Road over Crooked Run Creek and expand the current one-lane roadway north of the current right-of-way to accommodate the new bridge (Figure 1-3). This will involve the removal and

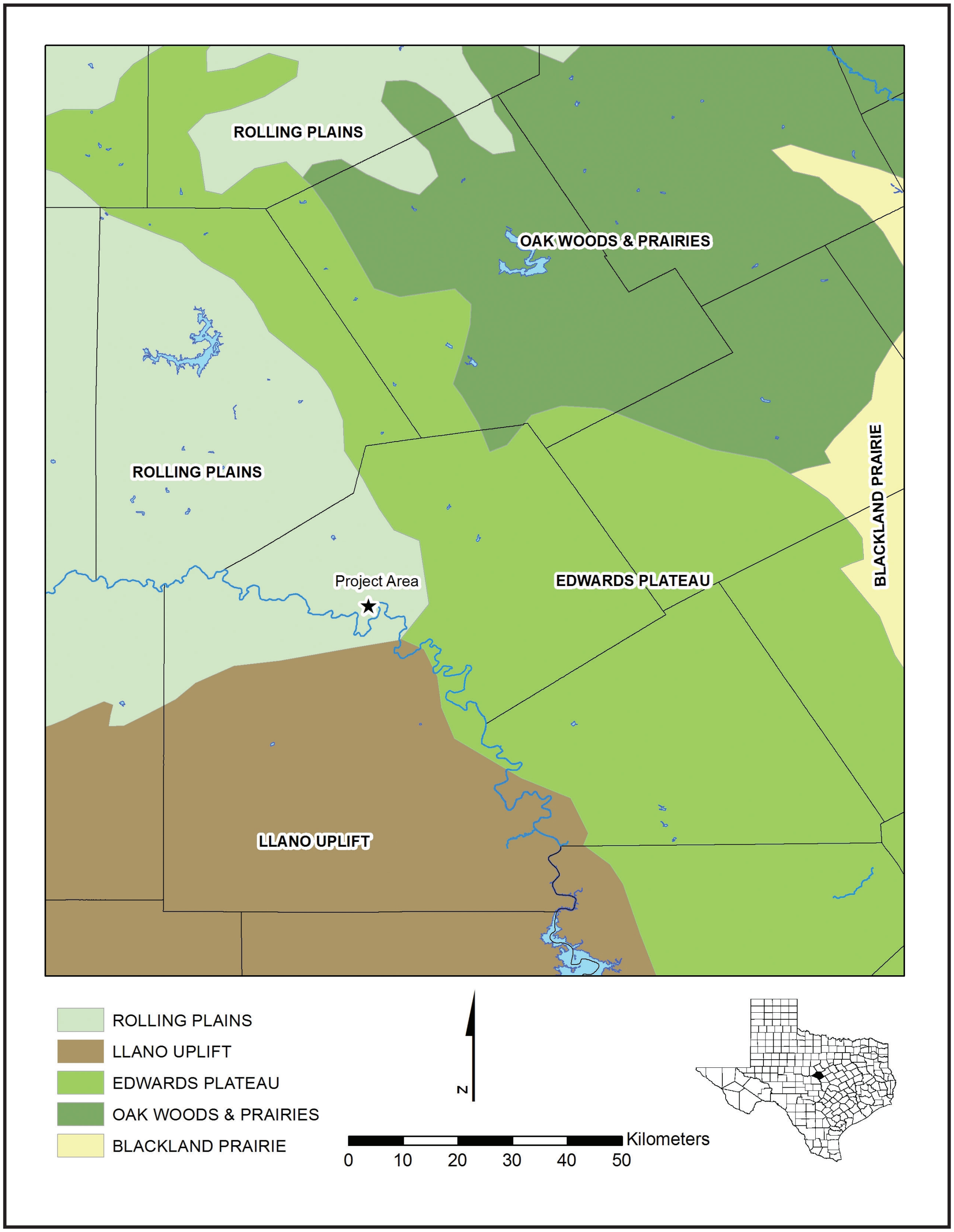

Figure 1-1. Project location in Mills County, Texas.

Figure 1-2. Vegetation in project area.

replacement of the existing bridge (Figure 1-4). In total the project will not disturb more than 2 hectares (ha) or 5 acres (ac).

The existing one-lane bridge, which consists of three spans of continuous steel, has deteriorated since its construction in 1956. The structure is 15.5 m (51 ft) long with an unpaved roadway width of 3.3 m (11 ft). The steel structure is not listed on, nor eligible for, the National Register of Historic Places (NRHP). The planned development includes widening the unpaved flexible base county roadway an additional 5 m (16.4 ft; see Figure 1-2). The proposed new bridge structure will have two 12.2 m (40 ft) concrete pan and girder spans that will be 24.7 m (81 ft) long with a 7.3 m (24 ft) clear roadway. The existing low water crossing 42 m (138 ft) south of the bridge will be used during construction (Figure 1-5). Plans show a widening of the crossing by 1.3 m (4 ft) for the purpose of the detour. The road primarily west of the creek and the bridge will shift slightly to the north. A limited amount of right-of-way 890 square meters (0.22 ac) on the north side of the structure will be required. The new right-of-way would be a wedge shaped section that is roughly 9.9 m (32.5 ft) wide near the creek and narrow back to meet the existing roadway. A temporary construction easement will be necessary to facilitate the project.

1.4 GENERAL PROJECT BACKGROUND

An initial environmental review by TxDOT personnel concluded that this project area had a high probability to contain previously unrecorded archeological sites, and an archeological impact evaluation was recommended. Records at The University of Texas, Texas Archeological Research Laboratory (TARL) revealed that several previously recorded archeological sites were present within 1.6 km (1 mi) of the project area (Kenmotsu and Ellis 1999).

On January 14, 1999, TxDOT staff archeologist Daymond Crawford conducted an archeological impact evaluation of this project. The entire area was

Figure 1-3. Existing roadway leading to old bridge.

Figure 1-4. Edge of old bridge and surrounding vegetation.

Figure 1-5. Original roadway leading to low water crossing.

visually inspected. A scatter of burned sandstone, believed to be the remnant of a hearth or hearths, was observed in the western portion of the project area, just west of the eastern intersection of the detour road with the county road (Kenmotsu and Ellis 1999).

On April 9, 1999 TxDOT staff archeologist Pat McLoughlin revisited the project area to obtain additional information concerning the identified archeological site, 41MI96. He excavated four shovel tests west of the creek, in the area of the proposed right-of-way expansion (Figure 1-6). Shovel Test (ST) 1 extended to 100 centimeters below ground surface (cmbs) and yielded one small flake from 35 to 40 cmbs and a flake tool at 50 cmbs (Table 1-1). Red clay was encountered at 80 cmbs. Shovel Test 2 was about 12 m west of ST 1 and yielded two flakes and several pieces of burned rock between 60 and 70 cmbs. At roughly 80 to 85 cmbs a red, sandy clay soil was encountered. No artifacts were found within this red soil and the test was terminated at 100 cmbs. Shovel Test 3 was about 20 m west of ST 2. At 20 cmbs, several large pieces of burned sandstone were encountered. Hand-excavation around these burned sandstone pieces revealed more large pieces of burned sandstone. Between 20 and 30 cmbs, all matrix around the burned rocks was removed, revealing a dense, very compact layer of burned rock (Figure 1-7). Shovel Test 3 was terminated at the level of these burned rocks. Shovel Test 4 was excavated south of ST 3 and south of the county road on a triangular-shaped area of land to determine if the burned rock extended farther south. Twelve flakes were recovered from ST 4 between 20 and 60 cmbs. Artifacts were also observed eroding out of cow trails on the slope of the crossing cut through the terrace leading to the low water crossing into which ST 4 was dug (Kenmotsu and Ellis 1999).

TxDOT presented the information gathered from the archeological impact evaluation to the THC in a three page letter on April 9, 1999 (Kenmotsu and Ellis 1999). The letter recommended that the area east of the bridge, which contained the eroded and presumed sandstone hearth remnants and which had been impacted by ditch construction and a two-track road, did not warrant further investigation. They argued that area lacked sufficient integrity to contain archeological deposits eligible for inclusion in the

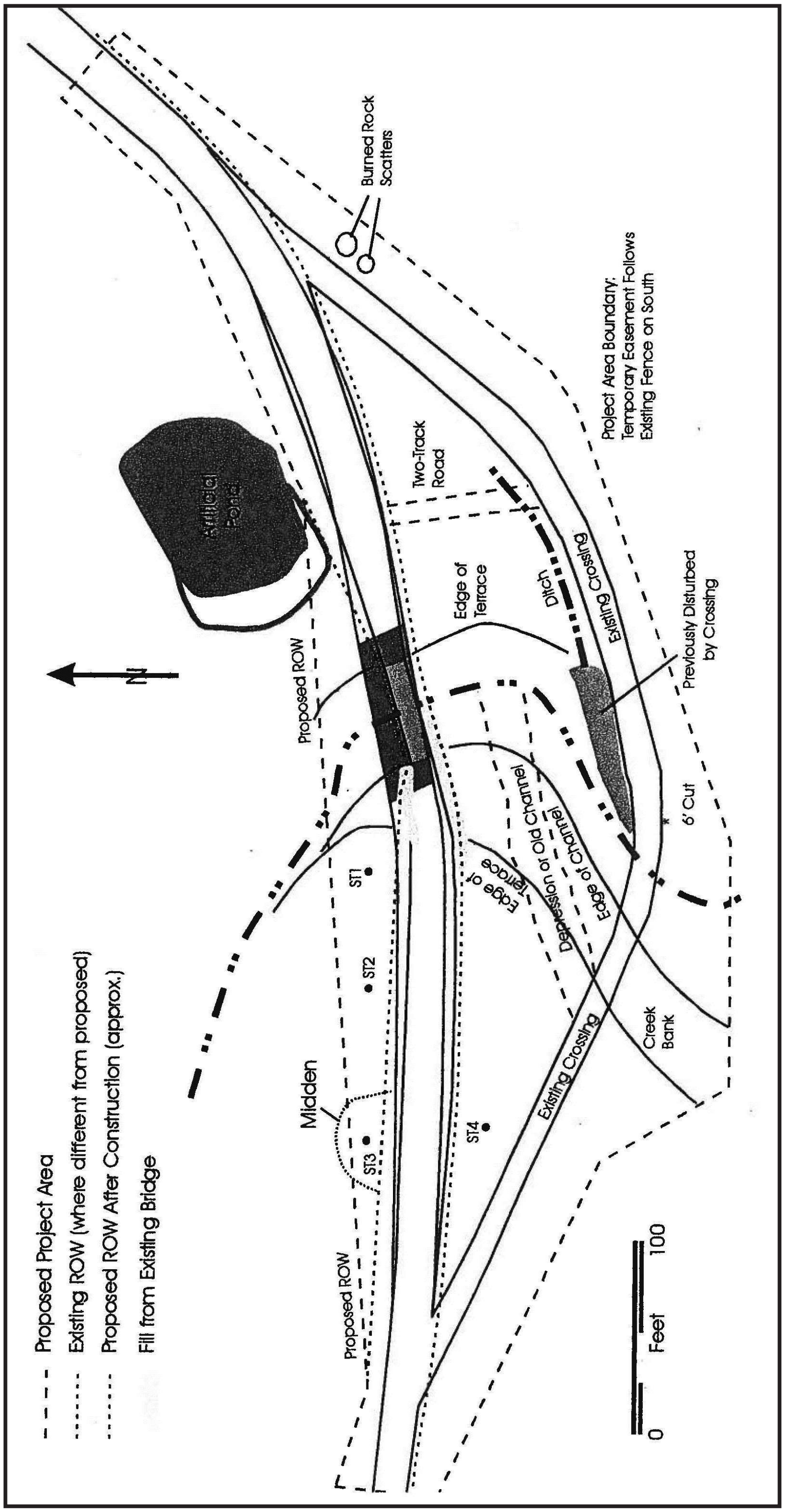

Figure 1-6. TxDOT plans for project area, land alterations, and location of four shovel tests and presumed burned rock midden.

Table 1-1. Data Concerning the TxDOT Shovel Tests.

Shovel Test No.	Depth Dug (cmbs)	Artifact Results	Comments
1	100	1 flake	flake 35-40 cmbs, red clay at 80 cmbs
2	100	2 flakes, several burned rocks	artifacts between 60-70 cmbs
3	20	layer of burned rocks	Rocks 20 to 30 cmbs
4	60	12 flakes	Flakes between 20-60 cmbs

Figure 1-7. Burned rocks at base of Shovel Test 3 in the T_2 alluvial terrace.

NRHP or for designation as State Archeological Landmark (SAL).

TxDOT also recommended that two intact areas west of the creek within the project area did contribute to the site's eligibility for inclusion in the NRHP and for designation as an SAL. These areas were the wedge of land between the county road and the low water crossing, plus the proposed new right-of-way north of the county road, containing the presumed burned rock midden at ST 3. The presumed midden appeared undisturbed and to have potential to yield information important to prehistory, in accord with the research issues outlined in Black et al. (1997). The portion of 41MI96 in the intact wedge, south of the presumed midden, was also thought to contribute to site eligibility because it appeared to have intact artifactual deposits and potential to provide complementary off-midden data. It was recognized that impacts to the wedge area south of the county road, which is privately owned, might be avoidable during construction. The THC concurred with TxDOT's recommendations presented in their letter of April 9, 1999 (Kenmotsu and Ellis 1999).

Subsequently, in May 1999, TxDOT staff archeologist Dr. G. Lain Ellis, serving as Principal Investigator, submitted a Texas Antiquities Permit application with an attached research design to the THC to perform a data recovery investigation at 41MI96. The research design centered on the presumed burned rock midden at ST 3 and presented hypotheses and research issues related to burned rock middens. As stated in the research design these issues included: a) midden structure and evolution; b) midden function as related to subsistence practices; c) chronology; d) burned rock cooking technology, and e) the nature of off-midden areas. Following the presentation of these issues, a data recovery strategy was presented by Dr. Ellis that included:

1) Scraping the surface to expose the top of the midden;
2) Mechanical excavation of a trench parallel to the road, through the midden, to obtain a cross section profile;
3) Photo-documentation and mapping of the cleared surface of the midden, and the midden profile/internal structure;
4) Recording and sampling of any sub-features observed on or in the midden;
5) Mechanical removal of overburden above any extra-midden features observed followed by manual exposure/excavation of features and immediate adjacent areas using 1-by-1 m units dug in 10 cm levels and screening of excavated fill through 6.25 mm mesh, plus collection of feature fill for flotation;
6) Collection of column samples of midden matrix for flotation and macrobotanical studies, radiocarbon dating, and geoarcheological evaluation;
7) Removal, counting and weighing all burned rocks present in the column samples;
8) Collection and mapping of all diagnostic artifacts observed on the surface of the midden, and/or within the midden;
9) Should trenches in the extra-midden deposits reveal evidence of well stratified deposits that could not be adequately sampled via the above methods, TxDOT would consult with THC about the need for additional manual excavation (Ellis 1999, Texas Antiquities Permit application).

Following TxDOT data recovery excavations of 5.5 m^3 at 41MI96, a four page letter report with six figures, one table, and a three page geoarcheological attachment by James Abbott, with accompanying figures, was prepared by G. Lain Ellis and submitted to THC on June 18, 1999. The letter briefly described the fieldwork and the initial findings, and requested concurrence with TxDOT's conclusion that the 5.5 m^3 of manual exaction from sixteen 1-by-1 m units in two blocks (1 and 2) showed that the deposits had very limited potential to yield data relevant to history or prehistory. TxDOT argued that the low stratigraphic integrity of the deposits and the limited array of artifactural and ecofactual materials did not contribute to the site's eligibility for inclusion in the NRHP or for designation as a SAL. THC concurred with TxDOT's recommendations on June 23 1999.

1.5 CONTENTS OF REPORT

Following this introductory chapter, Chapter 2.0 presents an overview of the modern/historical natural environment and regional paleoclimate at the projected time of the prehistoric occupations at 41MI96. Chapter 3.0 provides a regional overview of the Late Archaic period for central Texas assumed to be represented by the majority of the cultural remains encountered at 41MI96. Chapter 4.0 presents four general research questions used to guide and direct the analyses and discussions of the findings from the excavated burned rock features. Chapter 5.0 describes the field methods implemented in 1999 by TxDOT archeologists, the initial TxDOT laboratory work, plus the subsequent 2012 TRC laboratory and analytical techniques employed to generate data from the TxDOT findings. Chapter 6.0 presents the comprehensive information gathered from the field investigation and the subsequent laboratory analyses. Chapter 7.0 addresses the individual research questions presented in Chapter 4.0. Chapter 8.0 presents a summary and makes recommendations. These chapters are followed by a list of the references cited throughout the document. Finally, a glossary of technical terms used in this report that may not be familiar to all potential readers is presented.

Five appendices are presented following the glossary. These provide detailed data by technical experts who served as consultants on this project. Appendix A provides laboratory reports from Beta Analytic Inc. on the radiocarbon dates obtained from the materials submitted, the procedures used in the dating process, and the various calculations for the dates. Appendix B contains the processing procedures and individual results of the high-powered microscopic lithic use-wear analysis performed on 15 stone tools by Dr. Bruce Hardy. Appendix C presents the detailed procedures, handling, and individual results for 20 burned rocks and 20 stone tools subjected to starch grain analysis by Dr. Linda Perry. Appendix D provides the laboratory procedures and results on the 20 burned rocks subjected to lipid residue analysis by Dr. Mary Malainey and Timothy Figol. Appendix E is the "TxDOT Lithic Protocol Version 2.1, Chipped Stone Analytical Protocol" that was followed during lithic analysis.

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2.0 ENVIRONMENTAL BACKGROUND

Robert A. Ricklis

2.1 INTRODUCTION

41MI96 is situated on the T_1 and T_2 terraces above Crooked Run Creek, a small tributary stream of the Colorado River in Mills County, Texas. The site is approximately 1 km west of a broad, north-trending meander loop of the Colorado, near the western edge of the floodplain and the base of higher upland terrain comprised of a plateau made up of sandstones of the Pennsylvanian Strawn group (Figure 2-1). Although technically north of the extensive Cretaceous limestones of the Edwards Plateau, the uplands to the north and west of the Colorado River floodplain are physiographically and biotically similar to those of the Plateau proper. Mills County is generally listed among those central Texas counties that are commonly included within the Edwards Plateau (Texas Parks and Wildlife Department, accessed online 5/6/2012). Johnson and Goode (1994, 1995) consider Mills County as part of the eastern Edwads Plateau in reference to past vegetation and climate changes. 41MI96 is situated close to the interface of at least two major biotic provinces, the Balconian and the Kansan (Blair 1950), and is near the boundary between the physiographic areas of the Edwards Plateau and the Rolling Plains of north-central Texas (see Figures 2-2 and 2-3).

2.2 CLIMATE

Climatically, Mills County is characterized as warm-temperate. Winters tend to be mild, though punctuated by recurrent cold spells resulting from southward-moving continental cold fronts. Summers are generally long and hot. Average annual low and high temperatures in Mills County are 1.1°C (34°F) in January, and 30.6°C (87°F) in July, respectively (Hunt and Leffler, accessed online May 1, 2012). Precipitation falls almost exclusively in the form of rain, as snowfall is a rare occurrence. Annual average precipitation is around 68.6 cm (27 in), adequate to maintain essentially perennial ground cover of grasses and trees. Due to a clinal gradient in average annual precipitation in Texas from east to west, 41MI96 is in an environment drier than the coastal plain to the east and moister than the western part of the Edwards Plateau (Figure 2-4).

2.3 HYDROLOGY

As noted above, 41MI96 is located approximately 1 km west of the Colorado River. With headwaters far to the northwest in the Texas panhandle, and its mouth at the Gulf of Mexico shoreline, the Colorado is the longest (1,387 km) river entirely within the boundaries of Texas. As such, it would have provided prehistoric people with a ready means of transportation and potential access to resources from a wide range of environmental zones across the state. Additionally, the river would have served as an important source of aquatic food resources. Crooked Run Creek, the small tributary of the Colorado River next to which the site is situated, flows intermittently and therefore may not have been a reliable source for such resources.

2.4 GEOLOGY AND SOILS

The site is located near the boundary between the extensive Cretaceous limestone bedrock of the Edwards Plateau and the older sandstone bedrocks that extend to the west and underlie the Rolling Plains area of north-central Texas. As noted by Abbott (1999), the bedrock beneath the site pertains to the Strawn Group of Pennsylvanian sandstones. Nodular clasts of chert are abundant in the area, and can be collected from the ground surface in the immediate vicinity of the site (A. Bettis, personal communication 2011). Igneous granitic rocks of Precambrian and Ordovician ages are exposed at the surface of the massive Llano Uplift, located some 30 to 40 km south of 41MI96 and the Colorado River.

Abbott (1999) has identified the soils at and in the vicinity of the site as the Weswood series (citing Clower 1980), a silt loam typical of floodplains in the middle Colorado drainage. Other soils in the area around the site include the Winters, developed in loamy-to-clayey alluvium, and the Throck, Callahan and Bonti soils, found on the slopes and uplands that surround the site. The last three soil types are developed variously on marls, shales and sandstones.

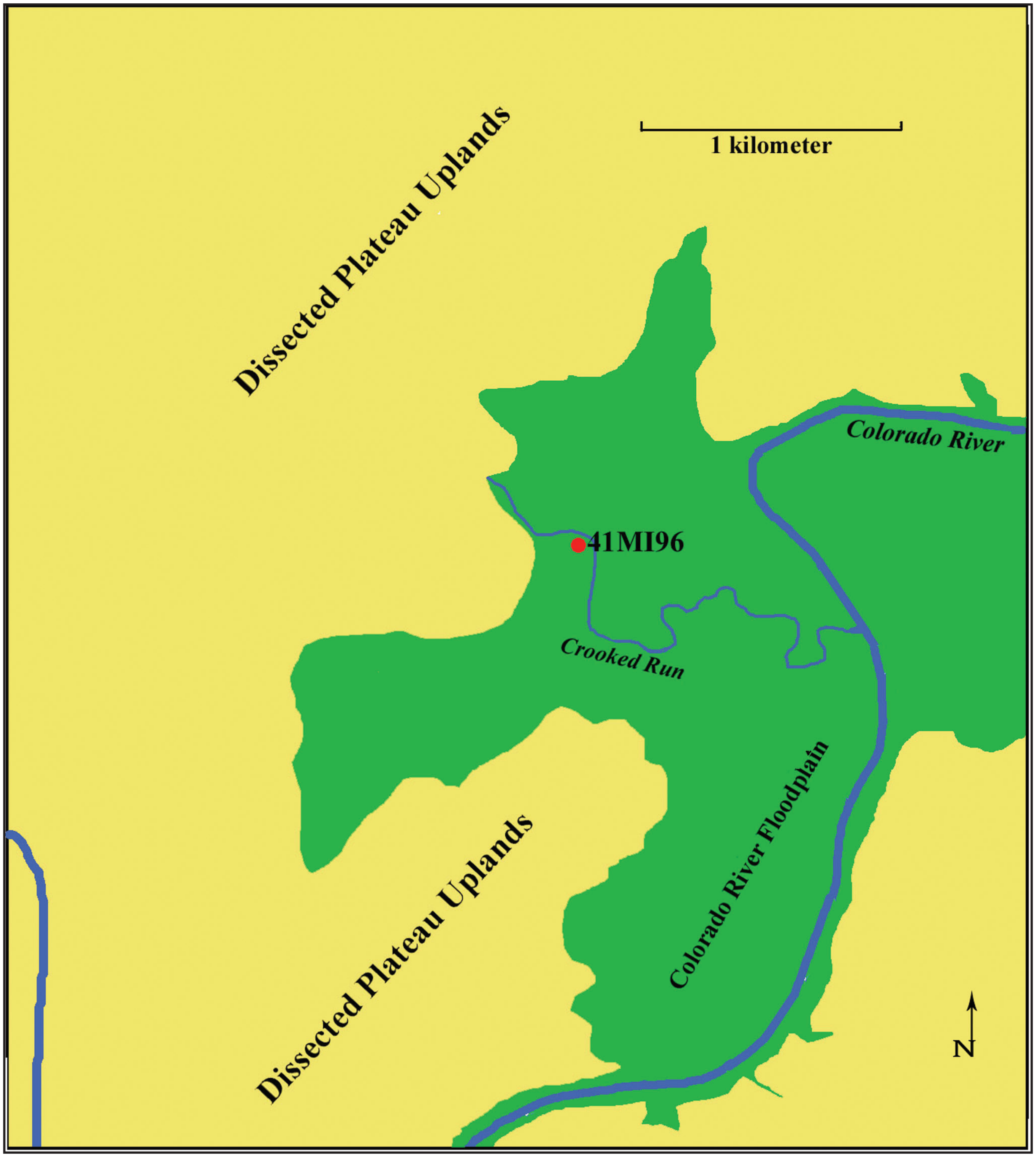

Figure 2-1. 41MI96 location next to Crooked Run Creek, near edge of Colorado River floodplain, at junction with uplands of nearby dissected plateau landform.

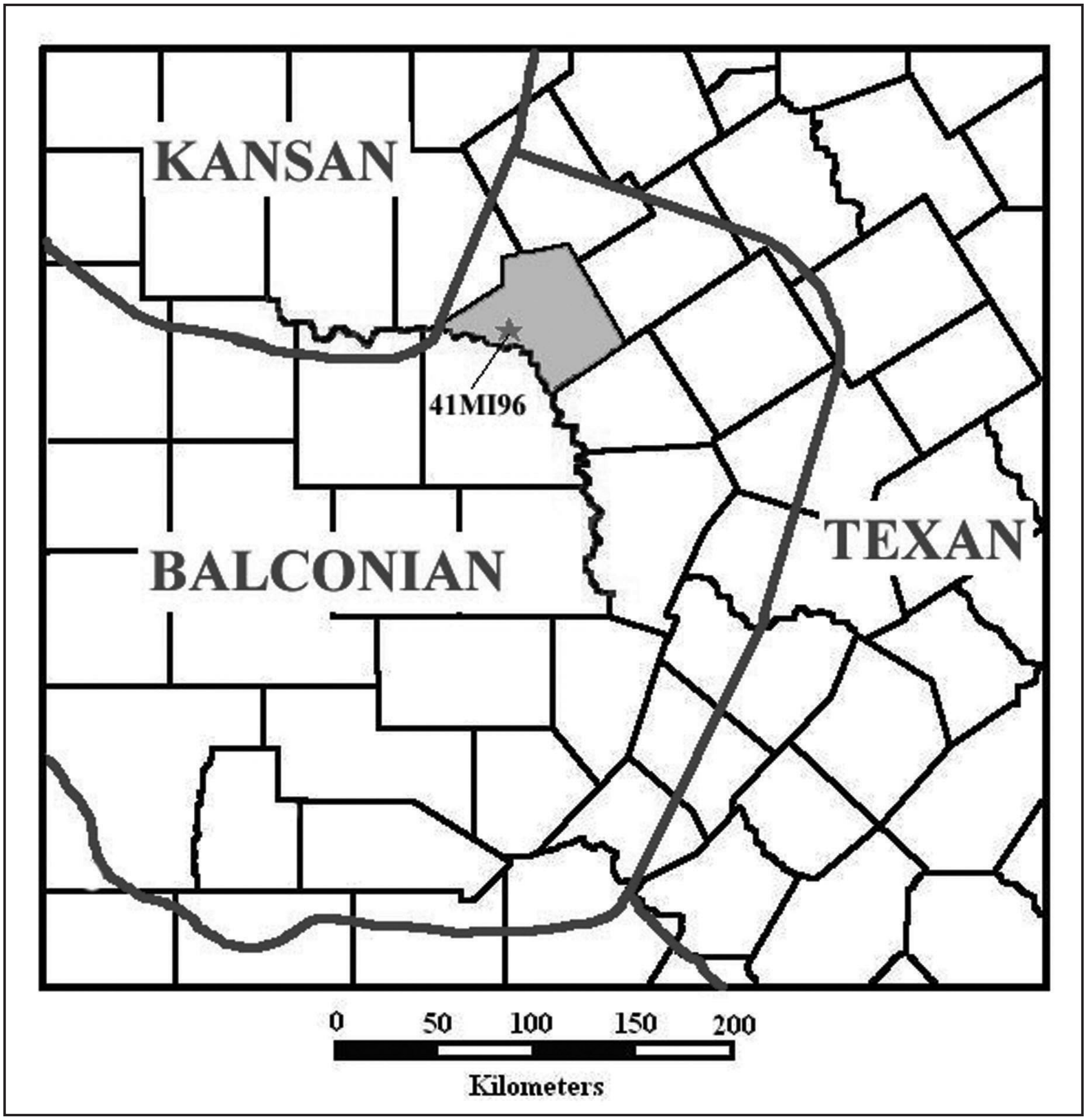

Figure 2-2. Locations of 41MI96 and Mills County (gray-shaded) in relation to central Texas counties and extent of major biotic provinces as defined by Blair (1950).

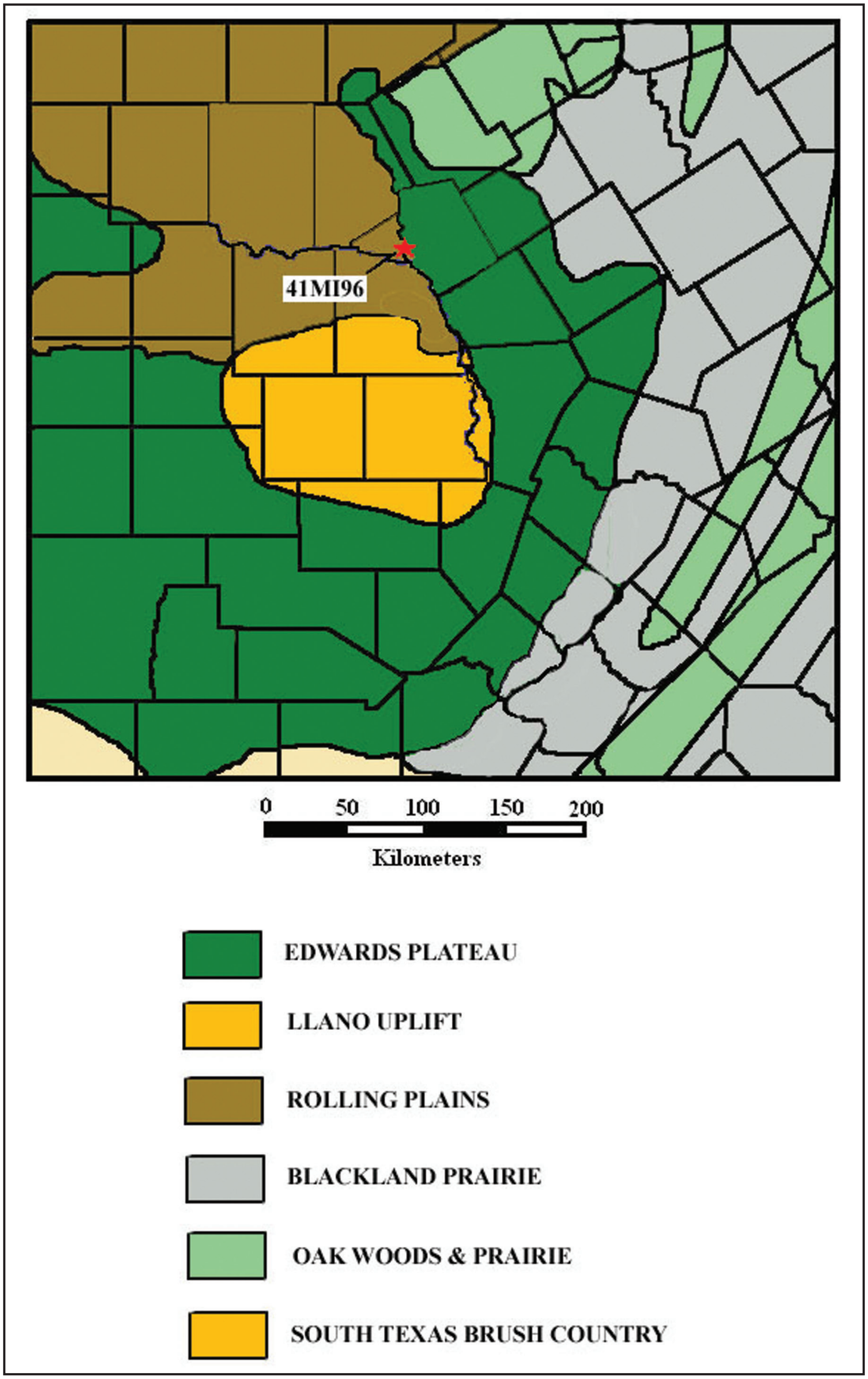

Figure 2-3. Location of 41MI96 in relation to several physiographic/ecological zones within or extending into central Texas area (after map from Texas Parks and Wildlife Department).

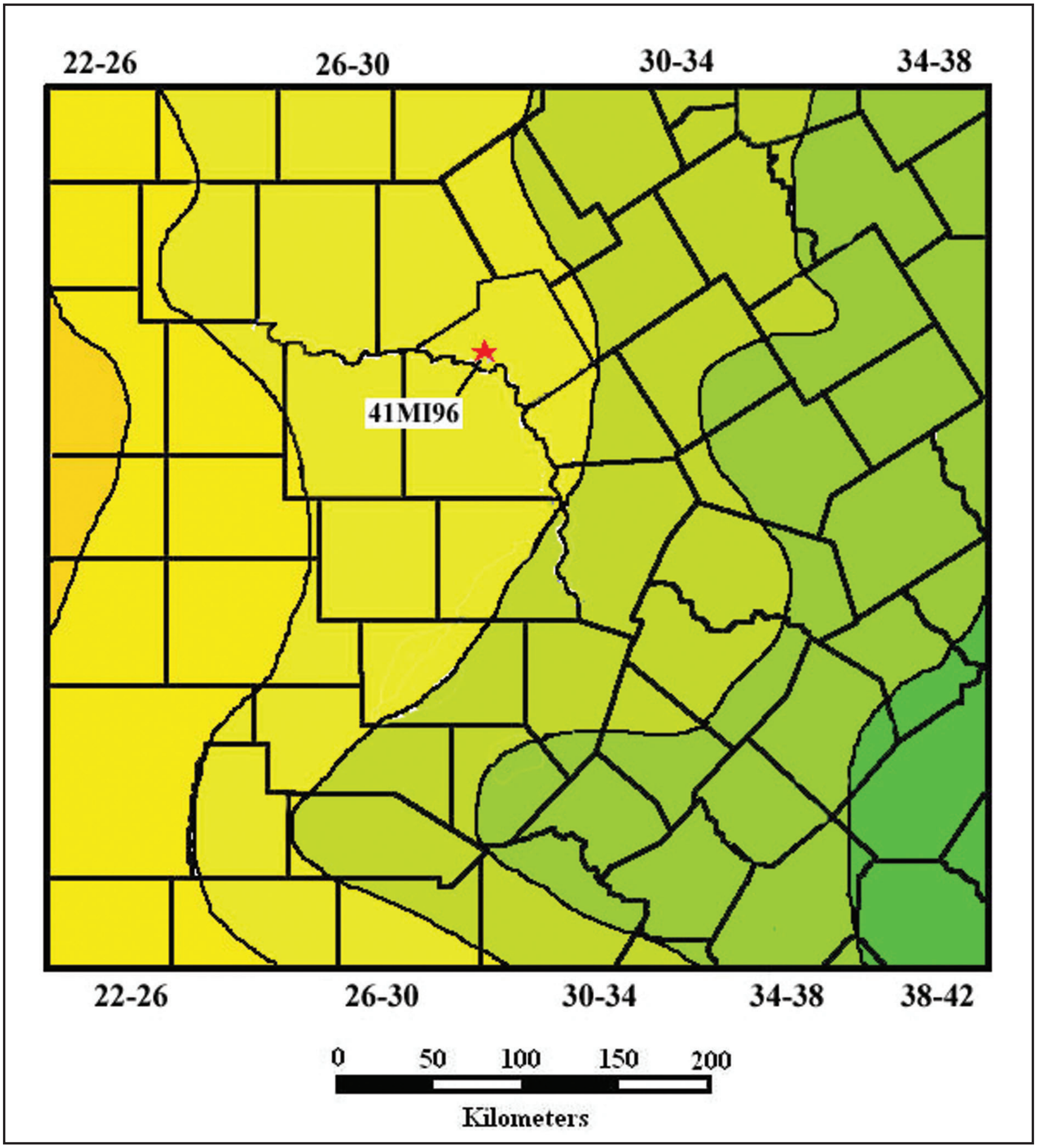

Figure 2-4. Map of the central Texas area showing clinal east-west gradient in average annual precipitation, with location of 41MI96 indicated. From Spatial Climate Analysis Survey (2000).

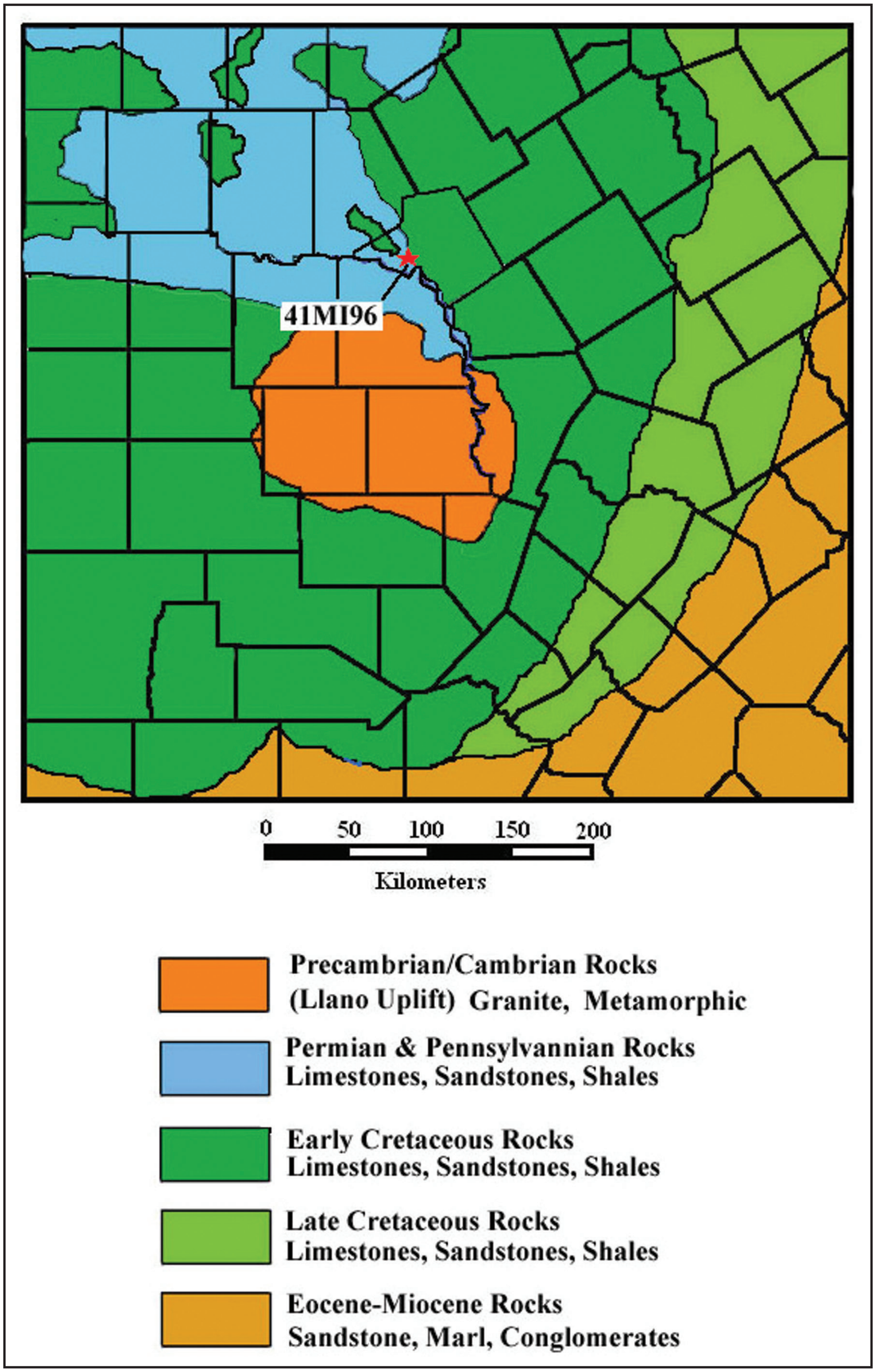

Figure 2-5. Location of 41MI96 and central Texas area with simplified version of the surface distribution of different kinds of rock of varying geologic age (simplified from Renfro et al. 1979).

2.5 BIOTA

2.5.1 Flora

Vegetation typical of the Edwards Plateau includes a variety of grasses and relatively small trees. Grasses include switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), beardgrass (*Bothriochloa* spp.), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), Canada wildrye (*Elymus canadensis*), curly mesquite (*Hilaria belangeri*) and buffalo grass (*Buchloe dactyloides*). Arboreal species include ashe juniper (*Juniperus ashei*), plateau live oak (*Quercus fusiformis*), Texas oak (*Q. texana*), Texas persimmon (*Diospyros texana*), elbowbush (*Forestiera pubescens*), and Texas mountain laurel (*Sophora secundiflora*). Additional plant species include the cacti prickly pear (*Opuntia* spp.) and pencil cactus (*Opuntia leptocaulis*).

On the Rolling Plains, west of 41MI96, native prairie vegetation includes tall and mid-height grasses such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), sand bluestem (*Andropogon halli*), sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), Canada wildrye (*Elymus Canadensis*) and western wheat (*Agropyron smithii*). Trees in this area include mesquite (*Prosopis glandulosa*), shinnery oak (*Quercus harvardii*), and Juniper (*Juniperus* spp.) along the slopes of river channels.

Relatively larger arboreal species are found in the perennially moist bottomlands along the Colorado River. Species include pecan (*Carya Illinoinensis*), elm (*Ulmus Americana*), ash (*Fraxinus* spp.), cottonwood (*Populus* sect. *Aigeiros*) and black willow (*Salix nigra*).

2.5.2 Fauna

Mills County is contained within the Balconian Biotic Province (Blair 1950), which has 57 species of mammal, including the white-tailed deer (*Odocoileus virginiana*), raccoon (*Procyon lotor*), fox squirrel (*Sciurus niger*) and various mice and rats. The American buffalo (*Bison bison*) frequented the area historically, and was present during at least some parts of the prehistoric cultural sequence. Around 400 bird species are known in the Balconian Province. Reptiles include turtles, lizards, and snakes, including western diamondback rattlesnakes (*Crotalus atrox*) and water moccasins (*Agkistrodon piscivorus leucostoma*). The Kansan Biotic Province (Blair 1950), essentially isomorphic with the Rolling Plains region to the west of 41MI96, has minor differences in species of smaller mammals, but would have contained most of the same economically useful plant and animal species found in the Balconian Province.

2.6 PALEOENVIRONMENTAL PARAMETERS

The nature of the environment around 41MI96 during the prehistoric past cannot be assumed to have been the same as is observable in the historic present. While the patterns of environmental change in central Texas are not fully or precisely known, it is clear that there were significant changes in climate since the end of the Pleistocene some 10,000 years ago. Various lines of empirical evidence (e.g., palynological, geostratigraphic, faunal) all indicate significant fluctuations in moisture with marked effects upon overall biotic productivity and resultant changes through time in regional plant and animal communities. Such changes would have directly affected the kinds and quantities of resources available for human exploitation and presumably the adaptive strategies of the region's hunter-gatherer populations. As mentioned elsewhere in this report, the inferred dry period identified as the Edwards Interval (Johnson and Goode 1994), lasting some 2,500 years (ca. 5,00 to 2500 cal B.P.) is thought to have resulted in a proliferation of xerophytic plants across the Edwards Plateau and an increased human reliance on plants such as sotol and agave to meet basic subsistence needs. This may have resulted in a significant intensification of hot rock cooking used to bake these plants and accelerated formation of massive fire cracked rock deposits, known archeologically as burned rock middens, during this period. This sequence of causes and effects is summarized graphically in Figure 2-6.

Given the significance of the postulation of long-term shifts in climatic moisture and its effects on human adaptation and the archeological record, it is worthwhile here to briefly consider the currently available information on Holocene climatic trends for central Texas. It must be noted that the variously proposed models of climatic change are not all in perfect agreement, and that any such review of Holocene climate change cannot account for the full range of variability in moisture and resource availabilities at any given location, due to the complex mosaic of local conditions across the region (see discussion in Ellis et al. 1995).

Here we briefly review several reconstructions of broad patterns of Holocene climate change proposed for central Texas and adjacent areas in recent years. These are based variously on palynological studies (Albert 2007; Bousman 1998 as presented in Collins 2004), micro-faunal analysis (Toomey et al. 1993), and shifts through time in the proportions of C_4 plants during the Holocene (Thoms 2007). Additionally, we refer to a postulated Holocene climate history presented by Johnson and Goode (1994, 1995) that synthesizes a number of different kinds of data, including palynology, microfauna (after Toomey et al. 1993), and geostratigraphic evidence from various locations in and around central Texas.

The studies based upon fossil pollen data are particularly instructive, as they document long-term shifts in species compositions of plant communities directly affected by climatically controlled temperature and moisture conditions. The climatic trends shown in Figure 2-7 are based on pollen sequences from radiocarbon-dated sediment cores from the floodplain of the Guadalupe River near the Buckeye Knoll site (41VT98) in Victoria County (Albert 2007) as well as dated cores from two east-central Texas bog sites (Bousman 1998; Collins 2004). Also compelling is the evidence from Hall's Cave on the Edwards Plateau, where documented changes in the relative abundances of the desert shrew (*Notiosorex crawfordi*) and the more xeric least shrew (*Cryptotis parva*) in the cave's sediment deposits (Toomey et al. 1993) serve as proxy indicators of long-term climate change and resultant environmental moisture levels.

A glance at Figure 2-7 shows that, while none of these five climate-history reconstructions are identical, they all exhibit certain key similarities. In all but one case, extended periods of relatively dry environmental conditions are indicated for the temporal interval between ca. 7000/8000 cal B.P. and ca. 5500 cal B.P., followed by a relatively short interval of moister climate between ca. 5500 and 5000 cal B.P. Between 5000 and 3000 cal B.P., there is another extended dry interval (the "Edwards Interval" of Johnson and Goode 1994, 1995), except in the case of the climate history indicated by long-term shifts in abundances of C_4 plants at the Richard Beene site (41BX831) near San Antonio (Thoms 2007), where the pertinent data suggest that this dry interval lasted until as recently as ca. 1500 cal B.P. he key point, for our present purposes, is that all five

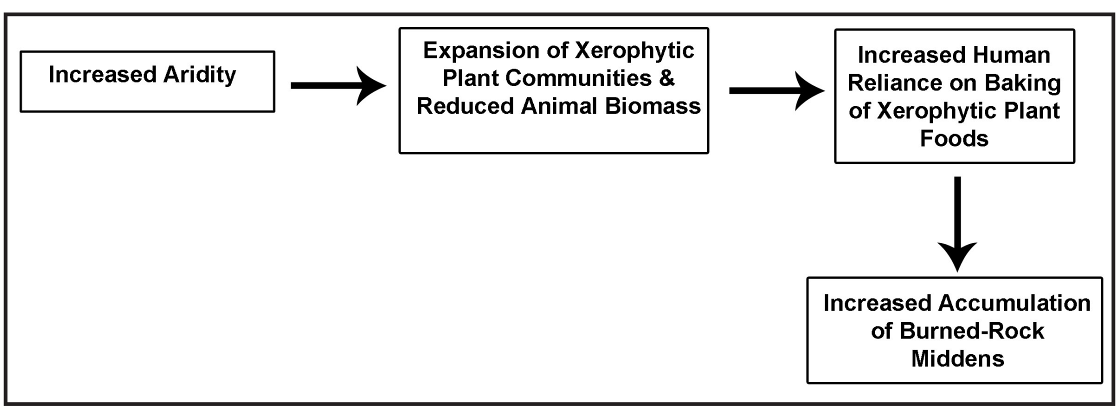

Figure 2-6. Inferred cause-and-effect relationships of climatic conditions, certain human adaptive patterns, and prevalence of burned rock middens in central Texas during the dry Edwards Interval, ca. 5000 to 2500 cal B.P. (ca. 4400 to 2600 B.P.).

reconstructions of Holocene climate history suggest an extended period of relatively dry conditions between ca. 8000/7500 cal B.P. and 5500 cal B.P. and again after ca. 5000 B.P., during a period often thought to have been the 'heyday' of burned rock midden formation (e.g. Weir 1976; Johnson and Goode 1995; Collins 2004). The only exception is the reconstruction offered by Johnson and Goode (1995), wherein the drying trend begins only at, or shortly after, ca. 7000 cal B.P., approximately a millennium later than in the other models. Since, among the various data represented in Figure 2-7, only the Hall's Cave data was available to Johnson and Goode (the east-central Texas bog pollen data was available, but had not yet been adjusted by Bousman [1998]), we are inclined to believe that the longer period of dryness suggested by the other models is probably a more accurate representation, and that it is reasonable, on the preponderance of the evidence, to regard the two-millennia period between 7500 cal B.P. and 5500 cal. B.P. as an interval of sustained, relatively dry climate and correspondingly xeric environmental conditions.

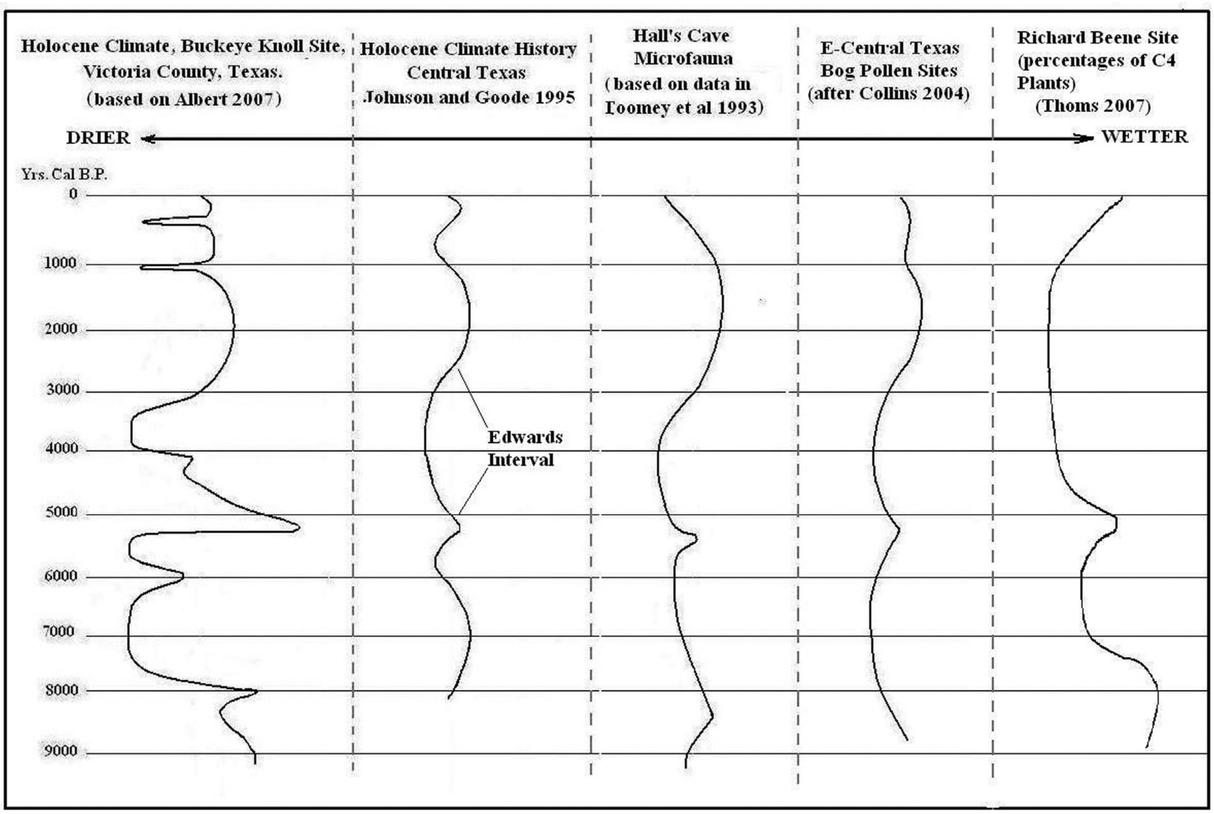

Figure 2-7. Five presentations of basic patterns of Holocene climate fluctuations (relatively dry to relatively moist) based on pollen studies (Albert 2007; Bousman 1998, as summarized in Collins 2004) shifts in microfaunal species in cave deposits (Toomey et al. 1993), and fluctuations in percentages of C_4 plants, based on carbon isotope values (Thoms 2007). The Holocene climate history presented by Johnson and Goode (1994, 1995) draws upon various data sets, including sediment stratigraphies reflective of shifting hydrological conditions believed due to climate change.

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3.0 CULTURAL BACKGROUND: THE LATE ARCHAIC OF CENTRAL TEXAS

Robert A. Ricklis

3.1 CHRONOLOGICAL CONSIDERATIONS

The temporal parameters of the Late Archaic cultural period in Central Texas prehistory have undergone significant changes since the mid-1990s. Although Black and Ellis (1997), in their introduction to a volume on hot rock cooking technology on the Edwards Plateau, referred to the shifting perspectives on the Archaic chronology as "…the usual thrashing and rehashing of culture history systematics…" (Black and Ellis 1997:20), the trend toward a revision of Archaic chronological taxonomy is, in fact, a response to substantive issues relating to regional prehistoric cultural development, and thus merits attention.

As a conceptual baseline, it can be noted that the term 'Archaic' refers to both a stage of cultural development (Willey and Phillips 1958) and a long interval of time (e.g., Black 1989; Collins 2004; Prewitt 1981, 1985). In central Texas, the Archaic is generally viewed as a long temporal interval beginning at the end of the Paleoindian cultural period, ca. 8000 to 9000 B.P. (ca. 6050 to 7050 B.C.), and lasting until ca. 1300 B.P. (ca. A.D. 650). Thus, the Archaic was the longest-lasting major cultural period in the regional cultural sequence, as currently conceptualized. At the most basic level, the Archaic was characterized by human adaptations based on pre-/non-agricultural subsistence economies by relatively small socioeconomic groups of people who practiced residential mobility across the landscape for effective utilization of spatially and/or seasonally variable resources. Archaic residentially mobile hunting and gathering is perceived to be generally distinguishable from the previous Paleoindian pattern as more territorially circumscribed by relatively localized adaptations to opportunities and constraints afforded by post-Pleistocene environmental parameters. Additionally, empirically discernible changes in styles of stone projectile points accompanied the shift from Paleoindian to Archaic lifeways. The typically unstemmed, lanceolate dart forms of the Paleoindian era (e.g., Bousman et al. 2004) gave way to the stemmed/notched dart types that characterize Archaic assemblages (e.g., Prewitt 1981; Collins 2004). It should be noted, however, that the stemmed Wilson type is assigned to the late Paleoindian (Dial et al. 1998; Bousman et al. 2004), while the lanceolate Angostura type is generally thought to pertain to the earliest expression of the Archaic (Prewitt 1985; Collins 2004). The Archaic in central Texas ended ca. 1300 B.P. (ca. A.D. 650) with the introduction of the bow and arrow as the primary weapon system technology, a shift readily recognizable in the archeological record by the presence of relatively smaller, thinner, chipped stone arrow projectile points. This shift did not occur simultaneously across all parts of Texas, as demonstrated in north-central Texas at the Root-Be-Gone (41YN452) site (Quigg et al. 2011a). There, the use of large dart points was documented to overlap with the arrow point users of the Austin phase. Mobile hunting and gathering persisted into the post-Archaic or Late Prehistoric period. Despite the taxonomic distinction between the end of the Archaic and the subsequent Late Prehistoric period, currently available evidence indicates a basic continuity in adaptive patterns into the early part of the Late Prehistoric. Significant changes in adaptation and material culture patterns are not apparent in the archeological record until ca. A.D. 1300, with the introduction of ceramics and an emergent reliance on bison hunting as a mainstay in the subsistence base (e.g., Prewitt 1985; Collins 2004; Johnson and Goode 1995:98-99).

Given the long duration of the Archaic, it is hardly surprising that Texas archeologists have devoted considerable attention to ways to subdivide it into shorter, more conceptually manageable subperiods. Generally, this has been done along the lines of a tri-partite division into Early, Middle, and Late temporal segments.

These chronological subdivisions are, to a significant degree, out-of-synch with the Early, Middle and Late Archaic periods as defined in eastern North America. This disjuncture did not pose much of a problem when Texas archeology was internally focused with building a strictly regional culture chronology and modeling patterns of culture change that took place solely on the Texas landscape. However, with recent realization that Archaic peoples in the Texas region were participating in geographically extensive patterns of cultural development (e.g., Hall 1981; Johnson and Goode 1994, 1995; Ricklis 2011), temporal discrepancies between Early, Middle and Late Archaic periods in Texas and those outside of Texas have become too awkward to ignore.

As a response to this uncomfortable taxonomic incongruity, Johnson and Goode (1994, 1995:90) proposed redefinition of temporal parameters of the central Texas Late Archaic to better align Texas cultural chronology with that of eastern North America. The authors suggest an inferable growth in human population density with corresponding increase in economic efficiency during the Late Archaic in Texas, as generally believed for the Late Archaic in the east. They also recognized, during the latter part of the Late Archaic (Late Archaic II, in their terms), hunter-gatherers in Texas were participating in certain mortuary rituals widespread across eastern North America during the contemporaneous Middle Woodland (Hopewell) period (Johnson and Goode 1994, 1995:96-97). Although no Woodland culture, per se, is identifiable in central Texas, Johnson and Goode believed shared artifact traits, particularly in mortuary contexts on the Texas coastal plain (e.g., Hall 1981, 2002) such as boatstones, stone two-hole gorgets, and large whelk-shell pendants, represent the spread of a Woodland-era religious belief system into Texas (Johnson and Goode 1994, 1995:96). At this time, peoples of the central Texas Edwards Plateau were making corner-tang bifaces from high-quality Edwards chert that were exchanged eastward and incorporated into the same mortuary contexts on the Texas coastal plain.

In light of these considerations, Johnson and Goode (1994, 1995) proposed a revised chronological framework in which the Middle Archaic, originally placed by Prewitt (1981, 1985) between ca. 4600 and 2300 B.P. (ca. 2650 and 350 B.C.), came to be bracketed between ca. 5600 and 4400 B.P. (ca. 3650 and 2450 B.C.). This interval produced projectile point types previously considered markers of Jarrell and Oakalla phases of Prewitt's Early Archaic such as Bell/Andice and Taylor/Baird/Early Triangular. Johnson and Goode consider the Late Archaic to begin ca. 4400 B.P. (ca. 2450 B.C.) and divided into two subperiods: Late Archaic I, 4400 to 2600 B.P. (ca. 2450 to 650 B.C.), and Late Archaic II, ca. 2600 to 1400 B.P. (ca. 650 B.C. to A.D. 550). The Late Archaic I is marked by a major climatic dry phase which they termed the Edwards Interval. The attendant emphasis on hot rock baking of xerophytic plant foods such as sotol and yucca resulted in increased formation of burned rock middens, as well as a proliferation of stone grinding implements used to process plant foods, as well as a sequence of dart point types such as Bulverde, Pedernales, Marshall, and Montell (Johnson and Goode 1994, 1995:92). The Late Archaic II saw climatic amelioration toward moister conditions and a sequential shift in dart point types. Marcos points were superseded by Ensor and Frio points, in turn replaced by Darl points, the last type in the long sequence of central Texas Archaic point types. Burned rock midden formation continued, but less abundantly than during the previous Late Archaic I period (Johnson and Goode 1994, 1995:94-95), as geographic ranges of xerophytic plants cooked in them receded westward.

The revised Archaic chronology put forth by Johnson and Goode (1994, 1995) has received much acceptance among Texas archeologists. Black and Ellis state they:

> *…follow Johnson's revised periodization of the post-chronological sequence for post-Paleoindian central Texas because… the more finely divided phases proposed by Prewitt (1981, 1985) are problematic in many regards. We consider the revised framework to be more accurate because it is more generalized [Black and Ellis 1997:20].*

In his summary overview of central Texas prehistory, Collins' (2004) chronological taxonomy closely follows that proposed by Johnson and Goode (1994, 1995). He places the beginning of the Late Archaic at ca. 4000 radiocarbon years B.P. (or ca. 2050 B.C. when calibrated) and the terminus at ca. 1200 B.P. (ca. A.D. 700/800), essentially the same temporal parameters set forth by Johnson and Goode. Collins does not divide the Late Archaic into formal subperiods. He presents a six "style interval" temporal sequence within the generalized period, marked by temporally diagnostic dart point types (Collins 2004:121):

Bulverde	4000 to 3400 B.P.
Pedernales, Kinney	3400 to 2400 B.P.
Lange, Marshall, Williams	2400 to 2000 B.P.
Marcos, Montell, Castroville	2000 to 1600 B.P.
Ensor, Frio, Fairland	1600 to 1300 B.P.
Darl	1300 to 1100 B.P.

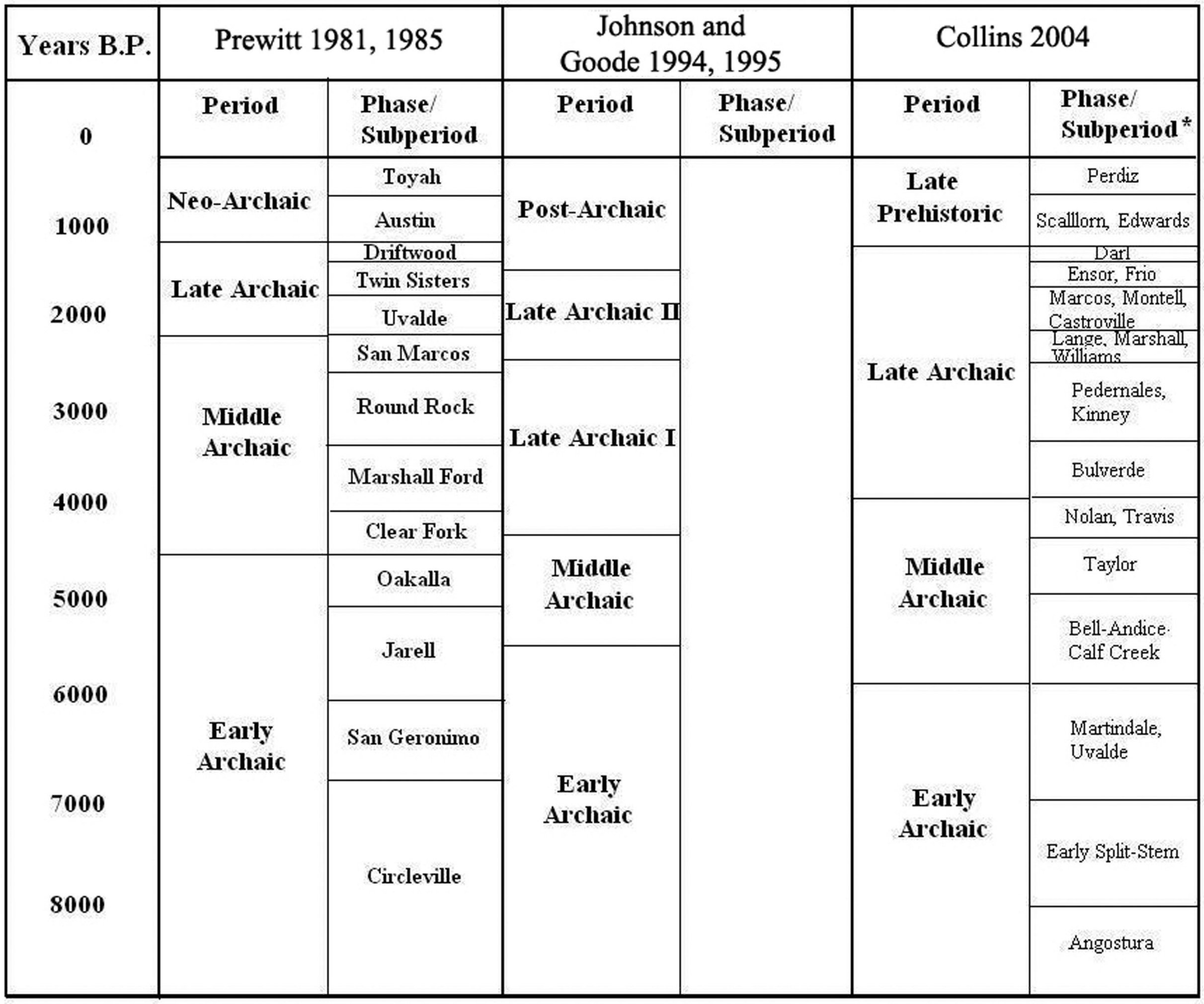
As suggested by Johnson and Goode (1994, 1995), Collins posits burned rock midden accumulation peaked during the Late Archaic segment marked by Pedernales points, dating to ca. 3400 to 2500 B.P., declining by ca. 2500 B.P. due to increasingly moist conditions and a resultant decline in xerophytic plants and hot rock baking activities in the eastern part of central Texas. Collins (2004) and Johnson and Goode (1994, 1995) note burned rock midden formation continued more or less unabated into Late Prehistoric times in the drier, western portion of the Plateau, although declining along the Balcones Escarpment and on the eastern portion of the Edwards Plateau at this time. The chronological divisions of the Archaic proposed by previous authors are shown graphically in Figure 3-1.

3.2 CHANGING CLIMATE AND ADAPTIVE RESPONSES IN THE CENTRAL TEXAS LATE ARCHAIC

As mentioned, Johnson and Goode (1994, 1995) and Collins (2004) suggested peak intensity in hot rock cooking of xerophytic plants that resulted in the proliferation of burned rock middens during the dry Edwards Interval of Late Archaic I times, a suggestion also put forth in summary of the regional prehistoric cultural sequence. These authors further indicate a general decline in these kinds of subsistence activities during the latter part of the Late Archaic and into the early part of the Late Prehistoric period, as climate became more moist and there was a general westward contraction in the ranges of targeted xerophytic plants such as agave and sotol (Johnson and Goode 1994, 1995; Collins 2004:121). Pedernales point association with the peak period of burned rock midden formation is also strongly suggested by Frank Weir's (1976) analyses, which indicated the Pedernales dart point was the type most abundantly represented in central Texas burned rock middens.

Black and Creel (1997) present a contrary view, based largely on radiocarbon dating of several burned rock middens more than 100 km west of the Balcones Escarpment. They take exception to the idea that there was a "Pedernales heyday" in the evolutionary development of hot rock cooking technology and burned rock midden formation, and suggest intensive use of that technology continued through Late Archaic and Late Prehistoric periods. They see burned rock middens as a long-lived tradition representative of more semi-sedentariness than generally recognized, ending only with the forceful incursion of mounted Plains raiders and introduction of demographically calamitous Old World diseases into central Texas during Protohistoric times in the seventeenth century (Ibid:302). In making this argument, Black and Creel assert that materials of the Late Prehistoric Toyah interval (ca. 700 to 250 B.P. or A.D. 1250/1300-1700) represent burned rock midden use/formation. However, Ricklis and Collins (1994), see the Toyah materials at 41HY209-M, the midden functionally, as unrelated overprints upon the remains of earlier human activities.

In effect, there are currently two competing interpretations of the basic history of burned rock midden use in central Texas, with different implications for modeling Late Archaic lifeways. One view, as articulated by Johnson and Goode (1994, 1995) and Collins (2004), sees a peak in burned rock midden formation and inferred intensity of hot rock baking of starchy xerophytic plant foods during the period defined as the Late Archaic I by Johnson and Goode. These authors acknowledge burned rock middens accumulated both before and after this period. However, they view the peak intensity of use and accumulation as representing a shift toward greater reliance on such plants during the Edwards Interval, an extended period of relatively dry climate in central Texas that peaked during Late Archaic I times. Black and Creel (1997), on the other hand, suggest that burned rock middens continued to proliferate through the Toyah Interval of Late Prehistoric times, and hot rock cookery remained as important during the Late Archaic II



* Note that Collins divides the major cultural periods according to predominant projectile point types, as shown here.

Figure 3-1. Chronological division of the central Texas Archaic, as defined by Prewitt (1981, 1985) and revised by Johnson and Goode (1994, 1995), and essentially reiterated by Collins (2004).

period as it had been in the preceding Late Archaic I. In summary, one perspective on burned rock use sees the Late Archaic II as a period during which basic subsistence economy was shifting away from intensive exploitation of xerophytic plant resources. Presumably, this resulted in greater emphasis on a different set of plant foods and perhaps an increasing importance for the consumption of meat from hunted animal species. The alternative view presented by Black and Creel (1997) implies relatively less change in economic patterns during the Late Archaic II, with continued intensive hot rock cooking of starchy xerophytic plant foods. The contrast between these two perspectives is summarized graphically in Figure 3-2.

It is our view that the verdict has yet to be decided as to which of these competing hypotheses is correct. It is certainly true that burned rock middens continued to accumulate through the latter part of the Late Archaic (e.g., the burned rock midden at 41HY209-M near the Balcones Escarpment in Hays County, which yielded a predominance of very Late Archaic dart point types such as Ensor, Fairland, and Darl referenced by Collins (1994). However, the case made by Black and Creel (1997) is questionable on at least two counts. First, those authors place considerable emphasis on the prevalence of relatively recent radiocarbon dates on charcoal collected from burned rock middens in central Texas (Black and Creel (1997). While the dates do tend to fall toward the latter end of the regional cultural sequence (see Black and Creel 1997, Figures 133-136), it is possible that this pattern reflects preservational bias, thus favoring recovery and dating of more recent charcoal, with the resultant skew that more recent periods are overrepresented. Black and Creel (1997) acknowledge the factor of preservational bias, but downplay the implications. They point out the use of the AMS technique for dating charcoal from burned rock middens has yielded higher proportions of relatively early dates on much smaller samples of charcoal than are suitable in conventional radiocarbon dating. The implication is the frequency of older episodes of midden use/formation is therefore more accurately represented despite the breakdown/deterioration of charcoal over time.

The potential fallacy in this line of reasoning is, of course, AMS dating cannot produce results from any charcoal that no longer exists due to complete disintegration over time. Thus, there is no way to control for bias introduced by preservational factors, which renders doubtful assumptions of one-to-one correlation between the number of radiocarbon dates obtained from middens and the interpreted timing of maximum midden accumulation. In this light, it is reasonable to believe temporally diagnostic lithic artifacts, inherently less perishable, may be more

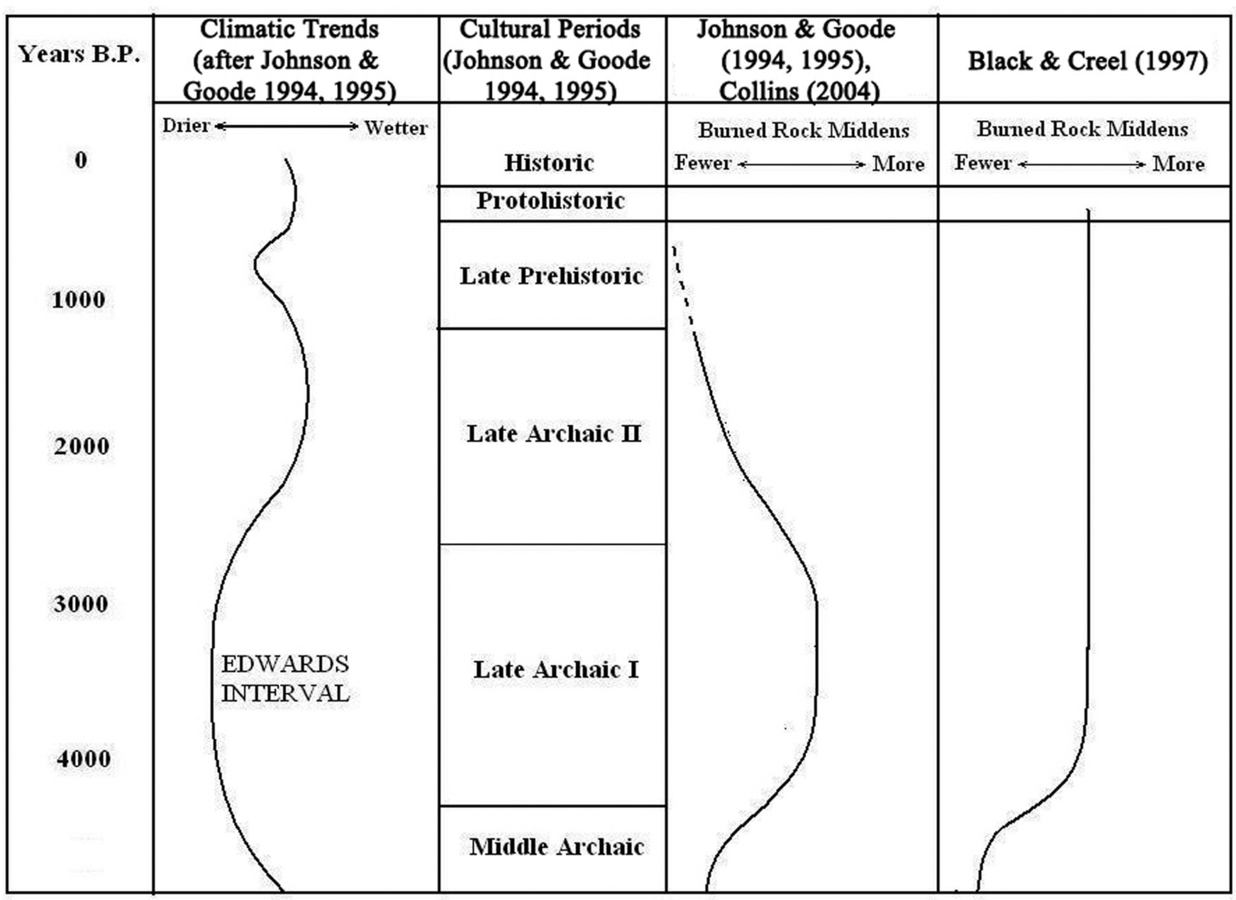


Figure 3-2. Schematic illustration of contrasting interpretations of intensity of burned rock midden formation through time in central Texas, as presented by Johnson and Goode (1994, 1995) and Black and Creel (1997). Note that Johnson and Goode suggest peak in midden formation corresponds with dry climatic period they refer to as the Edwards Interval.

reliable indicators of fluctuating intensity of midden use/formation than dating more perishable organic materials.

The second reason for questioning the model proposed by Black and Creel (1997) is their inferences are based largely on data from burned rock midden localities in Mason, McCulloch, and Uvalde counties, all situated more than 100 km west of the Balcones Escarpment at the eastern margin of the Edwards Plateau. Black and Creel (1997) found appreciable evidence of occupation of the pertinent sites during the Late Prehistoric period. However, these locations may be far enough west to have experienced significantly drier climatic conditions persisting substantially later in time than the eastern portion of the Plateau. Thus, even if the late materials at these sites do represent occupations involving the same sort of intensive hot rock cooking as earlier occupations, such localized factors should not be assumed to have uniform applicability throughout the central Texas region. This perspective was anticipated by Johnson and Goode (1994, 1995), who stated:

> *…burned-rock middens were much more abundant on the eastern Edwards Plateau in Late Archaic I times than in any other period. Nevertheless, in far western Texas as well as in Mason, Kerr, and Uvalde counties [areas that continued to experience fairly xeric conditions long after this dry period], burned-rock middens commonly accumulated also in Late Archaic II and Post-Archaic days…. But on the eastern Plateau proper, fewer burned-rock middens built up than during the Late Archaic I period, and became less common than in the west [Johnson and Goode 1994:33, 1995:94].*

3.3 THE QUESTION OF INTRA-SITE FEATURES DURING THE LATE ARCHAIC

Following long-term trends proposed by Johnson and Goode (1994, 1995) and Collins (2004), the Late Archaic (ca. 4000 to 1200 B.P. or 2050 B.C. to A.D. 700) can be defined as approximately three millennia wherein hunter-gatherers of central Texas shifted away from intensive emphasis on hot rock baking of sotol and other xerophytic plants toward a more generalized foraging strategy of more mesic plant resources and animal resources. This corresponded to a gradual shift to more mesic climatic conditions between ca. 3500 and 2500 B.P. (1550 to 550 B.C.).

It may be reasonable to infer a shift in resource use and cooking techniques should result in a discernible, correlated shift in the kinds of cooking facilities (i.e., archeological features) during this cultural period. There should be a reduction in the frequency and accumulation rate of burned rock middens, given that these features are believed to represent an intensive focus on the baking of xerophytic plants. As noted above, Johnson and Goode (1994, 1995) believe this to be the case, and suggest, a proposed 'heyday' of midden formation during the Pedernales interval of Late Archaic I times and a following reduction in burned rock midden formation during their Late Archaic II period. While Black and Creel (1997) have argued that there was in fact no 'Pedernales heyday', Collins (2004) has re-asserted that "Middle Archaic subsistence technology and associated burned rock middens continue well into the Late Archaic. During his second style interval (best known for its Pedernales points), he asserts the growth of burned rock middens was at its greatest, especially for the eastern parts of the area [of central Texas]" (Collins 2004:121).

Collins (2004:121) closely echoes Johnson and Goode (1994, 1995) in stating a correlative climatic shift accompanied this change in resource use and attendant cooking technology, and the Late Archaic "…began as effective moisture was at its lowest in central Texas (Johnson and Goode's Edwards Interval) but gradually the climate became more mesic" (i.e., during Johnson and Goode's Late Archaic II)."

If Collins' inferences are correct, fewer burned rock middens should be present on sites of Late Archaic II age, as compared to sites of the Late Archaic I period and the latter part of the Middle Archaic (i.e., Collins 1995, Nolan/Travis style interval). Additionally, it should be reasonable to expect a decrease in large thermal features and associated midden deposits used to bake xerophytic plant foods and a corresponding increase in small burned rock cooking features best suited to other forms of hot rock cooking such as boiling and grilling (see Ellis 1997 for different kinds of cooking features).

At this time, archeologists have yet to reliably distinguish systematically patterned attributes of thermal features according to their different functions. Numerous relatively small non-midden burned rock features have been excavated and documented in Late Archaic contexts. Various researchers have defined morphological distinctions between different types of these features (e.g., Collins 1994; Kleinbach et al. 1995; Abbott et al. 1996; Black 1997; Ellis 1997; Mahoney et al. 2003; Thoms and Clabaugh 2011); no consistent classification has been attained at a regional scale. Consequently, it is presently not possible to assess the relative degree of emphasis placed on differing food preparation techniques based on reported feature types, or by inference, particular types of plant and/or animal resources cooked within them. The numerous small-to-medium-sized clusters of burned rocks found in any given archeological context are sometimes given only the functional designation of 'hearths' (e.g., Mahoney et al. 2003), while in other instances interpreted as discard locations of expended burned rocks, or as the remains of 'earth ovens' or grilling platforms (e.g., Kleinbach et al. 1995; Abbott et al. 1996). It was interpretive ambiguities such as these that, over 20 years ago, led Collins (1991) to advocate for a program (detailed analyses) of micro-analysis of burned rock features. It is probable that only through consistent acquisition of micro-scale data (e.g., on lipid residues, starch grains, phytoliths, etc.) of individual features will result in a cumulative database that will permit confident correlations concerning feature size, morphology and function. Such studies may eventually permit accurate modeling of long-term trends in resource processing and utilization, and correlations between those trends and fundamental patterns of climatic and environmental change.

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4.0 RESEARCH QUESTIONS FOR 41MI96

Robert A. Ricklis, J. Michael Quigg, and Paul M. Matchen

4.1 INTRODUCTION

The following research questions were written in September 2011 to guide the data analyses and reporting. These questions were approved by TxDOT and specific technical analyses were selected and implemented to collect specific data to address these. At the time these were written, the stratigraphy at each of the two excavated blocks was not clear, but the field maps for Block 1 showed a number of small, intact burned rock features, whereas the data from Block 2 was apparently out of context. Consequently, at that time the questions were directed at what appeared as intact heating/cooking elements in Block 1 and so targeted in the subsequent analyses.

4.2 QUESTION 1: SITE CHRONOLOGY

41MI96 consists of remnants of prehistoric human occupation(s), primarily in the forms of abundant fragments of burned rocks (mainly sandstone) and chert debitage, resting within Holocene alluvial terrace deposits along Crooked Run, a small tributary of the Colorado River (Abbott 1999). Formal lithic tools, including time-diagnostic projectile points, are scarce, as are faunal and other organic remains. The sole reported time-diagnostic artifact from the site is a Marcos dart point (Ellis 1999), a type attributed to the Late Archaic period of central Texas and estimated to date to ca. 2500 to 1750 B.P. (ca. 600 B.C. to A.D. 200; Turner and Hester 1999:147; see also Prewitt 1985; Collins 2004; Collins et al. 2011).

The natural stratigraphy that contains the archeological remains is marked by two geologic units. Unit 1, the lower and older of the two, is estimated to date to the early-to-middle Holocene (Abbott 1999). This unit underlies the T_2 terrace on which the western and topographically higher portion of the archeological site is situated. Unit 2 comprises the T_1 terrace adjacent to the Crooked Run channel, and extends westward to drape over Unit 1. Cultural materials at 41MI96 were apparently confined to Unit 2.

The Marcos point (now reclassified as a hafted biface) was recovered from Level 4, next to Feature 4 in Test Unit 1 in Block 1 (Test Units 1, 7 through 16 or 11 m^2) near the contact between two major geologic strata, designated Unit 1 and Unit 2 (with Unit 1 the oldest and underlying Unit 2). The point rested within the lower part of Unit 2 at a stratigraphic position that was also marked by a vertical concentration of burned rock fragments. Hand-excavations conducted by TxDOT in Block 1 revealed discrete concentrations of burned rocks that were identified as cultural features in the forms of basin-shaped hearths and flat, “griddle-like” elements, as opposed to a more extensive burned rock midden that had initially been expected (Ellis 1999) and potentially was represented in Block 2.

While the presence of the Marcos point at a vertical position that is marked by abundant burned rock indicates that most, if not all, of the materials (including burned rocks and debitage) recorded at this stratigraphic location may represent a Late Archaic occupation at Block 1 in the site, the general paucity of diagnostic artifacts and the current lack of previous radiocarbon dates do not allow for confident assertions concerning the age or cultural affiliations of occupation. We suggest, however, that a primary intact component is identifiable in Block 1 at 41MI96, and that its chronological position can be ascertained using available materials, as follows:

A primary intact component in Block 1 is suggested by the fact that burned rocks show a strong tendency to be vertically concentrated in the lower portion of Unit 2, just above the contact with Unit 1. It was from this level that the Marcos point was recovered, in apparent association with a nearby concentration of burned rock features. Although the burned rocks found in Block 2 (Test Units 2 through 6 or 5 m^2), toward the eastern end of the investigated area near Crooked Run, may represent secondary deposition resulting from either discard by prehistoric occupants or by downslope erosional displacement, the discrete morphology of six defined cultural features in Block 1 (i.e., basin-shaped hearths and flat “griddle-like” features) suggests that these were intact features resting in their primary positions. Discrete and largely undisturbed features concentrated within a definable stratigraphic zone are indicative of an isolable prehistoric component. The apparent association of a Marcos point further indicates that this component pertains to the Late Archaic period.

Inferably due to the acidic nature of the soil matrix, faunal bones and charcoal were poorly preserved at 41MI96 (Abbott 1999; field notes). Additionally, none of the six excavated features contained charcoal, other than tiny flecks which may not be functionally associated. Therefore, we propose to obtain AMS dates on organic residues to be extracted from burned rocks, a technical approach which has been shown to be productive at other sites in Texas (Quigg 2001, 2003; Quigg et al. 2002a, 2002b, 2011a), and which should be feasible with the relatively porous burned sandstone rocks recovered from features at 41MI96. Multiple assays from such specimens can be expected to provide a temporal range for component/site occupation, and can hopefully support a Late Archaic placement, as is indicated by the presence of the Marcos dart point.

4.3 QUESTION 2: FEATURE FUNCTION(S)

As alluded to above, at least two different feature morphologies were observed in the field: basin-shaped concentrations of burned rocks interpreted as hearths, and flat "griddle-like" rock concentrations. Additionally, it was observed that the burned rocks from Block 2, the more easterly of the hand-excavated areas situated on the T_1 alluvial terrace, tended to be of smaller size than the rocks associated with features in Block 1. This contrast led Ellis (1999) to infer that the Block 2 rocks may represent discard from primary activity areas at the topographically higher T_2 surface.

Ellis' observations, in themselves, indicate that it may be possible to achieve an understanding of the functional variability of the six or more burned rock features at 41MI96. For instance, it might be speculated that the basin-shaped features were small heating elements used for baking plant foods, whereas the flat, griddle-like features were roasting platforms, perhaps for cooking meat. We propose to perform a series of technical analyses focused on microfossils or residues extracted from burned rock samples from various specific locations investigated by TxDOT, in order to acquire empirical data on the basis of which feature functions can be more reliably defined. These will include identification of starch grains, phytoliths, diatoms, and lipid residue analysis to determine whether plant or animal foods, or both plant and animal foods, and potentially which specific plants were prepared with a specific feature. If it is determined that diatoms are present on the collected rock samples, diatom analysis will be carried out in order to ascertain if some features may reveal evidence of contact of rocks with water, which would suggest use of heated rocks in stone boiling processes. The findings from these various analyses (provided that initial presence/absence studies indicate feasibility) will ultimately be correlated with recorded feature morphologies, in order to gain insight into the linkages between the formal characteristics of the features and their technoeconomic functions. Note the diatom and phytolith analyses were not supported by TxDOT for implementation.

4.4 QUESTION 3. RANGE OF RESOURCES EXPLOITED

Despite the general paucity of faunal remains at 41MI96, and the aforementioned poor preservation of charcoal and, presumably, other carbonized macrobotanical materials, it should be possible to gain insight into the relative economic importance of various plant and animal resources at this site. This will depend on identification of starch grains and phytoliths, if they still adhere to the rock samples, as well as identification of plant verses animal lipid residues that are likely to still be present within the outer "rinds" of the burned rocks. Further, by identifying specific chemical biomarkers, it may be possible to determine the actual taxa of plant and/or animal foods that were being processed. In the final analysis, it should be possible to ascertain whether the processing/cooking activities at the site involved a preponderance of plant food over animal foods, or vice versa or, perhaps, a more nearly equal reliance on both plant and animal resources.

Another aspect in the investigation of this question is the function of stone tools from the excavation blocks. High-powered use-wear analysis on informal/expedient tools (e.g., edge-modified flakes) and formal tools (i.e., bifaces and scrapers) will be employed to determine if they were used in cutting and/or scraping tasks involving animal products (e.g., butchering of meat, scraping of hides, scraping/cutting of bone) or rather were used to cut/scrape plant materials. Ground stone artifacts, if present among the collected clasts of sandstone, inferably would have been used to process plant foods, and the identification of various residues on such items may provide insights into the kinds of plants that came into contact with such artifacts.

4.5 QUESTION 4: LITHIC TECHNOLOGICAL ORGANIZATION

A sample of lithic debitage of sufficient size for meaningful analysis was recovered from 41MI96. The lithic assemblage from Block 1 that appears associated with the identified features will be targeted for detailed analysis. Using the Protocol for Lithic Analysis developed by TxDOT (2010), we propose to identify the general stage of lithic tool production conducted at this locality as well as the kinds of tools that were the preferred outcome of lithic reduction activities. Further, we also propose to determine whether or not locally available cherts were the preferred materials in use, through instrumental neutron activation (INA) analysis of the chemical constituents of debitage recovered from Block 1 and chert materials from off-site locations in the area immediately surrounding the site. Note the INA analysis was not supported by TxDOT for implementation, although many pieces did not fluoresce the normal yellow for Edwards chert.

4.6 SUMMARY

We believe that, despite the limited amount of excavation carried out at 41MI96, the data and materials recovered specifically from Block 1 have the potential to provide meaningful insights into prehistoric human adaptations in central Texas. The research questions formulated above are susceptible to productive investigation, even with the limited range of materials available from the site. These questions, when addressed using the proposed analytical techniques, can be expected to provide information on techno-economic dimensions of the presently posited Late Archaic occupation of the site. Further, through comparisons with comparable data from other central Texas sites, these questions and analyses potentially can contribute to a cumulative understanding of long-term change and/or continuity in the ways specific on-site subsistence activities were carried out by the hunter-gatherer populations of the region.

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5.0 GENERAL METHODS

J. Michael Quigg

5.1 TXDOT FIELD METHODS

An initial visual inspection of the project area was conducted by TxDOT staff archaeologist Daymond Crawford on January 14, 1999. He observed scattered burned sandstone in the eastern part of the project area just east of the eastern intersection of the county road and the low water crossing (see Figure 1-6). On April 9, 1999 TxDOT staff archeologist Pat McLoughlin revisited the project area and excavated four small, circular shovel tests (ST) across the area of potential effect (APE) west of Crooked Run Creek crossing (Figures 5-1 and 5-2). Various maps place ST 1 through 3 north of the county road, whereas ST 4 was south of those three in a triangular undisturbed area between the county road and the low water crossing road. Shovel test 1, closest to the creek on the T_1 surface, was excavated to 100 cmbs. Shovel test 2 was about 12 m west of ST 1, on the mid-slope between T_1 and T_2, and excavated to 100 cmbs. Shovel test 3 was about 20 m west of ST 2, on the higher T_2 surface, and furthest from the creek. It was terminated at a layer of burned sandstone at about 20 cmbs. Shovel test 4, south of ST 3, was excavated to 60 cmbs.

Based on these shovel test results, TxDOT archeologists decided the site was eligible for the National Register of Historic Places and upon concurrence by THC staff, TxDOT initiated a data recovery plan. The permit application for data recovery, accompanying research design, and scope of work by Lain Ellis were based on the presumption that a buried burned rock midden was present in the vicinity of ST 3 in the western part of the project area (see Figure 5-1). That assumed feature was the foundation for the research design and targeted in the data recovery excavations.

The data recovery field investigations began on May 24, 1999 under the field direction of Ellis (holder of the TAC permit) with a crew of four individuals. During the first week of investigations, a backhoe was used to excavate four trenches (1 through 4) west of the creek, within the APE and numbered from east to west (Figures 5-3 and 5-4). Backhoe trenches (BT) 1 and 2 were dug into the T_1 deposits, whereas BT 3 was dug into the sloping ground between T_1 and T_2. Backhoe trench 4 was dug on the eastern edge of Block 1 and into the T_2 deposits. James Abbott, TxDOT geoarcheologist, directed the mechanical excavation of the four trenches across the APE and described BT 1 and BT 4 in detail on 'Field Exposure Description Form' (Form 1967 [12-97]) and BT 2 in a more generalized manner. No descriptive records exist for BT 3. Backhoe Trenches 1 through 3 were excavated early on and monitored by Abbott. The documentation of the deposits is presented by Abbott in Section 6.1 below.

A backhoe was employed to scrape an area in the vicinity of ST 3 in an attempt to expose the top of the presumed burned rock midden. The scraping removed roughly 15 to 30 cm, over a roughly 3-by-8.5 m area, and exposed not a single, continuous burned rock midden as expected, but instead relatively dense area of burned rocks consisting of multiple, well-defined, small burned rock concentrations. A block of 11 1-by-1 m test units (Block 1, consisting of TU 1 and TUs 7 through 16) was laid out across the scraped area to target these burned rock concentrations (Figure 5-5) for hand-excavation. Block 1 was parallel to the east-west county road and at some point BT 4 was dug at the very eastern margin of Block 1 to provide a stratigraphic profile of the upper deposits. Test Unit 1 was established on the western edge of BT 4 and excavated to expose a possible burned rock feature visible at roughly 30 cmbs in the western wall of BT 4. Test Units 7 through 16 were laid out in a 2-by-5 m block immediately west of TU 1 to target the burned rocks concentrations exposed by the mechanical stripping. Three levels were excavated by hand in TUs 7 through 16, and four levels were excavated in TU 1, for a total of 34 excavated levels in Block 1. Level 1 of each unit was used to level off the irregularity created by the mechanical scraping. The second, third and fourth levels were 10 cm thick. Hand-excavated fill was screened through 6.4 mm (¼ in) mesh screens. Features were exposed, drawn in plan view, cross-sectioned to obtain a profile, and sampled for feature fill and burned rock. A confusing aspect of multiple level record drawings is that at times the tops of rocks exposed in the bottom of one level were drawn on that level

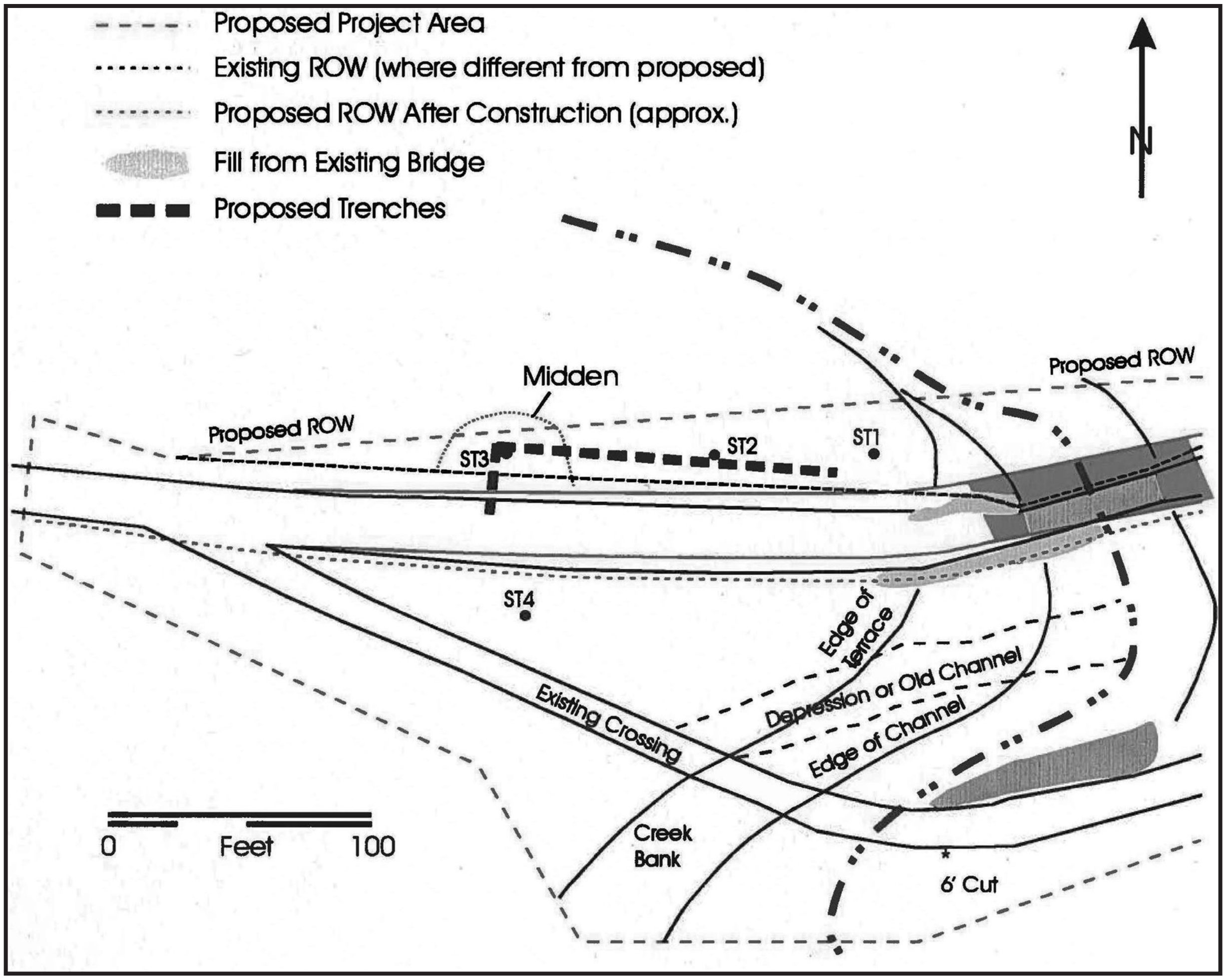


Figure 5-1. Western side of project area showing shovel test (ST) locations and proposed burned rock midden area.

Figure 5-2. Vegetation along northern side of roadway in area of potential effect.

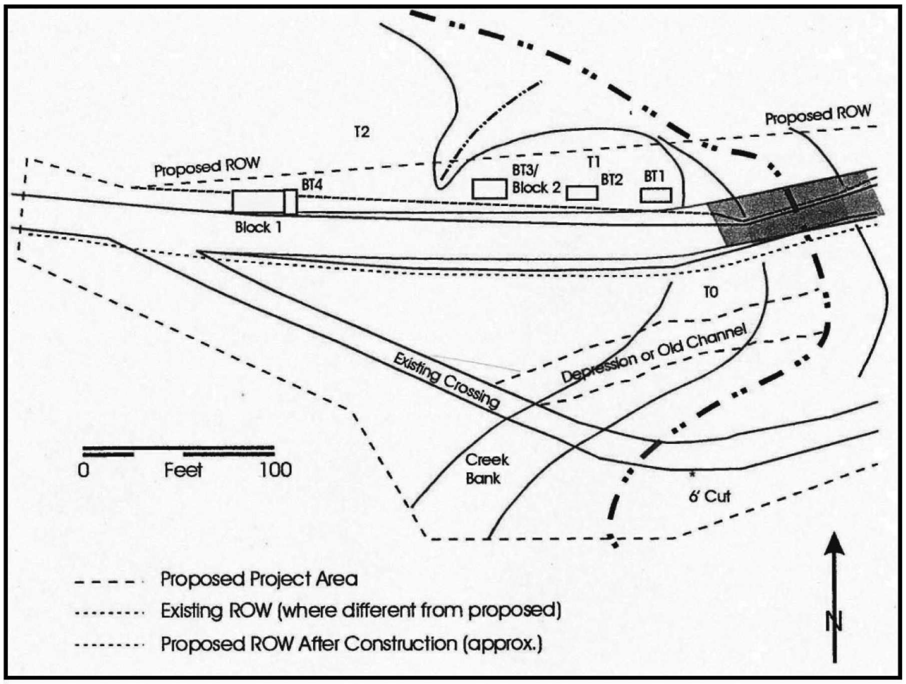


Figure 5-3. Western side of project area showing backhoe trench (BT) and block area locations.

Figure 5-4. Excavated Backhoe Trenches 1 and 2 along right-of-way.

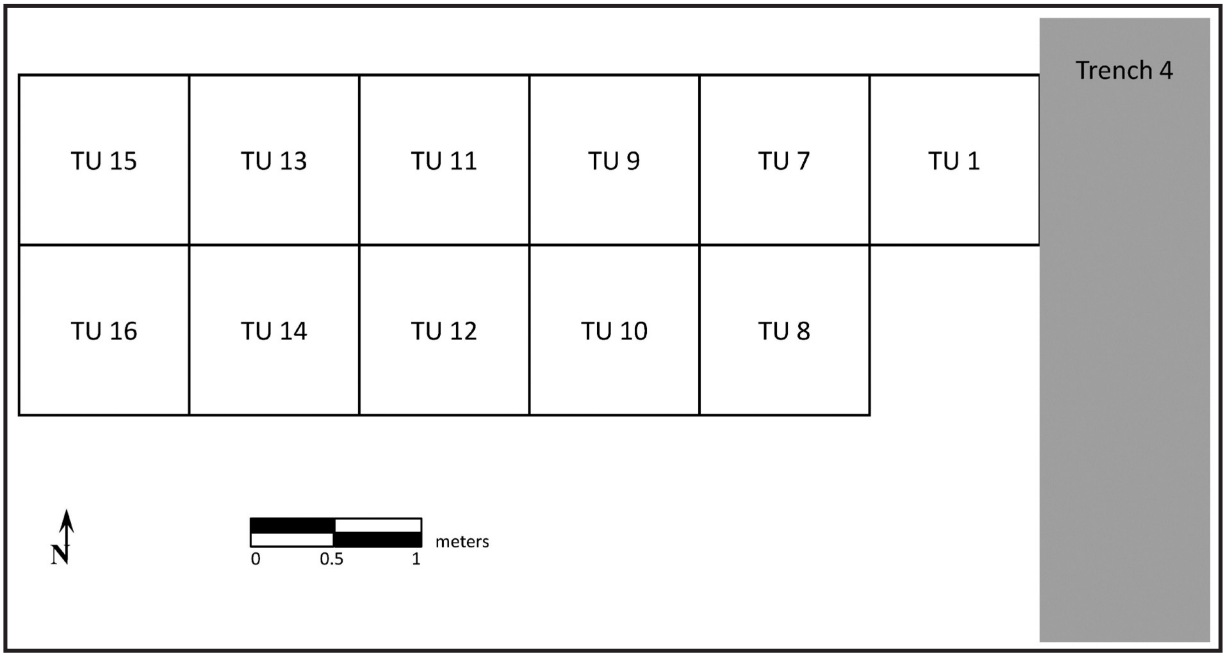


Figure 5-5. Layout of Block 1 test units in relationship to Backhoe Trench 4.

and then again in the next lower level, where the base of the rocks was encountered (e.g., Levels 1 and 2 in TUs 13, 15, and 16). Most level record plan maps appear to approximate the original rock size. Occasionally small burned rocks were not point plotted, just general position indicated by a written note on the level record.

A total of about 3.0 m^3 were manually excavated in Block 1. Twenty-five level records (nearly 81 percent of all levels excavated) plotted minimally 414 burned rocks, 6 burned rock features (assigned Features 1 through 5, and Feature 7), and a few artifacts labeled as cores. Few other cultural materials are depicted. Lithic debitage was not counted or recorded in the field, shown on the unit maps, or discussed in the level records.

Feature 1 was apparently hand-excavated before establishing Block 1 as the excavated northern half of the feature fell within the southern margin of the eventual Block 1, but not drawn in the Block 1 units. The rocks on the northern half were removed, which created a cross-section. A plan map was drawn of the southern half, a soil sample collected from the northern half, and a small sample of charcoal was also collected from under the rocks near the center of the feature. No level records were found for Feature 1. A 'Feature Recording Form', only partially completed for Feature 1, provides some basic information, but does not provide specific depths of the burned rocks or any other related materials. Unfortunately, only 17 of the 49 (35%) fields on each form were completed, and primarily consist of check box selections. All data recorded has been incorporated into the Feature 1 description.

The remaining five features were completely hand-excavated within Block 1 units and drawn on the level records as encountered. No standard feature forms were completed for these five features, and no actual rock counts, weights, rock depths, or other specific data are provided on the level records. Plan drawings and color photographs are all that is available.

Block 2 was presumably established near/at the location of ST 2, in the bottom of BT 3, where burned rocks were encountered during the mechanical trenching/scraping. Although the location of ST 2 was not specified in the notes, an overview photograph of Block 2 shows a small, roughly circular disturbance with burned rocks, just north of TU 6, and is potentially ST 2 (Figures 5-6 and 5-7). Block 2 targeted the burned rocks exposed during

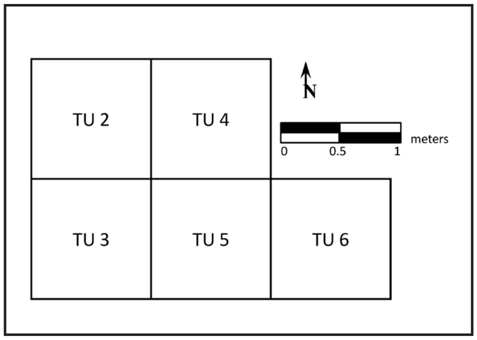


Figure 5-6. Layout of test units in Block 2.

digging this trench, to determine if they were an intact deposit. Five test units, TUs 2 through 6 were hand-excavated from the mechanically scraped surface down to the base of the burned rocks and fill was screened. In total, 23 levels were hand-excavated, though only 21 level forms are presently available for examination. As in Block 1, Level 1 in the Block 2 units was irregular in thickness, and not a full 10 cm thick. At least 2.5 m^3 were excavated in Block 2. Eighteen level forms (nearly 78 percent) were only partially completed for the hand-excavated levels, with no inventory counts of burned rocks and scant information on other cultural materials. Some recorded information on the level records is confusing (e.g., inconsistent directions for north and ambiguity concerning the vertical datum used for the occasional depth measurements). Although no feature designations were made for Block 2, the general site notes in the notebook indicate that one possible feature was detected in Level 5 of TU 6. The notes provide a general shape and size of this cluster of burned sandstone pieces and a sketch of their horizontal positions.

The 18 level records do not show any assigned features. A count of artifacts as plotted, results in roughly 403 burned rocks, a couple of items listed as cores, and no other cultural materials. Test Unit 4 Level 2 depicts a possible shovel test disturbance in the northeastern corner of the unit. Nearly 52 percent of the level forms show a north arrow, but in at least one instance north is not oriented to top of the page. Unit 6 records the burned rocks by depth,

Figure 5-7. Overview of Block 2 with small circular disturbance with burned rock to right of Test Unit 6 (possibly ST 2).

but it is not clear if the referenced surface is the stripped or natural ground, or from which datum the measurements were taken.

An unidentified individual recorded 13 pages of general site notes in a small yellow field notebook. These notes include: general comments about on-site activities, some short photograph notes for four of the seven rolls of color film, a layout sketch of the five Block 2 test units and the maximum depths of those units, some general observations on Features 1 and 4, and a sketch of the cluster of burned rocks in TU 6 Level 5 (not designated as a feature) in Block 2.

The form entitled 'TxDOT Record Form – Test Unit Level' (Form 8.89, revised 12/97) was most often used to record information by level. This form includes 19 data fields. On most forms, information was recorded in less than half of the data fields; generally, 3 to 10 fields were utilized. This single-page form also includes a gridded section for mapping data from the level within the unit. Data fields for recording the counts of lithics, burned rocks, or other cultural items were not present on the forms. Spaces for categories of burned rock sizes and/or shapes were also not part of the form. Beginning and ending depths were not often provided on the Record Forms. When depths were provided, it is not clear if they were from the original ground surface, the stripped surface, or an arbitrary datum.

The TxDOT Record Form was not used to record the first three levels of TU 1 information. A blank "Archeological Field Survey" form (Form 8.217, revised 12/97) was used to briefly record the first three levels with cursory notes, and a sketch of the position of TU 1 in relationship to BT 4. The actual feature plan map and profile of Feature 4 discovered in Level 4 were drawn with associated notes on a "Record Form – State Department of Highways and Public Transportation" (File 8.218, revised 3/82).

The fieldwork involved the collection of sediment and charcoal samples from a number of recognized features. However, those sediment and charcoal samples were no longer present with the boxes of artifacts from the site, when turned over to TRC for analysis.

5.2 TXDOT LABORATORY METHODS

Currently, no notes are available that discuss the initial laboratory processing procedures employed by TxDOT personnel once the materials arrived at the TxDOT Environmental laboratory. The available paper records include a 'Bag Inventory' of the lithic materials brought in from the field. This consists of 2 pages that list 75 bags, containing a total of 3,104 artifacts, divided by unit. The list does not specifically state that 3,104 items are lithic debitage, but it is assumed that was what was being counted. A six page 'Lot Number Index' is also present that provides only the most basic provenience information (Area, Unit, Level) in most cases, and some additional information (e.g., Feature, Rock Number). No lot numbers, however, were assigned to the items listed on the 'Lot Number Index'. A separate four pages of 'Lot Number Assignments - 41MI96' provides lot numbers, beginning with 001, to the units, levels, and bags. This list includes Lot numbers up to 113.

Some analyses of the lithic debitage were also conducted by an unidentified person, with counts by level and unit, and a general typology of flakes was presented by level and unit for Blocks 1 and 2. 'Table 1 Preliminary Summary of Artifacts Recovered from 41MI96' lists the counts of debitage by types. The counts by level were divided by material type (i.e., bone, shell, lithic) and by tool type (i.e., bifaces, projectile points, cores, unspecified tools). The lithic debitage was divided into pieces retaining cortical surfaces and those with thermal alteration. The percentage of cortex was not specified, and it is not clear if the thermally altered pieces were intentionally heat altered. In four units (TUs 13, 14, 15, and 16) in Block 1, a more complete lithic analysis was conducted, recorded by level on four pages. This includes the recorded flake fragments, flakes with: platforms, pot lids, thermal alteration, cortex, modified edges, as well as shatter, and separation by size categories (i.e., ¼ in, 3/8 in, ½ in, 1 in, 1.25 in, 1.5 in, and 2 in). A handwritten note at the bottom of the TU 13 record sheet states "In general when cortex is present (for all TU's) it is primarily on platforms – haven't seen one decort. (sic) flake in 16-13". It is not clear who performed the debitage analyses or when it was conducted. Although this recorded debitage data is available, it was superseded by data from new TRC analyses instead (see below).

5.3 TRC LABORATORY PROCEDURES AND TECHNICAL ANALYSES

Materials turned over to TRC for temporary curation and analyses included one box of lithic debitage that also contained a few stone tools, a single mussel shell, one bag of calcium carbonate pieces labeled as bone fragments, and two boxes of burned rocks collected from five features in Block 1, and some non-feature associated from Block 2. In general, TRC artifact processing entailed washing, sorting, and labeling of most cultural materials, except burned rocks. Prior to washing, all bags of lithic debitage were examined for formal and informal tools, including flakes with modified edges. All identified stone tools were bagged separately without washing or further handling. On unwashed specimens, a portion of one surface was cleaned so that an archivally stable ink label could be placed on the artifact. A selected set of 15 tools that included 11 edge-modified flakes, 2 bifaces, and 2 choppers was then submitted for use-wear analysis. Nitrile gloves were used when handling these selected tools. Prior to sending the tools for use-wear analysis, metric and nonmetric observations were recorded and the items were photographed in case of loss during shipment.

All cultural materials were assigned Provenience Numbers (PNUMs), and were entered into an electronic database. These unique PNUMs were assigned to individual excavation levels, as well as other proveniences. All provenience information available and pertinent data from the collection bags and level records were entered into a Microsoft Access format database.

TRC's cataloging system assigns strings of numbers to artifacts that encode information on provenience, artifact class, an unique identifier, and samples taken from the artifact or lot for specialized analyses. The PNUMs (e.g., #155) were assigned to lithic debitage, stone tools, and burned rocks. PNUMs are sequential integers that designate the overall provenience unit (i.e., excavation unit, backhoe trench, modern ground surface) and level, or depth, within that provenience unit and can be cross referenced to a master list of PNUMs. Within each PNUM, the various artifact classes were assigned a secondary designation referred to as the artifact class number: lithic debitage (001), faunal bone (002), burned rock (003), soil (004), feature (005), shell (006), macrobotanical remains (007), ceramic sherds (008), and historic material (009). Individual tools and other unique items were assigned individual artifact numbers starting with the number 10 within the same unit and level designated by the PNUM. Thus, individual tools were assigned a PNUM and an individual unique number appended to the PNUM (e.g., #155-10, #155-11, and #155-12).

In a few instances, individual burned rocks were removed from the collection for specialized analyses including radiocarbon dating, lipid residue, and starch grain analysis. Once a burned rock was selected for analyses, it was broken into multiple pieces, and parts of that same rock were then sent for each kind of analysis. For example, if a selected burned rock was designated as #155-003 for starch grain analysis, then that burned rock would be designated as #155-003-1 to indicate it constituted the first sample from that burned rock group. In another words, the catalogue number #155-003-1 would identify that specific burned rock as the first sample (1) taken from the burned rock class of artifacts (003) within a specific provenience unit (#155). If burned rock #155-003-1 was subdivided into two pieces for two different types of analyses, such as lipid residue and starch grain analyses, then lower case letter designations (e.g., a and b) would be added following the last number in the sequence (i.e., #155-003-1a and #155-003-1b) to signify that two parts (part a and b) were taken from burned rock #155-003-1. The complete two- or three-part number sequence assigned to each object or class of objects constitutes the accession number. This process allows individual pieces of large collections of various materials to be individually handled and tracked without the risk of a loss of provenience information.

About one in ten items (10 percent) occurring in bulk material classes (e.g., chert debitage) within specific provenience units (e.g., a level) were individually labeled. Object size was also a major consideration for labeling purposes, as many lithic pieces are less than 1 cm in diameter and were not labeled. Artifact labeling consisted of inscribing the State of Texas Archeological Site Trinomial (41MI96) and the catalog number on designated artifacts using black indelible ink. After the ink was dry, the artifact labels were coated with clear Acryloid B-72 with reagent-grade acetone solvent to preserve the inscriptions.

Permanent paper tags were included with each individually bagged artifact or class of artifacts collected from a single provenience. These tags include the site trinomial, provenience information (unit and depth), the class or type of artifact(s), the date of excavation, the excavator's initials, and the quantity of items in the bag. These permanent tags were printed on acid free, 30.4 kg (67 lb) card stock and filled out with pencil.

Stone tools, lithic debitage, burned rocks, field records, and photographs from TxDOT fieldwork are to be permanently curated. Individual artifacts and artifact lots, including all stone tools, lithic debitage, and burned rocks are in clear, zip top 4 mil thickness polyethylene bags according to provenience. Each such bag contains an archival-quality, acid free curation tag that lists the site number, provenience data, date of excavation, excavator(s) name, artifact type, and quantity. Digital photographs were not taken at the time the fieldwork was carried out; only color-print photos were made. All original field records are on acid-free paper and were placed in acid-free reinforced file folders for curation.

5.3.1 Analytical Methods

Artifacts were subjected to different metric, nonmetric, typological, and specialized analyses, such as use-wear analysis. A set of predefined attributes for each material class were first encoded on paper, and then entered into TRC's electronic database management system utilizing Microsoft Access 2007 software, which constitutes the master database for the investigations at 41MI96. A copy of this database is provided on the CD-ROM attached to the back cover of this report. The specific data recorded for each class of artifact are presented below. Analytical methods pertinent to each data class and the various secondary suites of software used for specialized analyses are discussed in detail in the appropriate parts of this report.

5.3.1.1 Chipped Stone Artifact Analysis

A protocol for analysis of debitage and chipped stone tools has been developed by TxDOT archeological staff (TxDOT ENV 2010) in an effort to standardize data collection and presentation in analytical and interpretive chapters of archeological reports sponsored by TxDOT (Appendix E). This protocol was incorporated into the research design at the onset of this project, and TRC has made an effort to conform to the general structure and goals of this protocol. When possible, terminological and taxonomic considerations have been made in this presentation that would allow for this assemblage to

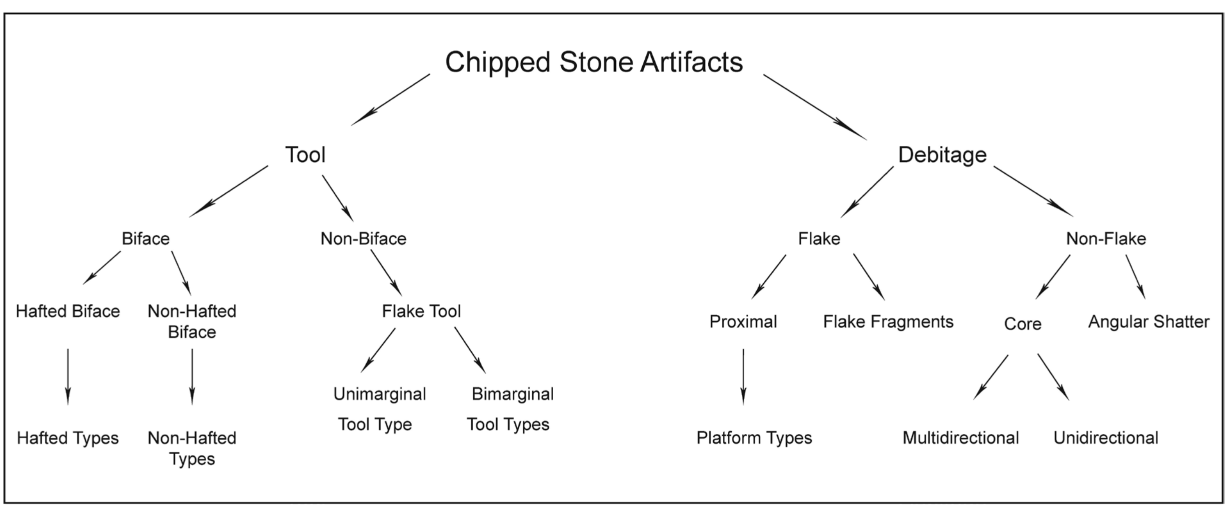


Figure 5-8. Chipped stone artifact analysis flowchart.

be comparable to future analyses employing these specific TxDOT protocol guidelines.

Data entry forms were created to record qualitative and quantitative attributes of chipped stone artifacts for analytical procedures and interpretive insights. A morphological typology (based on Andrefsky and Bender (1988); Andrefsky et al. 1994; and TxDOT ENV 2010) was used that allowed analysts to classify and sort chipped stone artifacts first into debitage or tools, and then into more specific categories (Figure 5-8). The edges and surfaces of each piece of debitage were macroscopically examined for signs of use as a tool. If worked areas were identified, the artifact was assigned to a morphological and/or technological category based on general form and inferred function. Sets of observations were recorded for all tool classes recovered. The following subsections provide definitions of major tool classes.

Bifaces

Bifacial tools, whether finely or crudely produced, appear to have completed the manufacturing process. This is evidenced by secondary retouch, edge straightening, hafting preparation, notching, and similar characteristics. Bifaces are defined predominantly on the basis of morphological characteristics, but they may also have functional associations (e.g., cutting, piercing, chopping, drilling). Bifacial tools exhibit purposeful, usually patterned, flake removals on both faces (ventral and dorsal). Most or all of both faces may be covered with flake scars, and in some cases one face may be completely modified, whereas the opposite face exhibits only partial modification. Bifaces may be fashioned either from large bifacial cores or from flakes. Included within this overall morphological category are diverse functional groups such as projectile points (see below). The measurements of 25 morphological attributes were recorded for each biface. Attributes included nonmetric observations concerning the completeness of the specimen, overall morphology, manufacturing characteristics, and manufacturing stage based on morphological classes adapted from Callahan (1979). Metric measurements included edge angles, maximum width, maximum thickness, maximum length, and weight, and were recorded for both complete and incomplete specimens. These attributes were used to evaluate tool stage, circumstances of use and reuse, and discard.

Projectile Points

Projectile points are a functional subset of the biface class specifically designed to be hafted to the distal end of a shaft used in stabbing, throwing, or shooting to penetrate animal hides and flesh and kill the animal. Projectile points are bifacial tools given their final form by means of fine secondary retouch, usually with basal modification in the form of notching, stemming, or thinning of the proximal end for purposes of hafting. Dart points, arrow points, and indeterminate dart/arrow points are all classes of projectile points. Dart points are those employed to tip hand-held darts or spears, arrow points are used to tip arrows, and indeterminate points are, as the name implies, of uncertain usage. Whereas dart points are usually manufactured from bifacial preforms, arrow points are often manufactured on thin flakes.

Projectile points were assigned to recognized types whenever possible. In traditional archeological literature, projectile points are normally referred to by their typological designation, which are usually based on a set of morphological characteristics, shared in common by groups of similar points, which generally focus on the hafting modification. Point classifications were conducted by TRC's personnel in reference to established point typologies in use in Texas archeology (Suhm and Jelks 1962; Turner and Hester 1999).

A comprehensive suite of 44 metric and nonmetric observations was recorded for the projectile points recovered. Nonmetric attributes recorded include descriptors of overall morphology and manufacturing characteristics. Some 21 quantitative measurements also were recorded (Figure 5-9). Metric measurements were recorded for complete and incomplete specimens. Tool edge angles were also recorded. These measurements were used to evaluate tool stage and if possible, circumstances of use and discard.

Unifaces

Unifaces are those tools that exhibit flake scars on one face only. Like bifaces, unifaces are defined based

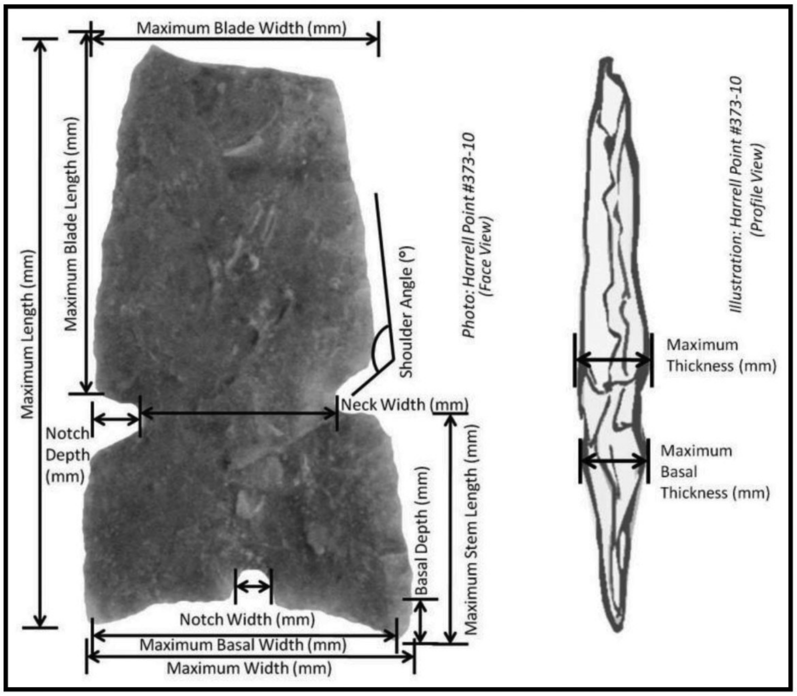


Figure 5-9. Selected projectile point terms and metric measurement locations.

predominantly on morphological characteristics, but they also tend to have functional associations (e.g., scraping, planing, cutting, engraving). Unifacial tools exhibit purposeful flaking across most or all of one face, whereas the opposite face most often remains flat and unmodified. Unifaces may be fashioned from cobbles or flakes and include such functionally diverse groups as scrapers, gouges, edge-modified flakes, gravers, and spokeshaves. One or more edges of a unifacial tool may exhibit manufacture and/or use-related flake removals that may be patterned or random. To some degree, unifacial tools form a continuum ranging from formal tools exhibiting intentional, patterned, and manufacture-related edge flaking to informal, expedient tools that show only use-related edge scarring. The former tend to fall within the scraper and gouge categories, whereas the latter are generally classified as edge-modified flakes.

Edge-Modified Flakes

Edge-modified flakes are minimally modified flakes, flake fragments, or pieces of angular debris that are characterized by one or more areas of flake scarring along margins. The edge flaking may be patterned or unpatterned, continuous or discontinuous, and may result from use-related activities or from intentional pressure retouching to prepare an edge for use. Many edge-modified flake tools exhibit combinations of these characteristics, and many have more than one working edge. The modifications, however, usually are restricted to the edges of the piece and do not significantly alter the original flake form. Such edge modifications may be either unifacial or bifacial. Edge-modified flakes are usually considered 'expedient' tools, pieces of raw or minimally modified material that are utilized for a short time, and subsequently discarded soon after use. Twenty-one metric and nonmetric attributes were recorded for edge-modified flakes. Metric measurements including length, width, thickness, and weight were recorded for each specimen even if it was broken.

Choppers

A chopper is a modified nodule of hard lithic material, usually dense siliceous rock such as quartzite or sometimes a chert nodule, used for direct percussion on hard substances. These pieces usually exhibit areas of flake scar removal on multiple sides and/or edges with at least one V-shaped edge which exhibits evidence of intensive battering and/or crushing. Metric and nonmetric observations were recorded for choppers. Measurements of dimensions were taken on the tool no matter if it was broken or not.

5.3.1.2 Ground Stone Tool Analyses

This broad artifact class includes pieces of natural rock that have been modified by grinding, pecking, or battering, either to intentionally shape an implement or as a by-product of use. Ground stone tools are recognized by the presence of intentional abrasions, grooves, and striations and/or smoothing. Significant rounding, flattening, and/or pitting of utilized surfaces may also be identified. Categories of ground stone tools include manos and metates (milling stones or grinding slabs).

The edges and surfaces of potential ground stone were macroscopically examined for signs of use as a tool. If battered, smoothed, unnaturally flattened, pitted, ground, striated, incised, or pecked areas were identified, then the artifact was assigned to a morphological and/or functional category based on general form and inferred function. Sets of observations were recorded for the tool classes recovered. The following subsections provide definitions of major ground stone tool classes.

Manos and Metates

Manos and metates are generally used together to grind friable materials (nuts, seeds, other vegetal matter, and sometimes pigments) into powder. A mano is a hand-held grinding stone, generally characterized by a round to ovate shape, usually of hard, dense siliceous rock such as quartzite or sandstone. One or more surfaces exhibit a smooth or polished, and/or possibly flattened area caused by grinding action against another hard surface (the metate). In some instances, the edges exhibit crushed or pitted areas indicating possible use as hammerstones as well. Sometimes one or both faces may be pitted, which may result from the user roughening the smooth surface to facilitate the grinding. Generally, these are water worn cobbles that exhibit no other alterations to the natural cobble.

A metate is often a large slab of a dense siliceous rock such as sandstone or possibly limestone which has functioned as the base on which the mano is used to grind materials. The grinding action most often wears the natural surface and creates a shallowly concave face that is smoothed and/or polished. Extensive and continued use creates a deeper concave basin and in some instances, both faces may have functioned as a base for grinding. Deep, oval, basin-like or elliptical grinding surfaces are common on metates from the Great Basin region, while the long, rectangular trough shape, characteristic of metates of Southwestern agricultural cultures, are sometimes recovered from Plains Village sites. Occasionally, the edges of metates are artificially shaped, usually by direct percussion removal of flakes along the margins. Metric and nonmetric observations were recorded for manos and metates. Measurements of dimensions were recorded for each piece no matter if it was complete or not.

5.3.1.3 Lithic Debitage Analysis

Chipped stone debitage is the unmodified debris that results from lithic reduction activities associated with the manufacture and maintenance of stone tools. Lithic debitage lacks any macroscopic indications of use or modification. Pieces that exhibit any sign of use-wear or intentional modification are placed in the appropriate tool category. The debitage collection from each excavation block was subjected to detailed analysis; with individual pieces sorted into the reduction classes listed below (see Appendix E for the TxDOT 2010 debitage sorting protocol).

Beside the total count, the pieces were classified by: completeness/type of debitage represented (whole, proximal fragments, distal fragment, shatter/blocky debris); size grade into 6.4, 12.8, 19.2, and 25.6 mm groups; cortex percentage (0, 1 to 25, 26 to 50, 51 to 75, and 76 to 100 percent); platform type (indeterminate, cortical, flat, complex, abraded, faceted, multifaceted, and rejuvenated [after Andrefsky 1998:93-96]); observed presumed purposeful thermal alteration; technique used in reduction (indeterminate, hard hammer, soft hammer, indirect, pressure, and bipolar); and raw material type. Counts and weights for debitage were documented for artifact groupings (analytical assemblages) that were created through the analytical process (see Appendix E for TxDOT 2010 debitage analytical protocol). A summary of the debitage typology implemented for this analysis is outlined below.

Core Reduction Flakes

This category includes flakes, flake fragments, and pieces of angular debris associated with initial core preparation activities, such as test flakes (removed to determine the quality of raw material within a cobble) and flakes removed to decorticate a cobble for further reduction. Items in this category tend to have cortex covering on more than 50 percent of their dorsal surfaces. By definition, most items tend to be relatively large (smaller flakes with dorsal cortex often fall within other categories, such as early biface reduction flakes or indeterminate flakes, depending on their diagnostic characteristics). Core preparation flakes may or may not exhibit pronounced platforms, bulbs of percussion, or ventral concussion rings, though most do have one or more of these characteristics.

Biface Thinning Flakes

Biface manufacturing flakes were classified based on the presence of multifaceted striking platforms, multidirectional dorsal flake scars, parallel to slightly expanding flake margins, and slight to moderate longitudinal curvatures. This category was subdivided into early- and late-stage biface manufacture flakes. Early-stage biface flakes tend to be somewhat larger than late-stage biface flakes, have fewer and larger dorsal flake scars, and may retain a considerable amount of cortex on their dorsal surfaces. As employed in this analysis, early-stage biface flakes correlate roughly with Callahan's (cf. 1979) revised Stage 1, 2, and 3 bifaces ("blank," "rough out," and "primary preform" stages) while late-stage biface flakes correlate with Callahan's revised Stage 4 and 5 bifaces ("secondary preform" and "final preform" stages). In practice, Stage 1 ('blank') flakes are more likely to fall within the core preparation flake category due to the lack of clear diagnostic characteristics on many such specimens. Final percussion thinning, pressure thinning, and retouch flakes that do not clearly exhibit biface-manufacture characteristics, due to their small size, would likely be included in the thinning/retouch flakes category. The early- and late-stage biface flake categories may contain complete flakes, proximal flake fragments and distal flake fragments.

Thinning/Retouch Flakes

This category includes flakes and proximal and dorsal flake fragments resulting from the final stages of tool manufacture, including final percussion thinning and any subsequent pressure retouch. By definition, flakes in this category tend to be quite small, and it is difficult to distinguish whether they result from biface manufacture, uniface manufacture, or resharpening.

Angular Debris

Angular debris, or 'shatter', are angular pieces of lithic raw material that break away from the core as flakes are struck. In contrast to flakes, angular debris does not generally retain any diagnostic characteristics of the flint knapping process (i.e., platforms, bulbs of percussion, concussion rings, and definable dorsal or ventral surfaces). In this analysis, those few pieces of angular debris that exhibit characteristics diagnostic of biface manufacture were included in the appropriate biface manufacturing category (i.e., early- versus late-stage biface flakes).

Indeterminate Flakes

This category includes flakes and flake fragments that lack diagnostic traits that would permit their placement into one of the other categories. Generally, these are small fragments of flakes and/or thin pieces of angular debris that do not display clear evidence of a platform, concussion rings, or flake scar patterning on their dorsal surfaces. This category also includes a small number of pot-lid flakes and fractured heat spalls resulting from thermal alteration of raw materials.

Cores

A core is a cobble, pebble, or other mass of lithic raw material that exhibits one or more platforms and flake scars resulting from the systematic removal of flakes (Parry and Kelly 1987). Technically, any chipped stone tool may properly be classified as a core as it is the object created through the removal of flakes from the exterior surface of the original mass of lithic material. In common terms, however, cores are generally considered the non-utilized remaining masses of material from which one or more flakes were removed. In other words, cores do not exhibit any intentional or use-related flake scarring along any of their edges, though scars resulting from platform preparation may be evident. A core expediently used as a tool is classed as such (e.g., extensive crushing damage along one or more thick edges of a core would probably result in classification of the object as a chopper). Twenty metric and nonmetric observations were recorded for cores. Metric measurements of length, width, thickness, and weight were recorded for each specimen even if it was broken. Four basic kinds of cores are recognized according to the degree of knapping and the flake removal strategy: unifacial, bifacial, multidirectional, and blade core.

Unifacial Cores
A unifacial core is one that exhibits flake scars removed from only one face. The flake removals may be in various directions and exhibit no pattern or structure to the removals. There are usually only one or two platforms.

Bifacial Cores
A bifacial core exhibits flake removals from both faces and may be in multiple directions. The parent, or objective rock, is generally a cobble that exhibits two distinct faces. The flakes were driven from the lateral edges, thus, the platforms are along the edges.

Multidirectional Cores
The multidirectional core is generally a chunk of raw material that does not necessarily exhibit two obvious faces. Generally, a number of platforms, most often in different directions, are present.

Blade Cores
Blade cores are chunks of raw material intentionally prepared to facilitate the removal of a specific kind of desired flake. These generally exhibit two or more parallel scars driven from the same platform in the same direction with the same overall shape. The cores often have a distinctive conical polyhedral shape, resulting from repeated, parallel removal of long, narrow flakes known as prismatic blades.

5.3.1.4 Mussel Shell Analysis

The mussel shell was compared to TRCs extensive modern and prehistoric comparative collection that has been identified and individually labeled. Original identifications were performed by Dr. R. G. Howells. To confirm identification, the specimen was compared to other modern pictures. Habitat data were obtained from literature sources (i.e., Howells et al. 1996).

5.3.2 Analytical Techniques

The following four outsourced analytical techniques were performed on a selected suite of artifacts. The high-powered microscopic use-wear analysis was conducted on a small sample of formal and informal stone tools. The radiocarbon dating, starch grain and lipid residue analyses were conducted on a limited suite of burned rocks collected from five identified features. The latter two techniques were performed to gain greater insights into, and understanding of, materials cooked in these features. It was anticipated that the results would contribute to the interpretations of the feature function and foods prepared.

Only a few burned rocks were collected from five individual identified features in Block 1, individually assigned a number in the field within their specific feature and marked on the feature maps. Burned rocks were selected for the various technical analyses from those few feature associated collections. Pieces of the same selected 20 rocks were sent to Dr. Linda Perry for starch grain analysis, to Dr. Malainey for lipid residue analysis and pieces of six rocks submitted for the lipid residue and starch grain analyses were also sent for direct radiocarbon dating at Beta Analytic, Inc. through the Archeological Studies Program at TxDOT. The fundamental belief is that multiple analyses on exactly the same rocks would strengthen the final interpretation of the function of the rocks/features and the foods cooked. Pieces of the rocks used in the various analyses were also curated for future reference.

Following TxDOT approval of the research questions, the technical analyses were conducted by highly skilled individuals working at institutions who applied their expertise and knowledge, then offered their interpretations based upon the obtained results. The technical reports are presented in the appendices and provide details concerning methods, analytical results, and interpretations. The results from these diverse technical studies are incorporated into the body of this report. The combined results are used to address the research questions presented in Chapter 4.0. Each technical analysis employed is briefly discussed below.

5.3.2.1 Radiocarbon Dating Analysis

Charcoal, the preferred material for radiocarbon dating, was not available. Consequently, the burned rocks, with the potential for organic content absorbed during cooking activities, provided the only means of potentially obtaining absolute dates. An absolute date can be obtained from the organic materials trapped in the pores of the rocks, though it may not be as precise as what one might obtain from charred seeds or wood. Recent direct dating of chunks of sandstone burned rocks from the Root-Be-Gone site (41YN452), which were paired with charcoal and bone, were consistently older by a few hundred years than the charcoal and bone results (Quigg et al. 2011a). Consequently, one must view the rock dates as more of a general ballpark date rather than a narrowly definable point in time. TRC selected six burned rocks for direct radiocarbon dating and requested approval from TxDOT personnel. Once approved, the six samples were submitted to Beta Analytical Inc., (Beta) in Miami.

With instructions from TRC personnel, Beta tried to extract only the darkened outer margins of the rocks for use in the dating process. Beta's extraction procedure included the "use of a chisel and hammer to remove the darkened rind from the surfaces of the rock, trying as best as was possible to just extract the stained areas. If we noted any larger wholly unstained chips (bits of substrate) present after we extracted the sample that material was removed prior to the combustions" (personal communication with Ron Hatfield May 18, 2012). As each sample differed due to the thickness of the rind and coloration it was unclear how much material would actually be needed. The amounts obtained are provided in Table 5-1.

Beta dates are reported as radiocarbon years before present (B.P.), with "present" being A.D. 1950 using the Libby 14C half-life of 5,568 ± 30 years. Each sample was measured for Carbon 13 verses Carbon 12 ratios ($^{13}C/^{12}C$) expressed as the delta 13 carbon ($\delta^{13}C$) and calculated relative to the internationally standard Cretaceous belemnite formation at Peedee, South Carolina (PDB or VPDB). Beta's individual laboratory reports with specific details concerning each sample are presented in Appendix A. Individual sample results are also presented and discussed throughout the body of this report.

5.3.2.2 Lithic Use-Wear Analysis

Most stone tools are generally categorized by their overall form with an assumed function. To gain greater insight into the actual functions, a suite of informal and formal tools were selected and submitted for high-powered (greater than 100 power) microscopic use-wear analyses. Fifteen artifacts were selected, mostly from Block 1 and predominately edge-modified tools, and sent to Dr. Bruce Hardy at Kenyon College (Gambier, Ohio). Most tools selected were assumed to have been handled in the field and

Table 5-1. Amount of Materials Processed to Obtain AMS Date.

Beta Sample No.	Wt. Before Pretreatment (g)	Wt. Combusted (g)	Yield of Carbon
321461	3.8	1.6	Normal
321462	1.1	0.82	Minimal just sufficient for AMS counting
321463	2.4	2.2	Normal
321464	1.2	0.96	Minimal just sufficient for AMS counting
321465	1.8	1.6	Normal
321466	1.2	1.1	Minimal just sufficient for AMS counting
323139	0.527	0.410	Normal
323140	0.268	0.184	Minimal just sufficient for AMS counting
323141	0.655	0.514	Minimal just sufficient for AMS counting

potentially washed by TxDOT personnel in their laboratory. In order to track individual specimens, a small spot on one face of each artifact was cleaned and an ink provenience number applied and then coated. Edge-modified flakes were intensively sampled as they presumably functioned in a variety of tasks and on a variety of materials. Therefore, the greatest functional diversity should be apparent in the edge-modified flake tool class. The edge-modified flake tools included a variety of edge shapes and sizes in anticipation of identifying a wide range of functions such as cutting, graving, shaving, scraping, and whittling. The analytical methods and individual specimen results of Dr. Hardy's findings are presented in Appendix B. The individual interpretations of the use-wear are also presented in the tool discussions in the body of the text.

5.3.2.3 Starch Grain Analysis

Starch grain analysis is becoming more widely used in Texas archeology (see Perry and Quigg 2011a, 2011b; Quigg et al. 2010, 2011a, 2013). A brief introduction is provided here as background to this discipline for those that might not be familiar with this technique.

Starch grains are microscopic granules that serve as the principal food storage mechanism of plants. These grains are found mainly in roots and tubers (e.g., crow poison, rain lilies, false garlic, wine cup, and spring beauty), and in the seeds of legumes and grasses, where they are often produced in abundant numbers (Perry personal communication 2008). Starch grains from different plants possess a large variety of species-specific forms that have been recognized for some time. Distinctive features of starch grains are genetically controlled and when carefully observed, can be used to identify plant taxa. At least 300 species and varieties of important economic plants from around the world have been described and can be preserved in archeological contexts (Piperno and Holst 1998; Piperno et al. 2000). Researchers around the world (particularly in the neotropics and in Australia) have been using these techniques with excellent results (Perry personal communication 2007). Starch grain remains have significantly increased the knowledge of plant domestication and crop-plant dispersal in various regions (Perry et al. 2006:76-77). Researchers have employed starch grain analyses to study diet, plant processing, plant domestication and cultivation, tool use, and uses of ceramic vessels. Starch grains have been extracted from soil samples, ceramics, and chipped- and ground stone tools to address questions of resource procurement and preparation of foods. Intact starch grains have been extracted from formal and informal chipped stone tools, both washed and unwashed (Perry personal communication 2007). Heat alone does not destroy starches, as they are found in ceramic cooking vessels and in burned rocks (Quigg et al. 2010; Perry and Quigg 2011a).

A total of 40 samples that include 20 burned rocks from five different cultural features and 20 stone tools from Block 1 were selected and sent for starch grain analysis. These were submitted to Dr. Linda Perry to determine the presence/absence of starches, processing alterations to the grains and, if possible, the specific taxa of starch grains. Dr. Perry's extraction methods, results, and interpretations are presented in Appendix C.

5.3.2.4. Lipid Residue Analyses

Burned rocks often account for a high percentage of the cultural debris recovered from hunter-gatherer campsites. These rocks were heated and generally used for heat conduction and transference to substances to be cooked. When used to heat or cook food, food residues may have been trapped in the tiny pores of the rocks. It is these food residues, chemically identifiable at the molecular level, that are targeted in this kind of analysis.

Twenty burned rocks were selected for lipid residue analyses and were sent to Dr. Mary Malainey in Manitoba, Canada. Dr. Malainey's and Figol extraction methods, results, and interpretations are presented in Appendix D. These samples represent five features from Block 1, and thus represent multiple events.

5.4 CURATION

Cultural materials were labeled according to the 2012 curation standards of the Texas Archeological Research Laboratory (TARL) of The University of Texas at Austin (L. Nightengale personal communication).

All curated artifacts and TxDOT field photographs are permanently curated at Center for Archaeological Studies (CAS), Texas State University in San Marcos. A previously approved artifact sampling strategy was employed to select items for curation. Curated artifacts include two to three burned rocks from each of the burned rock features in Block 1 and all those collected in Block 2. Individual artifacts and artifact lots, including all stone tools, debitage, and burned rocks, were bagged in clear archival polyethylene zip-locking 4 mil thick plastic bags according to provenience. Each polyethylene bag contains an archival-quality, acid-free curation tag that lists the site number, provenience data, date of excavation, excavator initials, artifact type, and quantity in pencil. Upon completion of laboratory cataloging, processing, and analysis, these bags of artifacts were eventually placed in acid-free cardboard boxes with lids for permanent curation. Photographs were submitted on CD, and a contact sheet and placed in archival photo sleeves for curation. All original field records are on acid-free paper and placed in acid-free file folders for curation. Any dirty or otherwise non-archival original records were scanned and printed on acid-free paper.

6.0 RESULTS OF INVESTIGATION AT 41MI96

6.1 NATURAL STRATIGRAPHY

James T. Abbott

6.1.1 Introduction

Site 41MI96 is situated in southern Mills County on the northern side of the Colorado River Valley. It lies at an elevation of approximately 372 m (1,220 ft) above mean sea level. The site is underlain by a wedge of Holocene alluvium inset into Pleistocene alluvium and sandstones of the Pennsylvanian Strawn Group. Members of the Strawn Group mapped locally include the relatively fine-grained sandstone 14 and relatively conglomeratic sandstone 15, which are brown to red, planar bedded to crossbedded sandstones, and the Strawn Group undivided, which includes marls, limestones, siltstones, and muds in addition to sandstones and conglomerates (Barnes 1976). The alluvium is associated with a small tributary of the Colorado named Crooked Run, which drains a small basin entirely underlain by rocks of the Strawn Group. The small stream bisects an older, elevated terrace (T) of the Colorado River, but all alluvium exposed in the immediate vicinity of the site is of probable Holocene age.

Three alluvial surfaces are developed on the Holocene fill, ranging from less than a meter to approximately 6 to 7 m above the modem channel of Crooked Run. The lowest terrace surface (T_0) is a narrow, discontinuous level surface that lies approximately 50 to 150 cm above the scoured bedrock channel. It is underlain by sandy to loamy sediments that exhibit no pedogenic modification, and probably dates to the last 100 years. The T_1 surface lies 4 to 5 m above the channel. It is relatively continuous and gently undulating, and is bounded by a steep rounded slope to the east and northeast and a steep to vertical cutbank to the north of the excavation blocks. The T_1 surface is underlain by stratified deposits of probable late Holocene age. The T_2 surface lies 6 to 7 m above the channel, and is separated from the T_1 by a gradual slope to the east and an abrupt, rounded scarp to the north of the excavated blocks. The T_2 surface rises very gradually to the west, imperceptibly merging with a broad Pleistocene terrace surface of the Colorado River.

The site area is mapped as the Weswood soil series (Clower 1980), while soils mapped in the vicinity include the Winters, Throck, Callahan, and Bonti series. The following soil descriptions are based on updated series descriptions downloaded from the United States Department of Agricultural web server (http://www.statlab.iastate.edu). The Weswood silt loam is a Udifluventic Ustochrept that typically exhibits an Ap-Bw1-Bw2-BCk-2BWb1-2Bwb2-2Bwb3-3Ab1-4Ab2 profile developed in stratified, calcareous loamy alluvium. It is typical of stream floodplains in the middle Colorado and Brazos drainage basins. Winters soils are mapped on the surrounding Pleistocene alluvial terraces. They are classified as Typic Paleustalfs and exhibit an Ap-Bt1-Bt2-Bt3-Btk-B’t profile developed in loamy to clayey alluvium. Throck, Callahan, and Bonti soils are typical of the slopes and uplands surrounding the site. Throck soils are Vertic Ustochrepts that have developed on residuum and colluvium derived from clayey marls and shales, and typically exhibit an A-Bw-Bk1-Bk2-BC-Cr profile. Bonti soils are Ultic Paleustalfs formed on residuum of interbedded sandstones and shales, and typically exhibit an A-E-Btl-Bt2-R profile. Callahan soils are Typic Haplustalfs that form on relatively steep slopes underlain by bedded sandstones and shales, and exhibit an Ap-Bt-Btk-Btk/C-Crk profile.

6.1.2 Backhoe Trench Descriptions

Four backhoe trenches were excavated on the T_1 and T_2 surfaces. BT l was excavated to a depth of 150 cm on the stream ward margin of the T_1 surface overlooking the channel of Crooked Run. BT l revealed a weak, multistory soil profile developed in stratified alluvium. The surface (A) horizon consists of very dark brown (10YR 3/3), weakly platy loamy sand. It is 15 cm thick and exhibited a clear, bioturbated boundary. It is underlain by a 20 cm thick, massive dark yellowish brown (l0YR 4/4) loamy sand C1 horizon that grades into a 10 cm thick, massive yellowish brown (10YR 5/4) loamy sand C2 horizon. This horizon is separated from the underlying 2Ab horizon by a clear, bioturbated boundary. The 2Ab horizon is 20 cm thick and consists of a massive, very dark grayish brown

(10YR 3/2) loamy sand. It grades gradually into a 55 cm thick, massive loamy sand 2C1 horizon. Bioturbation mottles and preserved remnants of primary bedding are common throughout this thick, brown to dark yellowish brown (10YR 4/4 to 5/3) horizon. The underlying 2C2k horizon, separated from the 2Cl by a clear boundary, consists of a 7 cm thick deposit of weakly blocky, dark reddish brown (5YR 3/3) calcareous sandy clay containing well-developed carbonate filaments. It was underlain successively by a thin (7 cm) deposit (2C3 horizon) of loamy sand similar to the overlying 2C1 and a dark reddish brown, structured calcareous sandy clay (2C4k horizon) similar to the 2C2k horizon. At the base of the trench, 10 cm of an underlying massive, dark brown (7.5YR 3/4) sandy loam containing common fine carbonate filaments was exposed. With the exception of the two reddish mud drapes and the dark brown basal deposits, the sediments in BT l are uniformly noncalcareous.

BT 2 was excavated on the flat T_1 terrace tread about 10 m west of BT l, and revealed a more distal version of the same stratigraphic sequence. It is uniformly noncalcareous throughout (Figures 6-1). The A horizon is 15 cm thick and consists of dark brown (7.5YR 3/3) sandy loam. It is underlain by 60 cm of brown (7.5YR4/4), massive to weakly stratified sandy loam (C1 horizon). This horizon graded into a 50 cm thick, dark brown (7.5YR 3/3) sandy loam 2Ab horizon, which graded in turn into more massive to weakly stratified, brown (7.5YR 4/4) sandy loam (2Cb horizon). At 180 cmbs, this horizon graded into a loamy gravel deposit dominated by well-rounded siliceous gravels. The trench was discontinued at a depth of 190 cmbs. Isolated burned sandstone rocks, almost certainly in secondary context, were noted at intervals between 25 and 125 cmbs.

BT 3 was excavated on the gentle riser between the T_1 and T_2 terraces, approximately 10 m west of BT 2. It was not completed due to the discovery of a continuous, stream warddipping zone of burned sandstone clasts approximately 60 to 80 cmbs. The upper horizons consisted of massive to weak blocky structured, noncalcareous, dark brown (7.5YR 3/2) sandy loam that graded into brown (7.5 YR 3/4) sandy loam with depth. Subsequent hand-excavation of Block 2 revealed that the rocks mantled a dipping erosional surface cut into an older unit of reddish brown (5YR 4/4) sandy loam containing sparse, well rounded siliceous gravels.

BT 4 was excavated on the T_2 terrace tread adjacent to Block 1. It revealed a section through a series of welded late Holocene flood drapes deposited on a probable early to middle Holocene alluvial fill (Figure 6-2). The upper 15 cm of the section (approximately) was removed by scraping during the preparation of Block 1, and was not described in detail. In general, it consists of a massive to weakly granular, dark brown (7.5YR 3/3) sandy loam (A1 horizon). At approximately 15 cmbs burned rock was encountered and scraping was discontinued. This depth approximates the transition from the sandy A1 horizon to a slightly darker, finer grained A2 horizon. This horizon is 30 cm thick and consists of a weak medium blocky structured, dark reddish brown (5YR 3/2) noncalcareous sandy loam. Burned sandstone slabs, small flat and basin-shaped sandstone features, and relatively abundant lithic debitage were dispersed throughout this horizon. Structure is weakly expressed, but fine, open pores are common. At approximately 45 cmbs, this horizon grades into a 10 cm thick AB horizon composed of weak medium blocky, dark reddish brown (5YR 3/2) sandy loam. Artifactual material was still common in this horizon. At approximately 60 cmbs, the AB horizon grades into a well-structured, dark reddish brown (5YR 3/3) 2Btk horizon that extends to 90 cmbs. Although no definitive evidence was noted, it is likely that this transition represents an unconformity blurred by pedogenesis (hence the designation 2Btk). The 2Btk horizon consists of sandy clay loam, exhibits weak discontinuous argillans on a few peds. Well-developed carbonate films are present on the ped faces and occasional weak filaments are present along root traces in the ped interiors. The horizon contains common artifacts.

With the exception of the visible secondary carbonate, the matrix is largely noncalcareous. At 90 cmbs the section grades relatively abruptly into the same type of older, reddish sediment observed beneath the burned rock in Block 2 (3B1k horizon). This unit also contains common carbonate filaments, and consists of massive, reddish brown (5YR

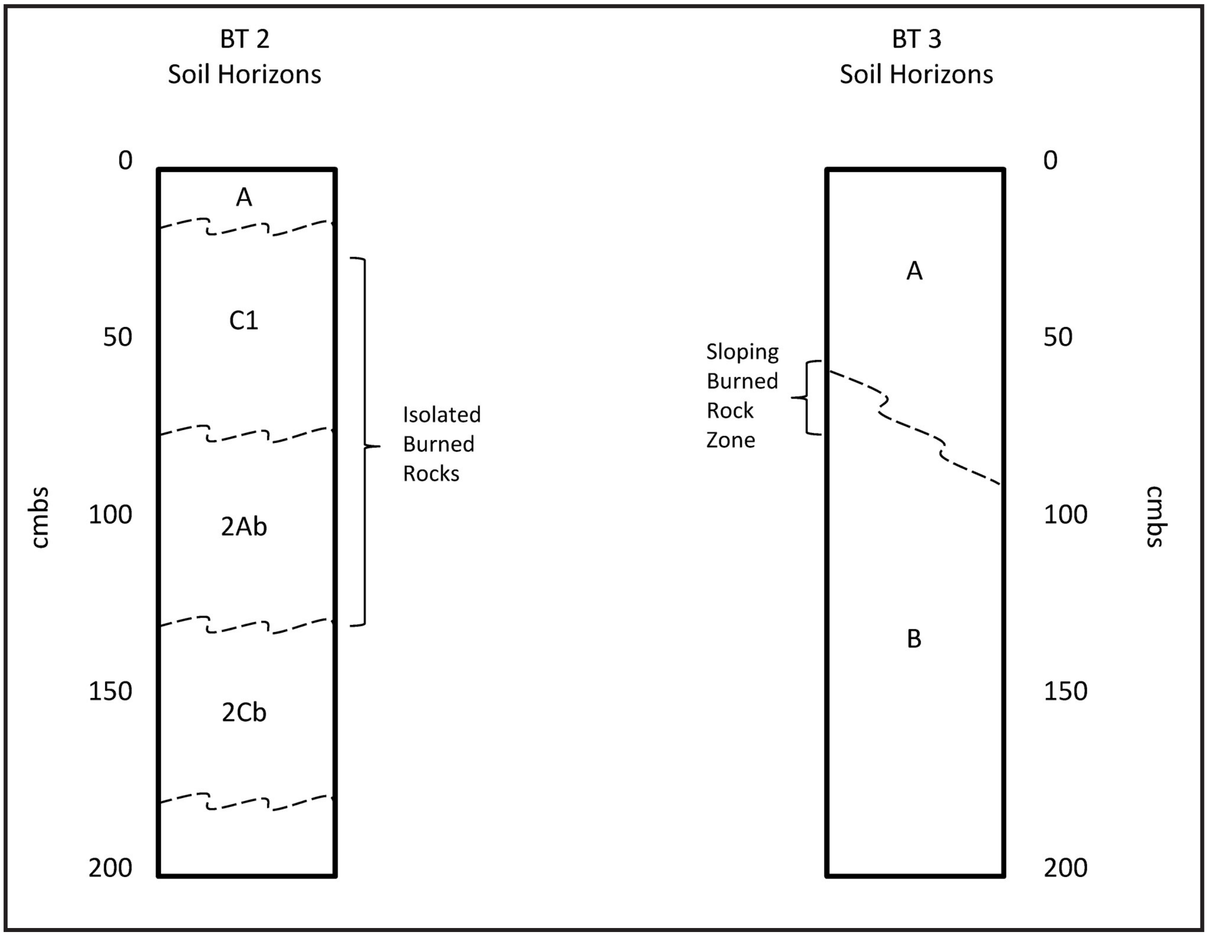


Figure 6-1. Broad soil horizons in Backhoe Trenches 2 and 3 at 41MI96.

4/4 to 5/4) sandy loam. With the exception of the violently effervescent filaments, the matrix of the 3B1k horizon ranges from very weakly calcareous to noncalcareous. Burned rock and flakes are still present, albeit in markedly reduced numbers. At approximately 120 cmbs, the profile grades into a slightly darker, finer grained version of the same unit. Small, stream-rounded siliceous gravels are dispersed throughout this horizon, and a few isolated burned sandstone chunks and two mussel shells were noted in section.

6.1.3 Discussions

Figure 6-3 illustrates the generalized stratigraphy of 41MI96. Two principal depositional units are identified in the cross-section. Unit 1 is a reddish brown sandy loam with common, dispersed, matrix-supported siliceous gravels, and forms the core of the T_2 terrace. Unit 2, a brown to reddish brown sandy loam with at least one weak intercalated paleosol, forms the body of the T_1 terrace and drapes up over the T_2 terraces as a veneer. This veneer contains the majority of cultural material observed at the site. The unconformable nature of Unit 1 and Unit 2 is clearly indicated by the burned rock mantled angular unconformity exposed in BT 3/Block 2. A third potential unit of intermediate age is represented by the thin 2Btk horizon exposed in BT 4/Block 1. This horizon is not present (laterally truncated) in Block 2, and it is unclear if it is younger than or roughly coeval with the Unit 1 fill, although the former is considered more likely. Like the rest of the alluvial veneer, it contains a considerable quantity of burned rock and lithic debitage. A third, very young unit, is present adjacent to the channel on the north side of the site only, and is not illustrated in the figure.

Figure 6-2. Photograph of profile of Backhoe Trench 4 at 41MI96.

Several aspects of the sequence are noteworthy. Although the soil developed in Unit 1 is broadly consistent with most characteristics of the typical, multistory Weswood soil series, it is somewhat coarser grained (sandier) than typical for the series. More importantly, the soils associated with Unit 1 deposits are usually noncalcareous, which is distinctly different from the typical Weswood soil. The exceptions to this generalization are the two thin beds of structured red mud found in the lower part of BT 1. These muds are interpreted as thin, slackwater mud drapes deposited during floods on the Colorado. In contrast, the remaining deposits are derived from calcite-poor Pennsylvanian sandstones in the small Crooked Run drainage basin, and are probably relatively acidic. This may well explain the marked paucity of bone, charcoal, and other organic remains recovered from the site.

Because the older deposits (Unit 1 and the 2Btk horizon) are derived from the same source area, they were also originally noncalcareous. The fact that they now exhibit a moderately well-developed stage 1 carbonate horizon indicates that the carbonate is probably of aerosolic origin. However, it is possible that the 2Btk horizon represents alteration of a thick slackwater mud associated with Colorado River flooding, similar to those identified in BT 1.

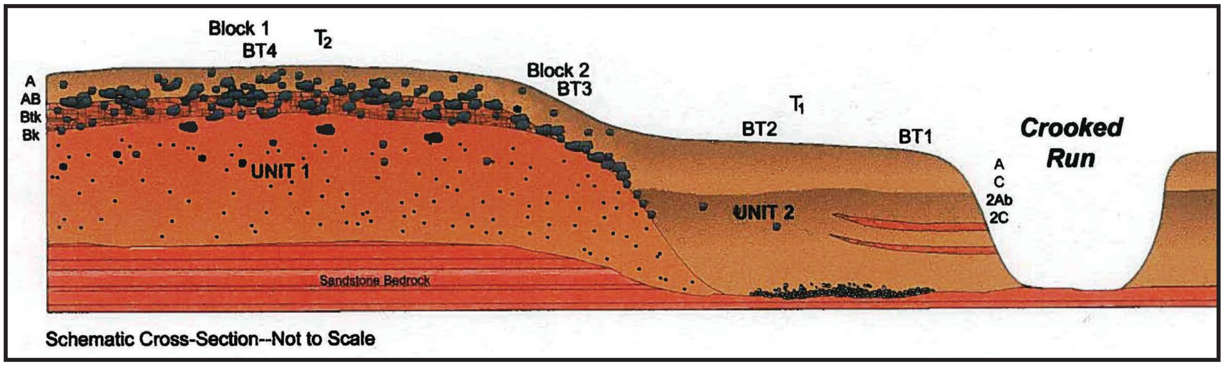


Figure 6-3. Generalized skematic cross-section of deposits at 41MI96.

6.2 CULTURAL STRATIGRAPHY

J. Michael Quigg

6.2.1 Introduction

This discussion of cultural stratigraphy is presented in two parts, each centered on one of the two hand-excavated blocks: Block 1, dug into the upper T_2 and Block 2, dug into the sloping zone between the T_1 and T_2. The stratigraphy for Block 1 is discussed first, followed by Block 2. Following these presentations, a concluding section presents the direction that TxDOT and TRC agreed upon for the analyses and reporting.

6.2.2 Block 1

As discussed in the section on natural stratigraphy above, BT 4 was excavated on the high T_2 terrace at ST 3 and into the late Holocene flood-drape deposits that are welded onto early to middle Holocene alluvial fill. Abbott documented the sequence of depositional events as revealed at the eastern side of BT 4 to a depth of 150 cmbs. In conjunction with the natural sequence, he noted the presence of cultural materials in the profile of BT 4 in relation to those deposits (Figure 6-4 profile). No hand-excavations were conducted from the original ground surface to the base of these alluvial deposits, and only Abbott's general observations of the locations of cultural materials are available for the entire 150 cm thick section of inspected sediments. In general, Abbott observed burned rocks throughout the entire section. Dense cultural materials were observed in the A horizon to a depth of about 45 cmbs, and continued into the transitional AB horizon to about 60 cmbs. The underlying 2Btk horizon, to about 90 cmbs, was distinguished by a compact dark reddish brown (5YR 3/3) sandy clay loam, and also contained numerous artifacts. Below 90 cmbs, in the 3Bk1, burned rocks and flakes were still present, but in reduced numbers. Below 120 cmbs were a few burned rocks and mussel shells. Abbott's notes and observations of cultural materials throughout the top 120 cmbs of BT 4 reveal remnants of multiple occupations within multiple soil horizons, but the precise number of represented cultural events is unclear. The roughly 20 cm thick zone in the A horizon, although it appears to be one of many zones that represent human occupation, was the only one targeted by the hand-excavations. The mussel shells and two associated large chert flakes at 90 cmbs indicate the presence of at least two zones of dense materials in the upper 150 cm of deposits.

Block 1, which consisted of eleven 1-by-1 m units, joined the western edge of BT 4 (Figure 6-5). The entire surface of Block 1 and BT 4 was mechanically scraped prior to hand-excavations in test units. When burned sandstone was encountered at roughly 10 to 30 cmbs, the scraping stopped and 1-by-1 m units were established inside the scraped area. The western side of the Block 1 was apparently scraped to about 30 cmbs, and the eastern side was scraped to 10 to 15 cmbs. In most hand-excavated units, no actual vertical measurements were recorded for the levels or the cultural artifacts encountered. Arbitrary levels were used in most instances to record the positions of encountered materials, but because of a lack of depth recording at the corners of the units, the precise depths of features cannot be reconstructed. Thus, there is considerable uncertainty concerning the exact vertical positions and stratigraphic association of artifacts and features.

Hand-excavations were conducted in roughly 10 cm arbitrary levels except for Level 1. Level 1 was effectively used to create a level surface after the uneven mechanical scraping, and thus, was less than 10 cm thick. The original starting depth below ground surface of Level 1 is not clear, though it appears that the hand-excavations were initiated at roughly 10 to 30 cmbs and extended to about 60 cmbs. The vertical distribution of lithic debitage and features in this depth range, which included four hand-excavated levels, is depicted in Figure 6-6. The dramatic drop in frequency in Level 4 is based on data from TU 1 only, and means that the dramatic decline in abundance is not real, but is rather due to the fact that only one unit was excavated to Level 4.

Unfortunately, burned rocks were not counted or weighed by level, so their frequency by level is generally unknown, except for piece plotted specimens on the level records. The burned rock counts presented here are derived from field illustrations on level records, and should be considered a minimum number, since not all burned rocks were plotted (Figure 6-7). At least 252 burned rocks were drawn on the level records.

The few field notes, combined with the level records, indicate that burned rock Features 1, 2, and 3 were in Level 1 and potentially associated vertically. Features 2 and 3 were in adjoining units, whereas Feature 1 was roughly 1 m to the south. All three features were toward the western end of Block 1. Burned rock Features 5 and 7, in Level 2 of TU 7 and Level 3 of TU 9, respectively, were apparently situated below Features 1, 2, and 3 and above Feature 4. The latter feature was in Level 4 of TU 1 at the eastern end of the block. However, Features 5 and 7 may actually

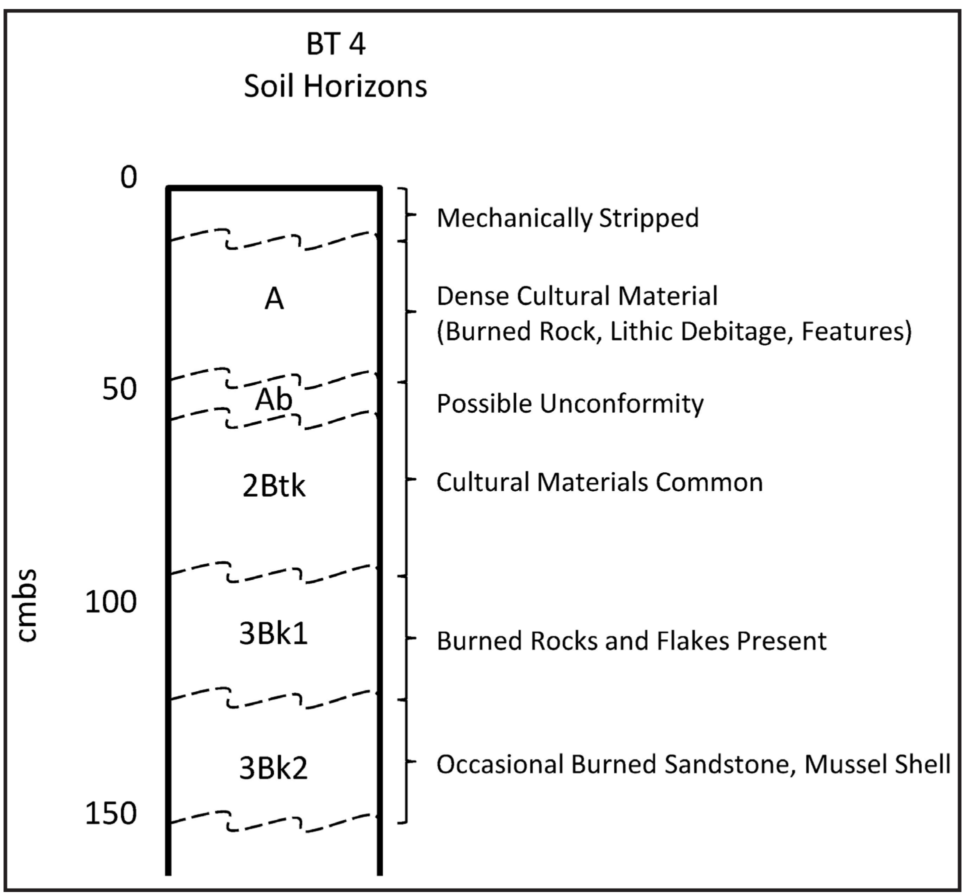


Figure 6-4. Cultural materials observed in relationship to soil horizons in Backhoe Trench 4.

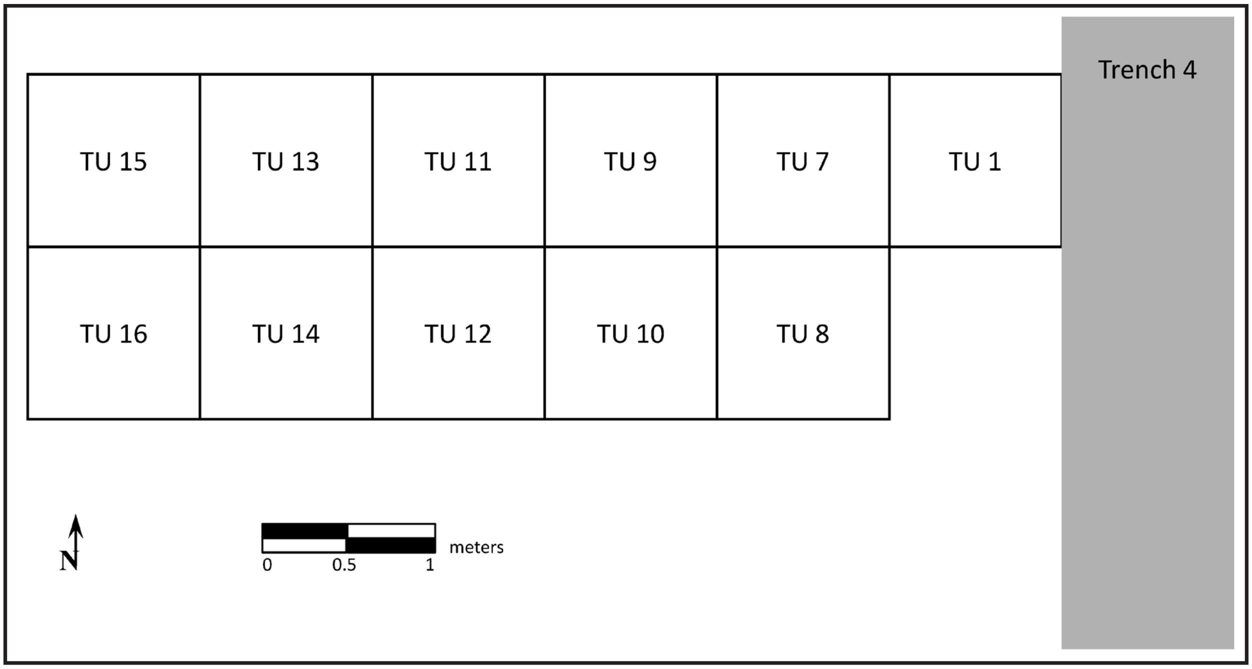


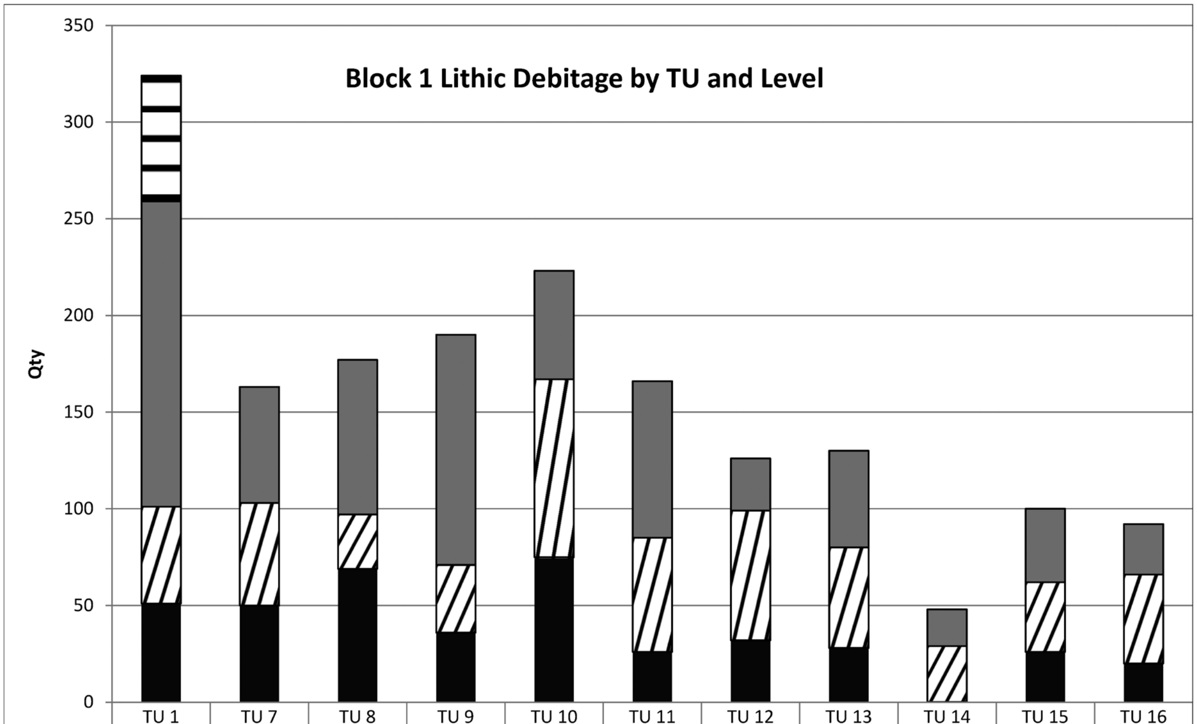
Figure 6-5. Test units in Block 1 in relationship to Backhoe Trench 4.

be in the same vertical zone, as the stripped surface was uneven and there was apparently some general slope to the deposits. Feature 4, the lowermost feature, appeared associated with a broad-bladed, corner-notched biface, referred to as a Castroville-like point in the field notes. This artifact was found *in situ* at 55 cmbs in TU 1, the same unit as Feature 4, but a slightly lower elevation. The specimen in question is significantly larger than most dart points and likely is a large hafted biface of a different function (see below for more discussion).

6.2.3 Block 2

The general area of ST 2, BT 3, and Block 2 on the gentle rise between T_1 and T_2 was approximately 12 m west of BT 2. Mechanical stripping in the vicinity of ST 2 occurred over a roughly 3-by-5 m area. The geoarcheologist did not complete documentation of the natural deposits in BT 2 due to the discovery of a continuous, streamward-dipping zone of burned sandstone fragments between about 60 to 80 cmbs. Following the discovery of the burned rocks in the bottom of BT 3, five 1-by-1 m test units (TUs 2 through 6) were established over the exposed burned rocks and the hand-excavations targeted this zone of rocks (Figure 6-8). Hand-excavation began below the original ground surface and included 23 levels.

Five levels were hand-excavated in TUs 2 through 6. Most levels were roughly 10 cm thick except for Level 1, which was apparently used to clean and level off the mechanically scraped surface. One composite drawing of the five units shows the elevations below a vertical datum of nail heads placed at the unit corners of the units at a below datum (bd) elevation. Next to that depth is the depth of the stripped surface at the bottom of Level 1. Notes from TU 3 indicate that Level 4 was at the transition from the A to B horizon. Level 5 was entirely within the B horizon and contained calcium carbonate along ped faces, but no burned rocks. Level 4 of TU 4 contained small gravels within the B horizon, but, again was devoid of burned rocks. The record for Level 4 in TU 5 mentions that "burned rocks seem to be at contact between A and B" horizons, while the record for Level 4 in TU 6 state that "burned rocks are following slope of B or slope of surface of B horizon, which seems to be sloping to the east". In at least one instance, the slope is projected to have a vertical dip of about 10 cm per linear meter of horizontal distance.



	TU 1	TU 7	TU 8	TU 9	TU 10	TU 11	TU 12	TU 13	TU 14	TU 15	TU 16
Level 4	65										
Level 3	158	60	80	119	56	81	27	50	19	38	26
Level 2	50	53	28	35	92	59	67	52	29	36	46
Level 1	51	50	69	36	75	26	32	28	0	26	20

Figure 6-6. Distribution of lithic debitage in Block 1 by test unit (TU) and level. Note TU 1 was the only unit with four levels excavated and Level 1 was only a partial 10 cm level.

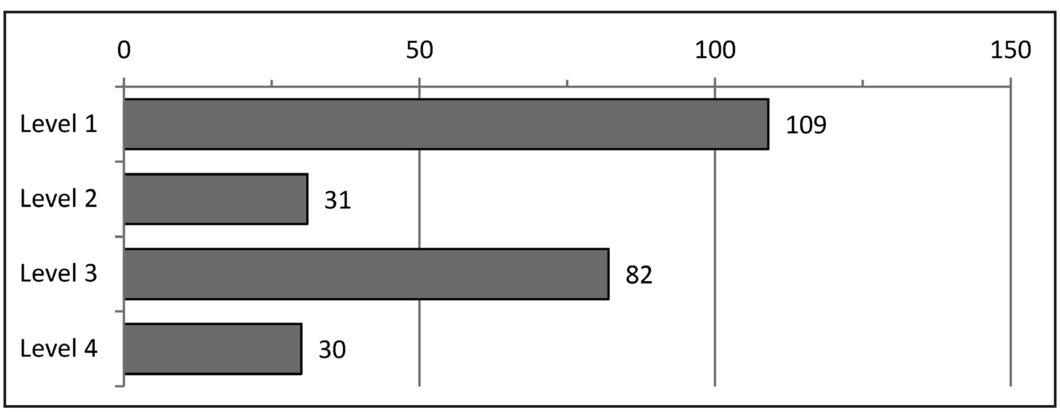


Figure 6-7. Vertical distribution of burned rocks in Block 1 plotted by level for all test units. Note: figure represents a minimum number based on counts of plotted pieces plotted on level records.

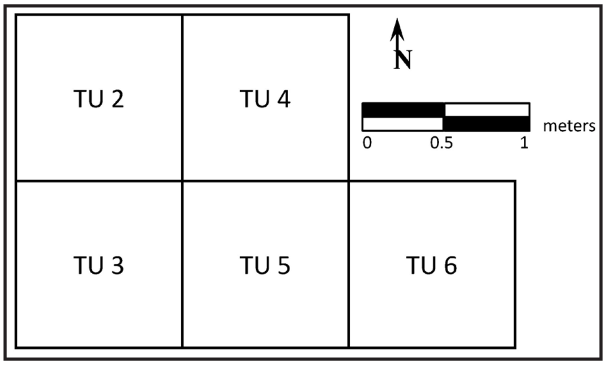


Figure 6-8. Test units in Block 2.

Fifteen level records showed horizontally plotted burned rocks in association with considerable lithic debitage. Roughly 340 burned rocks were plotted on the 15 level records, and nearly 1,100 pieces of lithic debitage were collected from these excavations (Figures 6-9 and 6-10). However, actual beginning and ending depths of the levels, and precise depths of the burned rocks within are unclear, as depths were inconsistently recorded, and when recorded, unclear whether referencing depth from the original ground surface, or from the scraped surface. The notes do mention that the burned rocks were concentrated along a sloping plane. No profiles evidencing this were documented, and plotting the rocks vertically is impossible, given unclear vertical provenience.

Consequently, it is assumed the burned rocks and lithic debitage were concentrated in a roughly 20 to 25 cm thick zone on the sloping surface noted by the geoarcheologist. No burned rock concentrations were designated as discrete features. The notes in the notebook and on Level 5 in TU 6 indicate that, in at least one instance, a tight concentration of 13 burned rocks was encountered and plotted. This concentration was in a tight, ovate pattern that measured about 36 cm north-south by 30 cm east-west, all at the approximate depth of 73 to 80 cm in Level 5 in TU 6. Although noted and drawn with depth measurements recorded, this cluster was not identified or treated as a feature. Consequently, this concentration was not cross-sectioned and samples were not collected. This cluster, and many other burned rocks in the surrounding units, were said to be resting at the bottom of the A horizon and on top of the B horizon. In the end, the geoarcheologist interpreted the burned rocks as resting on a dipping erosional surface cut into a reddish brown (5YR 4/4) sandy loam that contained sparse well-rounded siliceous gravels (see the Natural Stratigraphy section 6.1 above).

A review of differing depth measurements indicates that the zone of cultural materials, between 60 and 80 cmbs, as estimated by the geoarcheologist, was more or less accurate. Minimally, Level 5 in TU 3 was excavated into the compact reddish B horizon with carbonate filaments. No burned rocks were encountered and only 12 chert flakes were recovered from the B horizon and Level 5. The small flakes recovered may have filtered downward over time. Although no burned rocks were present in the reddish B horizon in TU 3, cultural materials were in and below the B horizon, and continued to at least 150 cmbs, similar to what was observed in BT 4 at Block 1.

6.2.4 Conclusions

Based on the presence of multiple intact, *in situ* burned rock features, associated with large quantities of lithic debitage, and at least one hafted biface in Block 1, this block has been targeted for more intensive and focused analyses and discussion in this report. The seemingly close vertical association of cultural materials may indicate a restricted time period of accumulation. This zone of cultural materials is conceptualized herein as a component, worthy of focused analysis, even though it may, in actuality, represent a palimpsest of events. Initially, it appeared the six features probably were assignable to the general Late Archaic period. However, radiocarbon dates, obtained on two burned rocks from Feature 3, indicate this, and possibly nearby Features 1 and 2, are likely Late Prehistoric in age or represent very late Archaic events.

In contrast, Block 2 lacked identified features, charcoal, formal stone tools, and diagnostic artifacts, which, combined with the paucity of details concerning depths of burned rocks, makes further analysis of those materials less informative. Therefore, the following report focuses on the multiple cultural features and apparent associated cultural materials in Block 1, which are thought to primarily represent a Late Archaic component. The materials from Block 2 will be presented in more

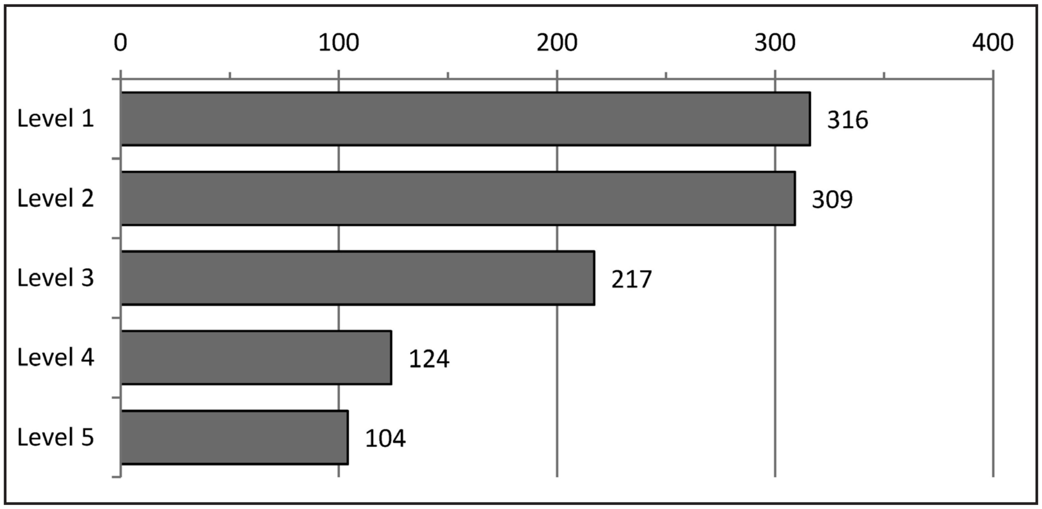


Figure 6-9. Vertical distribution of lithic debitage in Block 2 by level for all test units.

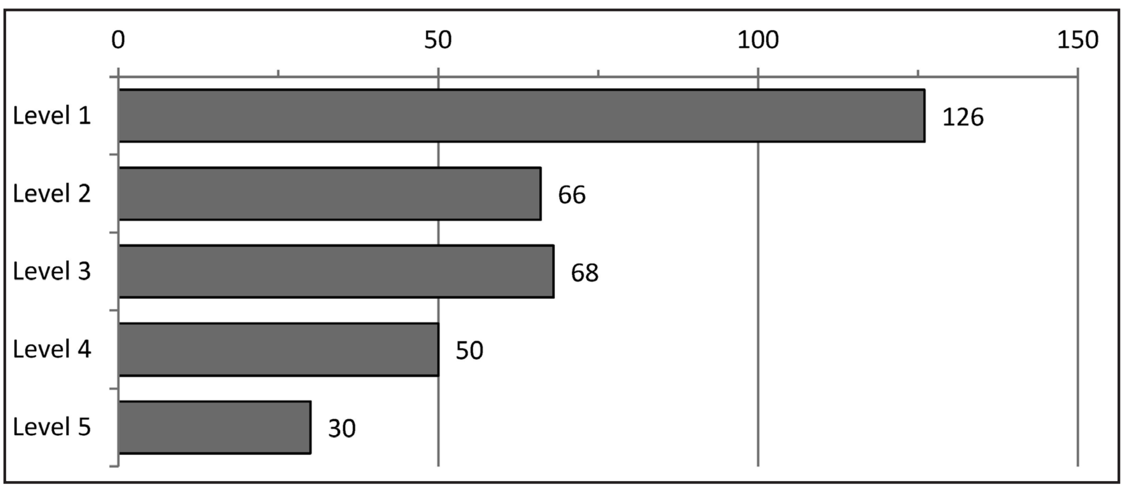


Figure 6-10. Vertical distribution of burned rocks in Block 2 by level for all test units.

limited format in a separate section as approved by TxDOT.

6.3 THE LATE ARCHAIC COMPONENT IN BLOCK 1

The following sections present the details on the findings and interpretations of the cultural materials from Block 1 of 41MI96. First, the features are described, along with the technical analyses conducted on selected burned rocks from the individual features. This is followed by descriptions of the chipped stone tools, including results of use-wear analysis conducted on selected tools. The debitage analysis is next, followed by presentation of selected attributes on the few burned rocks collected from the features.

6.3.1 Occupational Features

J. Michael Quigg

Six numbered features, Features 1 through 5 and Feature 7, were identified and excavated in Block 1 (Figure 6-11). Technically, Feature 1 was not excavated as part of Block 1, but it overlapped the southern margin of the block, and apparently was part of the group of features in Block 1. These six features are described and discussed below in numerical order. Selected burned rocks from certain features were targeted for technical analyses (i.e., radiocarbon dating to obtain relative ages, lipid residue and starch grain analyses to identify the foods cooked using the burned rocks) to contribute to an overall understanding of feature function. The results of the technical analyses are incorporated into the feature descriptions, where appropriate. Feature 6 is an unknown, as there are no TxDOT records for this feature.

6.3.1.1 Feature 1

This was a dense concentration of tightly clustered burned sandstone fragments discovered and exposed during the initial mechanical scraping of the surface at the assumed location of the proposed burned rock midden at ST 3. This concentration was investigated prior to the establishment of the 1-by-1 m units that formed Block 1. Even after mechanical scraping, this concentration appeared mostly intact (Figures 6-12 and 6-13). Feature 1 was roughly 25 to 30 cmbs into the A2 soil horizon. The feature was exposed, cleaned, photographed, the southern portion mapped, with the northern portion apparently removed, but not collected before mapping occurred. No level

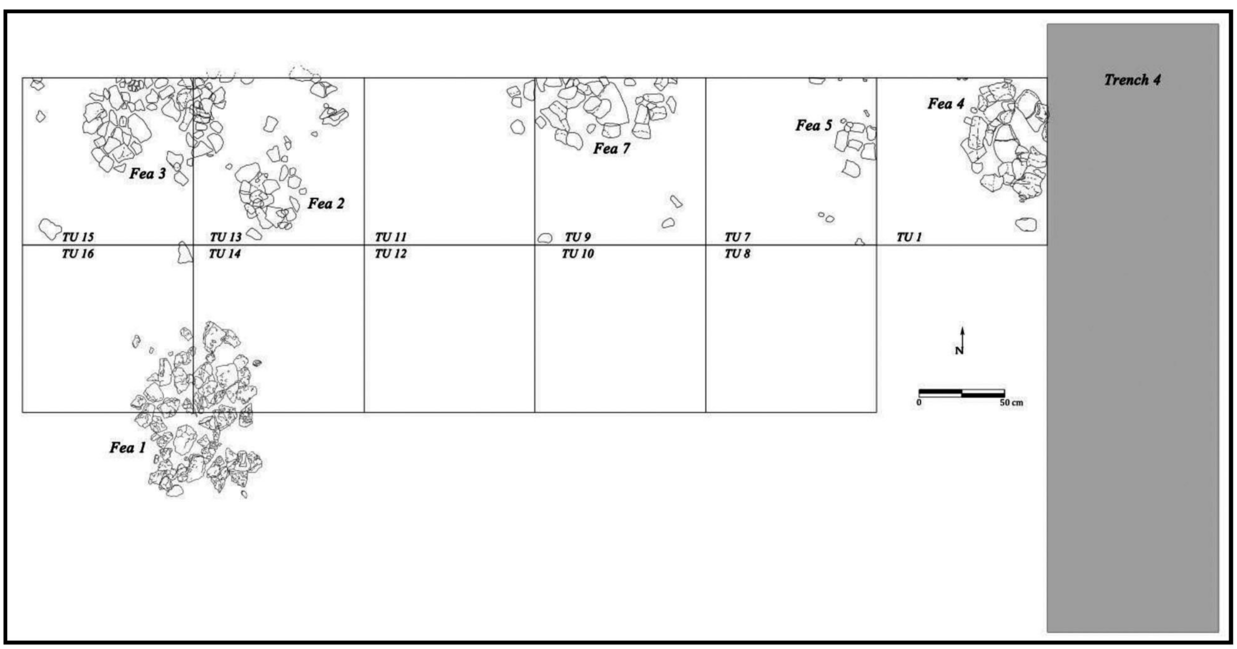


Figure 6-11. Horizontal distribution of Features 1 through 5 and Feature 7 in Block 1. Note that radiocarbon dates indicate the features are not all the same occupation.

Figure 6-12. Plan view of exposed Feature 1.

Figure 6-13. Profile of exposed Feature 1 burned rocks.

records were present for this feature, but a "Feature Recording Form" was completed.

The following data were extracted from the feature form. Feature 1 measured 91 cm north-south by 85 cm east-west. Twenty-three rocks were mapped in approximately the southern half. The rocks formed a dense, relatively ovate pattern with generally one flat layer of rocks resting on a more or less level surface. Several rocks were fractured *in situ.* Of the 30 burned rocks recorded, 17 were described as flat slabs, 12 as angular in shape, 1 unknown. Sizes varied: 10 were less than 3 cm long, 9 were 3.1 to 10 cm long, 6 were 10.1 to 15 cm, and 5 were longer than 15 cm. The largest slab appeared to have a possible ground surface on one side, and possibly was a fragment of a metate. Only one possible sandstone mano was collected from Feature 1. Evidence of light burning was observed under some rocks. Light charcoal flecking in a nearly undetectable lens under the rocks was observed and a small sample was collected from the center of the feature after the rocks were removed. A soil sample and the lithic debitage present were collected.

No specific rock depths or weights were recorded. Although collections of such were indicated in paperwork, no sediment or charcoal was available for analysis. The lack of collected burned sandstone pieces prevented analyses of the rocks that might determine the kinds of foods cooked and thereby elucidate the function of this apparent heating element.

With the establishment of the 2-by-5 m block of test units, TUs 14 and 16 encompassed the area where the northern part of Feature 1 had been. The southern half was outside the limits of the hand-excavated test units. Although the northern half of Feature 1 had been removed previously, the southwestern quadrant of TU 14 encompassed the northeastern quadrant of Feature 1. The remainder of TU 14 yielded a scatter of some 12 burned rocks, including some large and medium-sized burned rocks in Level 2. The southeastern corner of TU 16 encompassed about 20 cm of the northwestern corner of Feature 1. About 35 to 40 cm to the northwest of the projected limits of Feature 1 was a tight cluster of burned rocks, three of which were 15 to 25 cm pieces of sandstone, along with two or three smaller pieces.

Feature 1 is interpreted as a flat heating element, based on size and shape, and presence of charcoal and stained sediments immediately beneath the rocks indicates an *in situ* feature. The sparse nature of the charcoal is assumed to be a function of preservation. The lack of collected charcoal and burned rocks or other organic materials precluded direct radiocarbon dating of this feature. The absence of recorded rock depths also prevents assessment of Feature 1 association with other burned rock features located immediately to the north.

6.3.1.2 Feature 2

This was a relatively tight concentration of burned sandstone fragments located toward the south-central part of Level 2 in TU 13 (Figures 6-14 through 6-16). These rocks were within the A horizon, with tops exposed in Level 1 and the bases resting in Level 2. This feature was drawn on the level records and photographed in color. Roughly 22 rocks were mapped in this circular concentration, which measured roughly 60 cm north-south by 40 cm east-west. The rocks on the southwestern side were closely spaced, whereas some on the northeastern side were slightly scattered. Large (roughly 15 cm long) and small (roughly 4 cm long) rocks are depicted in the drawing; at least 11 have an arrow of slope indicating a roughly 5 to 10 degree dip in varied directions. The rocks were mostly slabs of reddened sandstone that ranged between 0.7 and 3 cm in thickness, with the largest being about 15 cm in length. A cross-section through the middle of the feature revealed a shallow, 10 to 15 cm deep basin filled with three to five courses of rocks. Many rocks had been fire-fractured *in situ.*

Two bags of feature fill for flotation plus four rocks (#1 through #4) for potential chemical analysis were collected. A few flakes were recovered in association, but no charcoal, oxidized soil or snail shells were noted.

The rest of Level 2 in TU 13 yielded a few scattered burned rocks towards the northeastern corner and a concentration of 8 to 10 burned rocks in the northwestern corner. The latter concentration was part of Feature 3, which was mostly in the adjacent TU 15. The field drawing indicates the possible association of Features 2 and 3 within the same

Figure 6-14. Plan view of Feature 2 (left of trowel) in Level 1 of Test Unit 13.

Figure 6-15. Profile of Feature 2 (foreground) with Feature 3 (background).

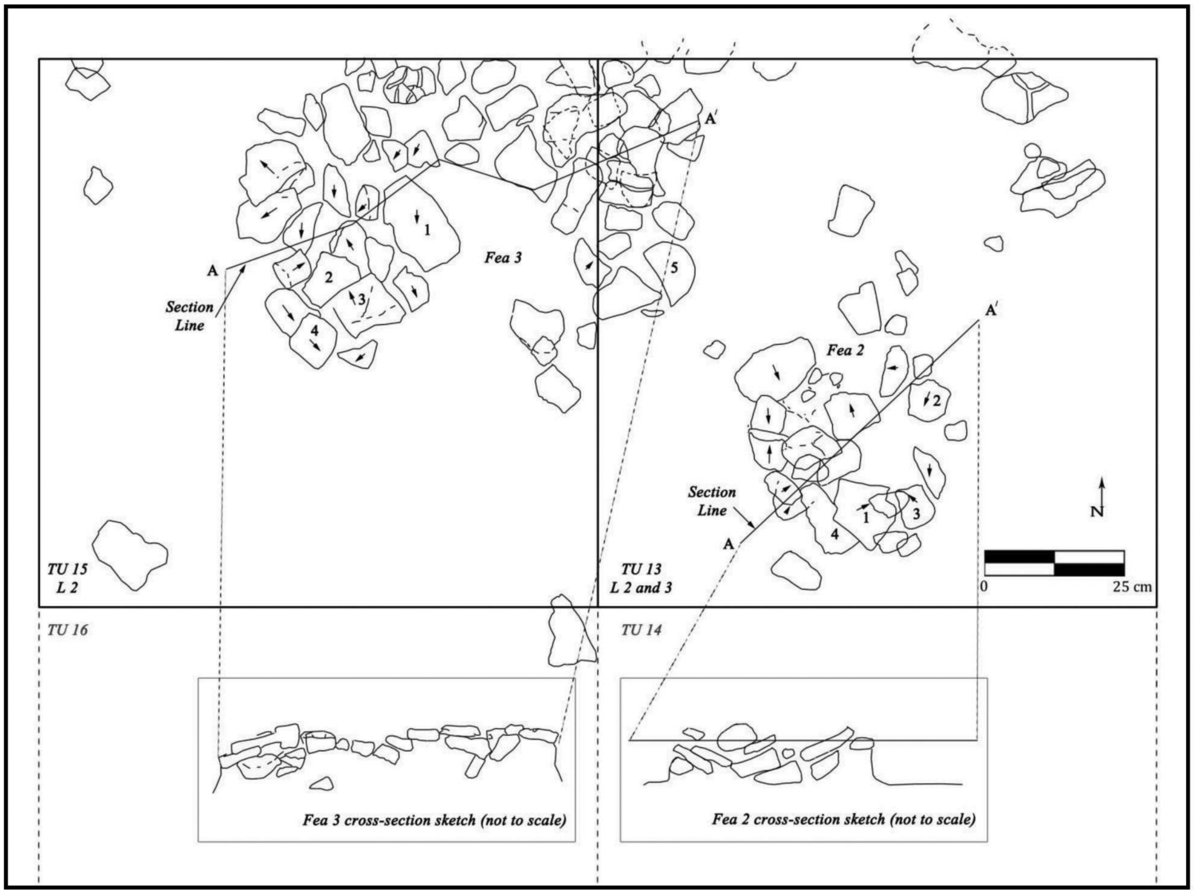


Figure 6-16. Plan views and profiles of Features 2 and 3 adjacent to one another.

vertical zone, but the association was not certain since actual rock depth measurements were not recorded. A few burned rocks were also mapped in Level 1 above this concentration and Level 3 below it.

Parts of four burned rocks (field numbers #1 through #4 [61-1 through 61-4]) were selected for both lipid residue and starch grain analyses. At the general level, lipid residues extracted indicate low to medium fat content. This was interpreted to represent plants with traces of animal products in all four fragments (Appendix D). Also detected was the presence of conifer products. This is likely the soot remains of juniper wood used in the fires to heat the rocks.

Starch grain analysis revealed multiple plant resources were cooked with these burned rocks, evident from starches present on three of the four rocks. Starch from a lenticular grass, likely either wildrye or little barley, damaged from grinding or gelatinization, was present on fragment 61-2. Maize starch was identified on two other rocks along with one unidentifiable grass grain (Appendix C). A 52 g piece of rock #2 (61-2c) was submitted for direct radiocarbon dating. The outer surface was targeted and yielded organic carbon suitable for AMS dating. This residue yielded a conventional AMS date of 910 ± 30 B.P. (Beta-323141).

Feature 2 is interpreted as a small, *in situ* basin heating element that was used to cook primarily plant products, although traces of animal products were detected.

6.3.1.3 Feature 3

This was a horseshoe-shaped cluster of tightly spaced burned sandstone, located primarily in the northeastern quadrant of Level 2 in TU 15 (Figures 6-17, 6-18, and 6-16). The extreme eastern end continued into the northwestern corner of Level 2 in TU 13. The rocks were first exposed in Level 1 of both units, but base depths were in Level 2. The mapped burned rocks reveal a horseshoe shape, with the opening to the south. The observed portion measured 80 cm east-west by at least 65 cm north-south. A very tight cluster of two to three layers was on the western side of the horseshoe and may have represented the principle intact portion of the feature. Roughly 23 rocks were in that tight cluster, with at least 15 tilted at an angle. The eastern part of the horseshoe had highly fractured rocks that were stacked one to two layers thick. An east-west cross-section was completed and drawn.

The area in the middle or opening of the horseshoe shape that was devoid of rocks revealed a slight, shallow basin with rocks stacked on either side. Many rocks appeared to have been broken in place.

This feature lacked obvious charcoal and snail shells, but a few chert flakes were encountered. Five numbered rocks (#1 through #5) were collected for potential chemical analysis. Numbered Rocks #1 through #4 (69-1 through 69-4) were part of the tight cluster on the west side of the horseshoe, while Rock #5 (62-5) was at the extreme eastern margin of the horseshoe in TU 13 (see Figure 6-16). The level records indicate that Rock #5 was a possible mano fragment. Two bags of feature fill were collected for flotation.

A soft mottled area about 40 cm in diameter was detected on the western side of TU 15. This may be an old fence posthole or, possibly the initial ST 3 in which burned rocks were found near the bottom. Only a couple of other burned rocks and one rock mapped as a possible mano fragment were drawn at the level of Feature 3. Scattered burned rocks were in Level 1 above and Level 3 below. The soft mottled area continued through Level 3.

Parts of four burned rocks (Rocks #1, #2, #3 and #5) were selected for both lipid residue analysis and starchgrain analysis. Lipid residues extracted indicate primarily traces of animal and plant products, with the exception of Rock #1, which yielded residues indicative of large herbivore (e.g., deer, bison) as well (Appendix D). Rock #2 also yielded traces of conifer products, which are most likely residues from juniper wood used in the heating of the rocks.

Starch grains were present on three of the four rock fragments, and include at least two maize grains and two unidentifiable grains. One maize grain exhibits damage from gelatinization, meaning it was in contact with heat and water which distorted its natural form (Appendix C). Gelatinization is generally associated with boiling.

Fragments of Rock #1 (69-1c) from Level 2 in TU 15 and Rock #5 (62-5c) from Level 2 in TU 13 were sent for direct radiocarbon dating. Although both pieces were relatively large (134 and 213 g respectively), only the outer discolored rind was targeted for carbon extraction and AMS dating by Beta Analytic, Inc. Rock #1 (69-1c) yielded a $\delta^{13}C$ (-22.2‰) corrected AMS date of 820 ± 30 B.P. (Beta-321465). Rock #5 (62-5c) yielded a conventional AMS date of 980 ± 30 B.P. (Beta-321464).

Features 2 and 3 appeared at approximately the same elevation and may be associated with one another. Feature 3 appeared to represent an *in situ*, shallow basin heating element surrounded by used rocks. However, the lack of charcoal, staining or oxidation is puzzling, since the absence of these traces would seem to contradict the interpretation of this feature as an *in situ* heating element. Most likely, the absence of charcoal reflects poor preservation conditions. The lipid residues from four rocks analyzed indicate both plant and animal products were heated and/or cooked. The apparent association with Feature 2 may be only horizontal and in the radiocarbon range of years, but may not represent concurrent utilization during specific events. However, if they were part of the same event, they may have served as companion features, one to heat rocks and one to cook foods, and allow for concurrent heating of rocks and cooking of resources next to each other.

6.3.1.4 Feature 4

A tight, well-defined concentration of burned sandstone rocks was discovered in the northeastern quadrant of Level 4 in TU 1 (Figures 6-19 through

Figure 6-17. Plan view of Feature 3 in Level 2 of Test Unit 15.

Figure 6-18. Profile of cross-section of Feature 3 in Level 2 of Test Unit 15.

6-21). This concentration rested on top of the reddish underlying deposit. It was nearly circular in outline with only a small section of the eastern edge removed in BT 4. The remaining cluster measured 68-by-60 cm in diameter, and was constructed with 25 burned rocks, as drawn on the plan map. The rocks appeared to rest in a roughly 12 to 18 cm deep basin. At least eight rocks were tilted or sloped in a variety of directions. Some rocks along the margin sloped inward to indicate the presence of a basin. An irregular void in the rocks, roughly 15 cm wide by 30 cm long, was observable toward the center of the feature. Most feature fill was collected from this void area for possible flotation. Most rocks appeared cracked *in situ*. Larger slabs of sandstone were along the bottom and edges, whereas most other rocks were blockier in shape. Most rocks were over 5 cm in length, with the largest being about 25 cm long, located toward the middle of the feature. No charcoal chunks or oxidation were observed under the rocks. Only a sketch of the basin was made, with no indication of associated soil zones.

Eight rocks, numbered #1 through #8 (15-1 through 15-8), and shown on the plan drawing, were collected, along with fill from near the middle of the concentration. Quantities of lithic debitage were recovered along the western edge of the rocks. A large corner-notched biface, referred to as a Castroville-like point in the field notes (but later referred to as a Marcos point), was drawn on the plan map in the very southeastern corner of the unit, only about 25 cm from the burned rock concentration. This biface came from near the bottom of the level. The remaining part of Level 4 and overlying Level 3 were nearly devoid of burned rocks.

Parts of four burned rocks (#2, #3, #6, and #8) were selected for both lipid residue analysis and starch grain analysis. Lipid residues extracted generally indicate both plant and animal products were cooked by the rocks. Rock #2 was interpreted to have plant seed oils, along with plants and animal products (Appendix D). All four rocks also contained conifer products indicative of wood residues, likely from juniper wood used in the fires to heat the rocks.

Starch grain analysis revealed positive results on three of the four samples. Grass starch is present on three pieces with one lenticular grain likely little barley or wildrye. The latter is also damaged through heating. One grass grain is also damaged through grinding. One other grain is unidentifiable as to species (Appendix C).

Figure 6-19. Plan view of Feature 4 in Level 4 of Test Unit 1.

Figure 6-20. Close-up of profile of Feature 4 in Level 4 of Test Unit 1.

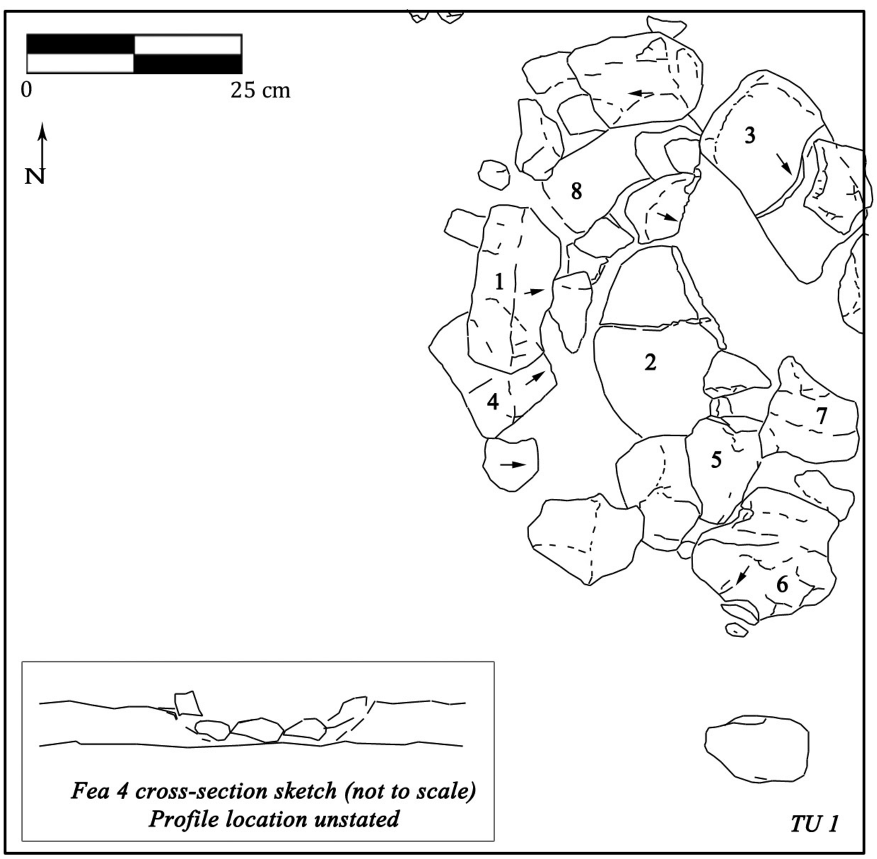


Figure 6-21. Plan view of Feature 4 in Level 4 of Test Unit 1.

Sizable fragments of Rock #3 (15-2c) and #8 (15-5c), 154 and 147 g respectively, from Level 4 in TU 1, were sent for direct radiocarbon dating. Only the outer discolored rind of each piece was physically removed and used for obtaining an AMS date. Rock #3 (15-2c) yielded a $\delta^{13}C$ (-21.7‰) corrected date of 1450 ± 30 B.P. (Beta-321461). Rock #8 (15-5c) yielded conventional date of 1410 ± 30 B.P. (Beta-321462).

Feature 4 is interpreted to have been an *in situ,* basin shaped heating element used for a relatively short period, and potentially for only one heating event. This interpretation is based on the observation that the rocks were still quite large and had not been highly fractured by repeated heating. This feature was the deepest documented and the oldest based on the two radiocarbon dated obtained; certainly deeper and older than nearby Feature 5. Feature 4 rocks were used to cook both plant and animal products, with some oily seeds represented, likely from multiple grasses.

6.3.1.5 Feature 5

This concentration was uncovered in TU 7, in the dark A horizon within Level 2 (Figures 6-22 and 6-23). This feature measured 33 cm north-south, according to the field mapping. The east-west dimension is unclear, as the feature extended into TU 1 where it was not mapped. Based on the mapping and the field photography (see Figure 6-22), this feature was a loose cluster of nine sandstone rocks of different sizes, with five that sloped more or less toward the center of the cluster. No profile or cross-section was drawn.

This feature appears to have been essentially flat and composed of sandstone slabs as well as some blocky pieces. No basin was apparent, and there were no obvious signs of *in situ* burning, although charcoal flecking was present in the Level 2 fill. Six burned rocks were mapped outside the margin of Feature 5. Six numbered rocks (#1 through #6) from within the feature were collected for future analysis. Chert flakes were found in the surrounding matrix. Fill at the base of the feature was collected for flotation.

Parts of four of the six sandstone burned rocks collected (Rocks #1, #3, #4, and #6) were analyzed for both starch grains and lipid residues. Starch grains were not found on any of the four rocks analyzed (Appendix C). Lipid residue was extracted and indicates plant and animal products were represented in all four rocks. Again conifer products, likely from juniper wood, were detected in all four rocks (Appendix D). This is likely from use of that wood for heating the rocks.

Figure 6-22. Plan view of Feature 5 in Level 2 of Test Unit 7 (facing east).

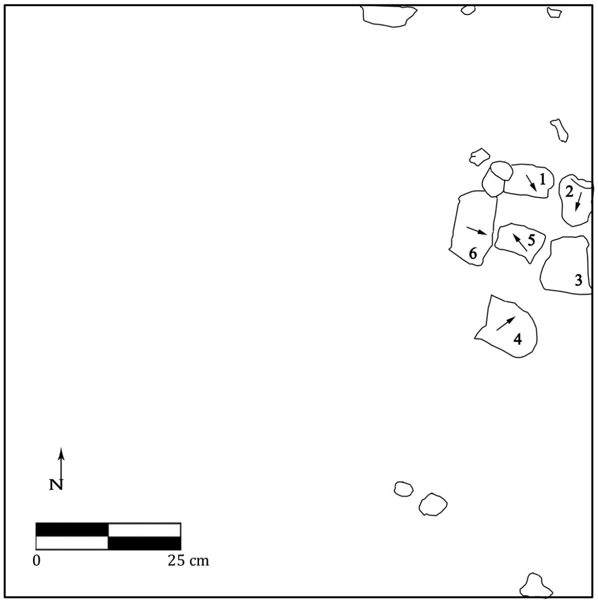


Figure 6-23. Feature 5 in Level 2 of Test Unit 7.

A 244 g fragment of Rock #2 (41-2a) was also sent for direct radiocarbon dating. Only the outer discolored rind was physically removed and used to obtain an AMS date (see Methods section for amounts). Rock #2 (41-2a) did not yield sufficient carbon for the normal $\delta^{13}C$ value or a measured AMS date, only the conventional date of 1160 ± 30 B.P. (Beta-321466). A second sample, a 90 g sandstone chunk of Burned Rock #5, yielded a conventional AMS date of 1330 ± 40 B.P. (Beta-323140). The two obtained dates indicates this feature was used during Terminal Archaic times.

Although no sign of *in situ* heating was observed and no basin was detected, the excavators interpreted this cluster as a heating element and/or hearth, but its characteristics are more in line with expectations for a small dump. No matter which interpretation, the rocks present were used to heat and/or cook both plant and animal products. The rocks were likely heated with juniper wood.

6.3.1.6 Feature 6

No information is available for this Feature. It is unclear whether this number simply was never assigned, or the records were lost.

6.3.1.7 Feature 7

This concentration of burned rocks across the northern 35 cm of Level 3 in TU 9 continued 12 to 15 cm into the northeastern corner of adjacent TU 11. These burned rocks were in the transition zone from the A to B soil horizon (Figures 6-24 through 6-26). The soil was a sandy loam to sandy clay loam that reddened with depth and contained occasional siliceous gravels in the lower 5 cm of the level. Based on this apparent position in the soil profile, Feature 7 would seem to have been at a lower elevation than Feature 4, although it is in a higher arbitrary level. Only a couple of other small burned rocks outside this feature were mapped in Level 3. The feature rocks were in no apparent pattern, and the boundary of the cluster was irregular. This concentration was roughly 100 cm east-west by at least 43 cm north-south, with the northern portion extending beyond the excavated unit and outside the block. At least 33 burned sandstone rocks were mapped and these formed a layer, one to two rocks thick. Some 16 rocks are depicted in the field notes as tilted or slanted, mostly dipping toward the south. The pieces were 8 to 12 cm in diameter, but most were blocky, 1.5 to 3 cm thick, and somewhat irregular in shape. One very large slab, about 28 cm long, rested near the bottom of the concentration. A cross-section through the very southern margin revealed that the rocks were not situated in a basin, and an absence of oxidation or charcoal staining below the rocks.

Two bags of matrix were collected for flotation, but were not available for analysis. Five numbered rocks (#1 through #5) were collected for possible analysis. One rock collected as a possible metate fragment, but was not identified as such in closer inspection in the laboratory.

Parts of Rock #2 (49-2) were sent for multiple technical analyses. One part was sent for lipid residue analysis, another part for starch grain analysis, and a third part (49-2c) for direct AMS radiocarbon dating. A 64 g chunk was submitted to Beta, but only the outer discolored rind was physically removed and used to obtain the AMS date (see Methods section for amounts). Rock #2 yielded a $\delta^{13}C$ (-21.7‰) corrected date of 1210 ± 30 B.P. (Beta-321463).

Figure 6-24. Oblique view of Feature 7 in Level 3 of Test Unit 9.

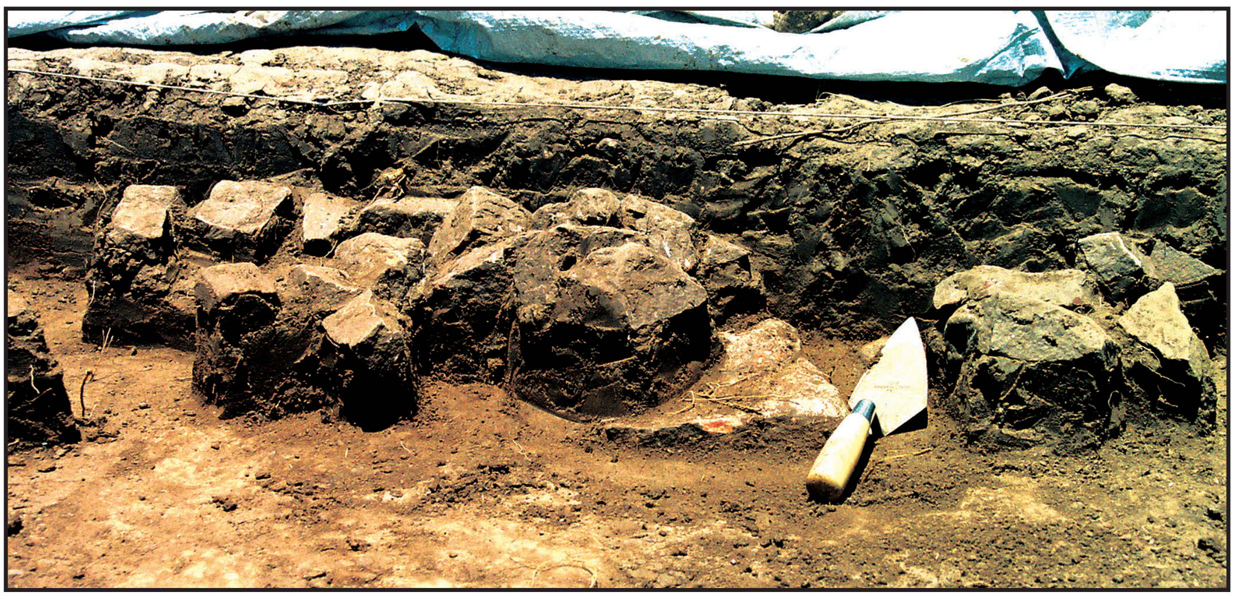


Figure 6-25. Close-up of profile of Feature 7 in Level 3 of Test Unit 9.

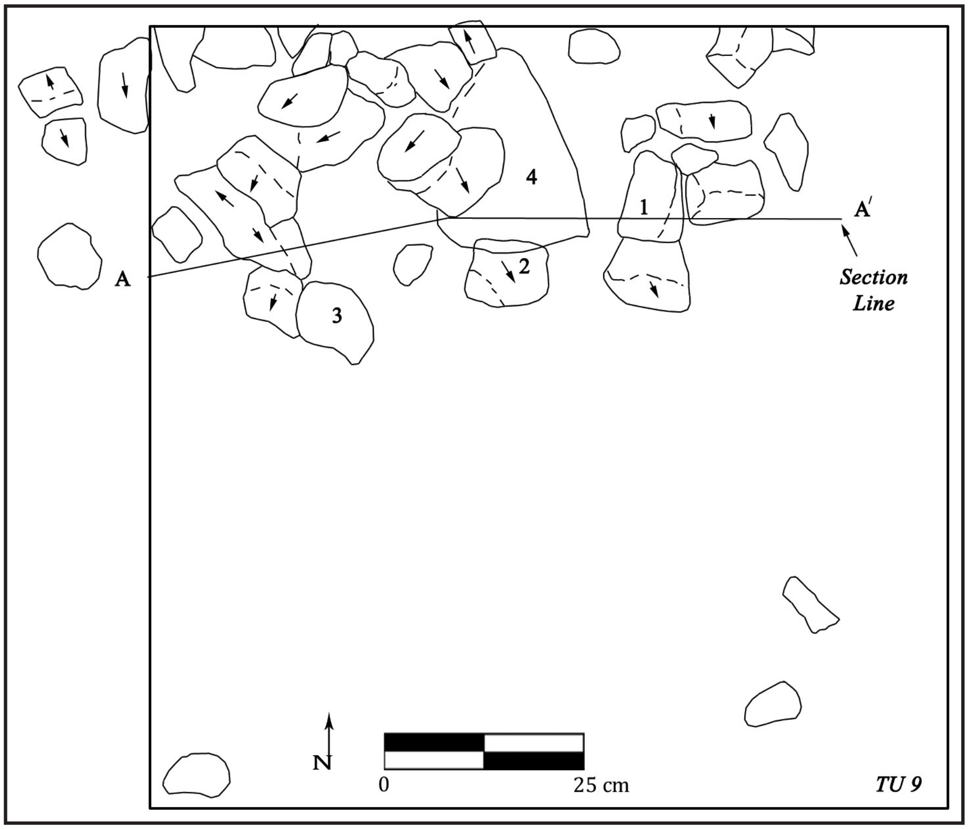


Figure 6-26. Plan view of Feature 7 in Level 3 of Test Unit 9.

Burned Rock #1 (41-1) was also dated in the same fashion. A 115 g chunk yielded a $\delta^{13}C$ (-21.4‰) corrected date of 1120 ± 30 B.P. (Beta-323139). The close correspondence of these two AMS dates indicates that the feature was likely in use during the same general period during the Terminal Archaic as the other features in this block.

Fragments of four burned sandstone rocks (#1 through #4) were also sent for both starch grain and lipid residue analyses. Lipid residues extracted generally indicate plant and animal products were present, with plant seed residues in Rock #1 and #3 (Appendix D). Traces of conifer products were also detected in Rock #3, likely indicative of juniper wood used to heat the rocks.

Starch grain analysis revealed the presence of starch on only one (49-1a) of the four samples. Four lenticular grains, likely of little barley or wildrye, were present, as well as one unidentifiable grain that was damaged from grinding (Appendix C). Grass appears to be the principle plant processed and supports the lipid residue results indicating the presence of plant seeds on this same rock (49-1).

Based on the lack of an observed basin, somewhat smaller rocks in comparison to other features, the apparent jumbled nature of their distribution, combined with the lack of oxidation and charcoal staining, Feature 7 appears to have been a dump of burned rocks that were used at some other location. Again, the rocks were used to cook and/or heat plant and animal products. As this is the only feature said to have been in the A/B soil transition zone, it may not be associated with any other feature identified here, although the AMS dates fit well with those from other features.

6.3.1.8 Summary of Features

In summary, the six burned rock features appear very similar in overall appearance; all were relatively small, contained only sandstone burned rocks, associated with very limited to no charcoal or other signs of oxidation, and no other obvious cultural materials such as faunal bones or mussel shells (Table 6-1).

Features 1, 2, 3, and 4 appear to represent *in situ* heating elements based largely on the presence of basins and rock sizes, whereas Features 5 and 7 appear to be dumps of used rocks that contained smaller rocks with no obvious basins or apparent organization. The near absence of charcoal and vertebrate remains may be due to poor preservational conditions. However, the lack of mussel shells likely reflects lack of utilization at this particular location. Although some visual clues as to function are present, identification of what was cooked and/or heated in these features must rely solely on analyses of micro-remains, i.e., lipid residues and starch grains. The lipid residues document the presence of mostly plant products, including at least some seeds, with traces of animal products, and in one instance from Feature 3, large herbivore products (Table 6-2). The lipid analysis has also enlightened us as to the possible wood used in the fires, even without the luxury of preserved charred wood. The rocks in all five features analyzed were apparently heated by conifer, here juniper wood being the most likely.

The starch grain analysis on 20 burned rocks from the features yielded evidence of multiple species of plant remains. This includes multiple grass species and maize from Features 2 and 3. Starch grains damaged through heating, grinding, and cooking provide strong support that these grasses were intentionally targeted as food sources.

Combined, the lipid and starch analyses document rocks from these five features were used to cook and/or heat available plant and animal resources. Plant use appears to be intensive, at least from the current results. The documentation of both plant and animal food resources is not unexpected, as most researchers imply prehistoric populations as hunter-gatherers. However, many earlier reports indicate only animals or mussels were cooked based on the presence of bones or shells. These techniques have documented that plants and specific types of plants were cooked, thus expanded the understanding of the foods cooked, including the use of multiple plants, in these types of small burned rock features.

6.3.2 Chipped Stone Tool Analysis

Paul M. Matchen

The Block 1 lithic artifacts were recovered from 11 test units (TUs) situated in the western portion of the APE just west of BT 4. Table 6-3 provides the breakdown of tool classes. Radiocarbon dates obtained from Features 2, 3, 4, 5, and 7 of this block range from 1450 to 920 B.P. (conventional age) based on nine acceptable dates on residues imbedded in the burned rocks from various features (see Chapter 7.0 for discussion of stratigraphy). The following presentation discusses tool data stemming from analysis that provides a characterization of the assemblage and contributes information with which to address research questions as presented in the research design (see Chapter 4.0).

The hand-excavations (the entirety of Block 1) yielded a sample of 83 chipped stone tools. This group represents 4.9 percent of the overall chipped stone lithic assemblage for Block 1, the remainder comprised mostly of debitage (*N* = 1,702). Chipped stone tool descriptions are presented below by tool class. A number of tools of each class were also selected for detailed description as representative examples of that class.

Several tools were selected for high-powered microscopic use-wear analysis (*N* = 15, or 18.1 percent of total chipped stone assemblage) and starch grain analyses (*N* = 20, or 24.1 percent of total chipped stone assemblage). This use-wear analysis focused on identifying specific tool functions through detection of microwear attritions left on tool surfaces, as well as identifying the organic materials left on the tool, presumably the result of contact with those materials. A summary of the use-wear results for each specimen is included in the individual tool descriptions below, where applicable.

6.3.2.1 Bifaces

Three bifaces comprise 3.6 percent of the chipped stone tools from Block 1. Table 6-4 shows the general dimension of each specimen.

Table 6-1. Summary of Feature Characteristics and Observations from Block 1.

	Feature 1	Feature 2	Feature 3	Feature 4	Feature 5	Feature 7
Unit	Outside edge of Block 1	TU 13	TU 13 & 15	TU 1	TU 7	TU 9
Level	NA	2	2 & 3	4	2	3
Soil Horizon	A horizon	A horizon	A horizon	Bottom of A horizon	A horizon	Transition A/B horizon
Feature Type	Heating Element	Heating Element	Heating Element	Heating Element	Dump	Dump
Basin Depth (cm)	None	Shallow, 10 to 15	Shallow	Deep, 12 to 18	None	None
Feature Shape	Ovate	Ovate	Horseshoe	Circular	Circular	Irregular
Feature Size (cm)	91 x 85	60 x 40	80 x 65+	60 x 68	33 x ?	100 x 43+
Feature Depth (cm)	25 to 30	unknown	Unknown	Unknown	Unknown	Unknown
Burned Rock Date * (Conventional Age, B.P.)	None	910 ± 30	820 ± 30 980 ± 30	1410 ± 30 1450 ± 30	1160 ± 30 1330 ± 30	1120 ± 30 1210 ± 30
Charcoal in Feature	Flecks	None	None	None	Flecks	Flecks
Bones in Feature	None	None	None	None	None	None
Mussel Shell in Feature	None	None	None	None	None	None
Lithic Debitage in Feature	Unknown	Unknown	Present	Unknown	Present	Unknown
Burned Rock Counts	30	22	23	25+	9	33+
Burned Rock Weights (g)	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Burned Rock Sizes (cm)	2 to 18	4 to 15	5 to 17	4 to 25	3 to 12	12 to 28
Burned Rock Material	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone	Sandstone
Burned Rocks Analyzed	None	4	4	4	4	4
Starch Grain Results	NA	2 grass, 2 maize, 1 ground, 1 gelatinized	2 maize, 2 unidentified, 1 gelatinized	3 grass, 1 unidentified, 1 heated, 1 gelatinized	No starches	4 grass, 1 unidentifiable, 1 ground
Lipid Residue Results	NA	Plant with traces of animal	Plant with traces of animal, large herbivore	Animal and plant, seed oils,	Plant and animal	Plant and traces of animal, seed residue
Burned Rocks Curated	1	5	5	8	6	5

* Dates run on organic residues from burned rocks

Table 6-2. Summary of Burned Rocks Subjected to Lipid Residues.

Feature No.	Test Unit	Level	TxDOT Burned Rock No.	Final PNUM	Wt. (g) of Piece Analyzed	Malainey's Lab No.	Lipid Residue Results and Interpretations
2	13	2	BR #1	61-1b	55.7	12MQ5	Plant, traces of animal products, conifer products
2	13	2	BR #2	61-2b	38.7	12MQ6	Plant, traces of animal products
2	13	2	BR #3	61-3b	14.9	12MQ7	Plant, traces of animal products
2	13	2	BR #4	61-4b	92	12MQ8	Plant, traces of animal products, conifer products
3	13	2	BR #5	62-5b	30.7	12MQ9	Plant, traces of animal products
3	15	2	BR #1	69-1b	58.6	12MQ10	Large herbivore, plant and animal products
3	15	2	BR #2	69-2b	104	12MQ11	Traces of plant and animal products, conifer products
3	15	2	BR #3	69-3b	44.1	12MQ12	Traces of plant and animal products
4	1	4	BR #2	15-1b	90.4	12MQ1	Plant seed oils, animal products, conifer products
4	1	4	BR #3	15-2b	109.5	12MQ2	Traces of plant and animal products, conifer products
4	1	4	BR #6	15-4b	94.4	12MQ3	Plant and animal products, conifer products
4	1	4	BR #8	15-5b	102.1	12MQ4	Plant and animal products, conifer products
5	7	3	BR #1	41-1b	57.3	12MQ13	Plant and animal products, conifer products
5	7	2	BR #3	41-3b	54.2	12MQ14	Plant and animal products
5	7	2	BR #4	41-4b	51.6	12MQ15	Plant and animal products, conifer products
5	7	2	BR #6	41-6b	40	12MQ16	Traces of plant and animal products, conifer products
7	9	3	BR #1	49-1b	103.4	12MQ17	Plant seeds, traces of animal products
7	9	3	BR #2	49-2b	103.9	12MQ18	Plant and animal products
7	9	3	BR #3	49-3b	49.6	12MQ19	Plant seed residues, trace of animal products, conifer products
7	9	3	BR #5	49-4b	94.9	12MQ20	Plant and animal products

Table 6-3. Chipped Stone Artifact Class Frequency for Block 1.

Block	Artifact Classes	Count (*N*)
1	Bifaces	3
1	Edge-Modified Flakes	76
1	Scraper/Wedge	1
1	Chopper	3
Total		**83**

Width-to-Thickness Ratios, Reduction Stage and Tool Use-life

As explained in the methodology section of this report, width-to-thickness ratios were recorded to provide a morphological index for the tools in this class. Specifically, Callahan (1979) devised this classification scheme to categorize trends observed amongst bifaces in Paleoindian assemblages and suggested that they represented indices in a reduction scheme: low width to thickness ratios denoted earlier reduction stages; high ratios denoted later reduction stages or perhaps finished forms. TRC has acknowledged in recent publications (e.g., Quigg et al. 2010, 2011a) that microscopic wear data on such bifaces appear to show evidence of use and hafting across a wide range of "early" through "late stage" bifaces. These data could very well suggest that diversity in width-to-thickness ratios represent different stages in use-life that may not be directly proportional to level of reduction. Should these discrepancies constitute a reinterpretation of biface use-life and its association to morphological form? We believe so. However, we stop short of changing our classification terminology (i.e., Stages 1 through 5) for comparative consistency across reports.

Metric and Non-metric Attributes of Biface Assemblage

No specimens in this class were recovered in complete form. Specifically, one is a proximal medial fragment, one is a medial fragment, and the third is a distal fragment. Two of the three bifaces were recovered from TU 1 in Feature 4. Specimens in this group were all visually recognized as fashioned from chert clasts originating from the Edwards Plateau. Descriptions of the bifaces are presented below with selected metric attributes presented for each in Table 6-4. Also included are supplemental data derived from use-wear analysis performed by Bruce Hardy (Appendix B).

Biface #14-10. During the 1999 field excavations, this tool was classified as a Marcos-like projectile point. Reexamination by TRC archeologists in preparation for this report has since reclassified #14-10 as a corner-notched biface fragment with a missing distal end (Figure 6-27). It was fashioned from beige-brown Edwards chert with dark brown streaks and spots/inclusions. The material does not appear to have been thermally altered. This biface was recovered from next to Feature 4 in the lowest excavated level (Level 4) of TU 1. Parallel flaking is exhibited along the lateral tool edges, from which the scars span approximately 1/3 the width of the biface. Analysis of debitage from TU 1 (see below) noted the presence of notching flakes, which supports the on-site manufacture of this specimen. This specimen was submitted for use-wear (see discussion below).

Biface #14-11. This specimen is a medial fragment that exhibits one lateral edge and two fracture planes (Figure 6-28). Like #14-10, biface #14-11 was recovered from Feature 4 in Level 4 of TU 1. The material is light beige Edwards chert with no apparent inclusions and no visual evidence of thermal alteration. Flaking patterns on both tool faces are somewhat random but do exhibit some parallel flaking along the edge. Specimen #14-11 was examined for the presence of use-wear (see discussion below) and starch grains. Starch grain analysis by Linda Perry yielded the presence of one maize starch grain on this artifact.

Biface #54-13. This specimen was recovered from the central portion Block 1, TU 12, within Level 2. Unlike the previous two specimens, this distal biface fragment was not directly associated with a cultural feature. The biface is grayish-brown Edwards chert that is slightly translucent. The distal end of this specimen exhibits an off-white, matte portion that most likely represents the outer radial portion of the originating chert clast. Namely, a portion was exposed to the effects of weathering from close

Table 6-4. Selected Attributes on Block 1 Bifaces.

PNUM	Unit	Level	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Raw Material	Completeness	Width to Thickness Stage
14-10	1	4	77.5	45.5	10.6	37.9	Edwards	Proximal/ Medial	4
14-11	1	4	25.7	18.3	5.5	2.1	Edwards	Medial Fragment	3-4
54-13	12	2	48.95	44.72	17.04	22.9	Edwards	Distal fragment	2-3

Figure 6-27. Notched biface #14-10 with an excurvate base. Note the perverse fracture at the distal end.

proximity to the cobble surface cortical layer. This specimen was sent for neither use-wear nor starch grain analysis.

In summary, the mean width of the biface group is 37.59 mm and the average thickness is 11.04 mm. The standard deviation of biface widths across all specimens is 15.48 mm. Biface thickness measurements represented have a standard deviation of 5.78 mm. This range in biface size may be indicative of the variation in the size of raw material packages (i.e., cobble/clast size). It is also possible that tool size variance may have been functionally related, but to determine this would require further examination on a larger group of specimens, which is not possible in this assemblage.

As a group, these bifaces reveal random flaking patterns, indicating an expedient or nonstandard reduction sequence. As mentioned above, Callahan (1979) provided a classification scheme for bifaces recovered from Paleoindian contexts, in which he used width-to-thickness ratios to determine biface reduction stages. In general, the preparation and reduction scheme for specimens included in Callahan's studies are more complex than what was observed at 41MI96.

Breakage of bifaces (100 percent of the assemblage) may have occurred during manufacture, use, or post-depositionally. By examining the break areas on each specimen, it was determined that bifaces #14-10 and #14-11 exhibited perverse fractures, probably caused by striking a platform above the biface plane during manufacture (Miller 2006). Biface #54-13, a distal fragment with a reverse hinge fracture type, is unclear.

Figure 6-28. Fragmented Biface #14-11 showing lateral edge and breaks.

Data from Bifaces Sent for Use-wear Analysis
Two bifaces (#14-10 and #14-11) were submitted for use-wear analysis. Biface #14-10, a corner-notched fragment broken at the distal end in a perverse fracture, had no observable evidence of wear (Figure 6-29). This biface, therefore, was interpreted to have an unknown use or was simply not used. Interestingly, even though this specimen was notched, microscopic examination did not yield evidence of hafting. Hardy did observe wood residue on this specimen on one face, just below the perverse fracture plane (Figure 6-30). Biface #14-11, a medial fragment exhibiting transverse and possibly perverse fractures, showed evidence of soft polish and striae on one face (Figure 6-30). Hardy interpreted this specimen may have been used to cut plants.

6.3.2.2 Edge-Modified Flakes

Seventy-six edge-modified flakes were recovered and are considered informal tools that were likely produced, used, and discarded on-site. This group is the largest chipped stone tool class, composing 91 percent of the Block 1 tool assemblage. Specifically, informal tools represent those specimens that have not been altered to a degree that significantly changed the shape and/or form of the original flake blank. In most instances, these flakes or parts of flakes have minimal, but noticeable, edge scarring, flaking, or rounding. These informal tools vary widely in size (Table 6-5). Edge angles measured for each modified edge were fairly consistent, with medians of 49 to 50 degrees, and standard deviations of 11 to 12 degrees, respectively. These values indicate that most edge-modified flakes were subjected to similar types and intensities of modification. This is not surprising since, by definition, informal tools are not modified to any great extent prior to use.

All of these specimens were fashioned from Cretaceous-aged cherts originating from the Edwards Plateau. These raw materials were most likely gathered nearby, before being reduced on-site. Within this class, 5.3 percent (*N* = 4) have 51 to 100 percent cortex, 10.5 percent (*N* = 8) have 26 to 50 percent cortex on the dorsal face, 39.5 percent (*N* = 30) exhibit 1 to 25 percent cortex on the dorsal face, and 44.7 percent (*N* = 34) have no cortex on the dorsal face. The high incidence of cortex on the dorsal face in this class is a direct result of flake removal from a cobble core. Because of generally small cobble sizes, a large number of flakes exhibit only remnants of the outer cortical surface.

Interestingly, 34 percent exhibit evidence of thermal alteration in the form of color changes and pot lidding. This is a much larger percentage than in any other tool class. Edwards Plateau chert is a high-grade material that does not usually require heat treatment prior to flaking, as the fracture predictability is already high. Therefore, it must be assumed that thermal alteration occurred post-use as these expedient tools were discarded or otherwise accidentally incorporated into the fires of heating elements.

Use-wear Analysis of Edge-modified Flake Tools
Eleven edge-modified flake tools were selected for use-wear analysis (#13-10, #13-11, #14-12, #14-13, #44-11, #45-10, #54-10, #57-10, #59-11, #60-10, and #65-10). Eight specimens analyzed had wear that indicate cutting activities. Two edge-modified flake tools (#14-13 and #59-10) exhibited evidence

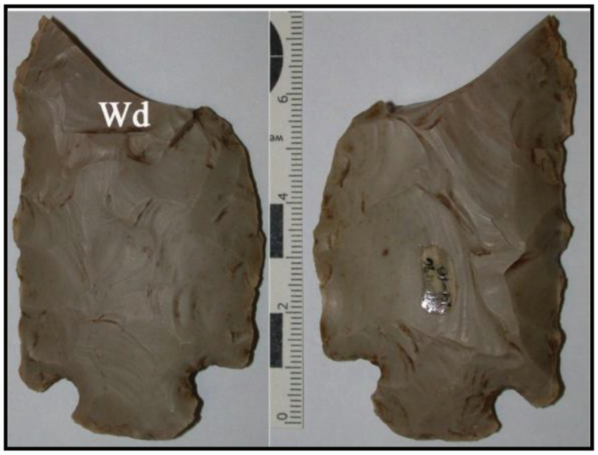


Figure 6-29. Biface #14-10 showing location of wood residue (see Hardy Appendix B).

of having been used to whittle wood (Figure 6-31). Specimen #45-10 showed wear that indicated scraping activities (Figure 6-31). Use-wear on the working areas of both tools was different. Most tools (*N* = 8; 72 percent) showed high/hard silica polish.

6.3.2.3 Wedge Tool

Tool #45-10 was recovered from TU 7 within level 2, and has three faces from which flakes have been driven (Figure 6-32). We classifiied this as a wedge, strictly on the basis of morphological characteristics. Two of the arrises between faces on this oblong tool have secondary edge flaking, possibly from use or subsequent shaping. It is dark gray (10YR 4/1) Edwards chert, with light gray (7/1) spots throughout. Cobble cortex covers most of the dorsal side and one end. Selected measurements for this specimen are presented in Table 6-6. This piece was sent for use-wear analysis, where residues of bone and hair were identified along one of the worked edges. In addition, high/hard silica polish was seen along an edge, as well as battering on one end. The function interpretation for this tool is somewhat uncertain, but it seems to have involved bone and hide scraping.

Figure 6-30. Biface #14-11 showing location of soft polish and striae (see Hardy Appendix B).

6.3.2.4 Choppers

Choppers are defined as those tools that are flaked on both faces with significant modification to at least one edge. Three bifacially-flaked choppers (#44-10, #47-10, and #81-10) were recovered from Block 1 (Figures 6-33 through 6-35). The flaking patterns on #81-10 are random and multi-directional, whereas those on #44-10 and #47-10 are unidirectional and parallel. In fact, chopper #44-10 may have been fashioned for hafting, as it exhibits a flaked edge on the opposing end. In addition to the large flakes driven off on each face in the formation of the wedge-shaped end, these tools also exhibit smaller retouch flaking on the working end. Like edge-modified tools, these specimens were likely produced, used, and discarded on-site. Choppers are expediently produced, and because of their size and weight were most likely not transported from one camp to the next. Selected measurements of these artifacts are presented in Table 6-7. All three choppers were sent for starch grain analysis. Two specimens (#44-10 and #47-10) did not yield any recognizable grains (Appendix C). The third tool (#81-10) yielded one lenticular grain that was damaged. As a result, these data could not contribute to an understanding of for what and how the tools were used.

Use-wear Analysis on Selected Choppers

Use-wear analysis was performed on two choppers (#44-10 and #81-10). Tool #44-10 exhibited wood residues and had high/hard silica polish, which Hardy interpreted as being used for scraping wood. Chopper #81-10 had plant fiber present near the bit end on one face, but no discernible wear patterns. The function of this tool, therefore, was interpreted to be unknown or possibly unused. However, the lack of visual use-wear may actually support this tool was used on soft plants, which would not provide obvious wear.

Table 6-5. Summary of Metric Attributes of Edge-Modified Flakes from Block 1.

Edge-Modified Flake (N = 76)	Length (mm)	Width (mm)	Thickness (mm)
Mean	31.37	20.4	5.64
Median	28.67	20.95	4.45

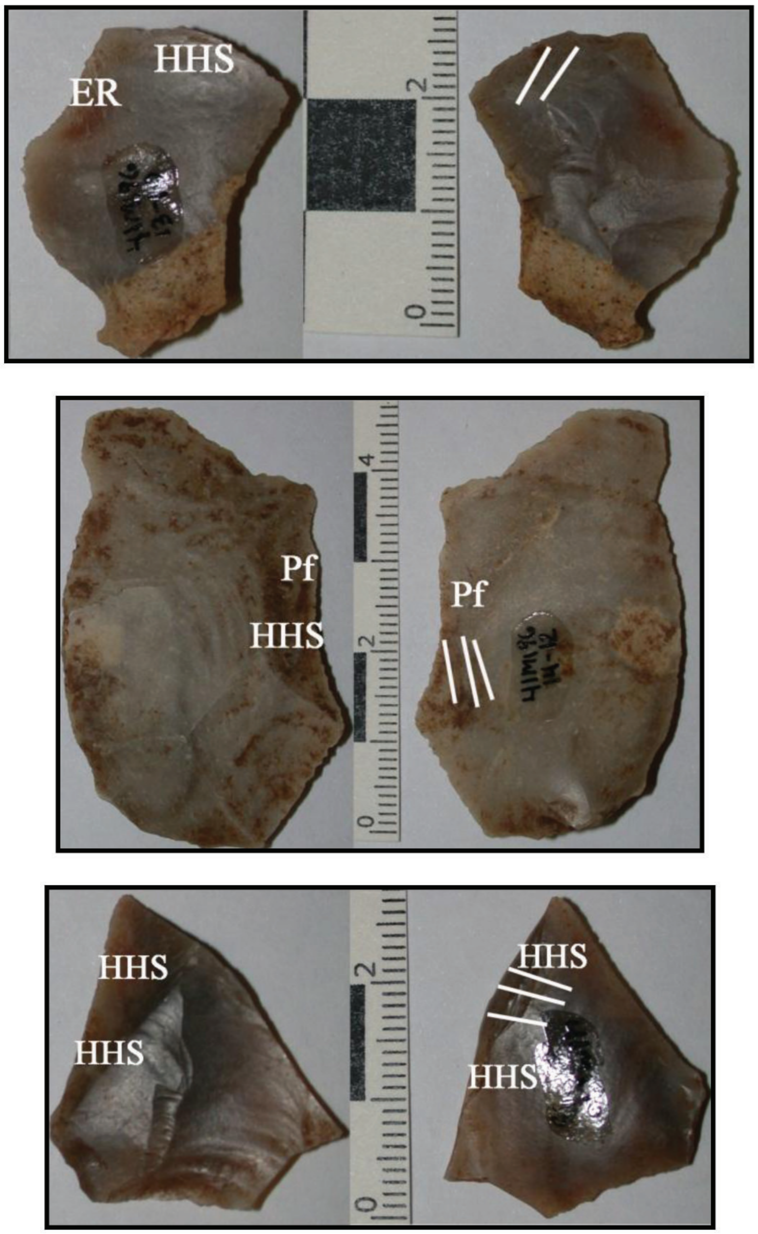


Figure 6-31. Observations from use-wear analysis of selected edge-modified flakes: top, #13-10 shows edge-rounding and high/hard silica polish; middle, #14-12 shows plant fibers and high/hard silica polish; and bottom, #14-13 shows striae and high/hard silica polish (all scales in cm).

Figure 6-32. Wedge #45-10.
Note battering on right end.

Table 6-6. Selected Measurements for Wedge #45-10.

PNUM	Unit	Level	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Raw Material	Completeness	Edge angle
45-10	7	2	44.2	86.9	44.7	120.3	Edwards	complete	75

6.3.3 Block 1 Lithic Debitage Analysis

Analysis of lithic debitage, the by-products of stone tool production, is an extremely informative means of defining certain patterns of human behavior (Andrefsky 1998). Attributes that can be documented within a debitage assemblage may be used to highlight trends that provide insight into resource procurement strategies, tool production locations, material reduction strategies, tool production techniques, and tool maintenance. The lithic debitage assemblage from Block 1 (*N* = 1,702) consists of platform bearing flakes, distal flakes/shatter/angular debris, and cores. These primarily occurred within the A Horizon, with the majority of material recovered from Levels 1 through 3 (Figure 6-36).

Ninety–nine percent of the debitage assemblage was composed of one primary raw material, Edwards Plateau chert (specifically a grayish-tan). Within this type six sub-varieties were observed. These include cherts with no inclusions, tiny dark dendrites, dark and light gray specks, white inclusions, dark and light bands, and banded with tiny dark spots. It is likely that all these varieties were collected from local drainages and uplands. In fact, naturally occurring chert cobbles were observed in a plowed field adjacent to 41MI96

Figure 6-33. Chopper #44-10 (bit end up).

(Bettis, personal communication). The less than one percent of non-Edwards chert includes dark jaspers, a conglomerate, and a couple of unknowns.

The majority of the debitage assemblage (*N* = 864; 50.7 percent) falls within the 6.4 to <12.8 mm size range (Figure 6-37). The second largest group is the <6.4 mm group (*N* = 627; 36.8 percent) with the next most abundant size, in the 12.8 to <19 mm range at 10.3 percent (*N* = 177). This indicates that a high proportion of smaller flakes were by-products of either an emphasis on finishing and resharpening activities (tool maintenance) and/or the use of relatively small cobbles in tool production.

Thermal alteration of chert among platform-bearing flakes (*N* = 103; 12.4 percent) has a fairly low representation in the Block 1 assemblage (Figure 6-38). The most obvious thermal alteration occurs in the form of potlid marks (saucer shaped divots) and thermal breaks. These alterations suggest that heating occurred unintentionally, after discard. Purposeful and/or intentional heating of raw material to improve quality for knapping would have involved removal from the heat source before such detrimental alterations could occur. The Edwards chert is a very fine–grained material, quite suitable for knapping without heating.

The breakdown of platform types is depicted in Figure 6-39. There are 830 platform-bearing flakes in the assemblage, constituting 48.7 percent of the Block 1 debitage. Of these, approximately 45 percent exhibit multifaceted platforms (i.e., faceted plus complex groups). These flakes originate from more intensively modified objective pieces (e.g., bifaces or cores with prepared platforms).

Flat striking platforms are the second most frequent type, representing 21 percent of the platform-bearing assemblage. Flat platform flakes were predominantly detached from nonbifacial tools or planar, unmodified core surfaces (Andrefsky 1998:94; Whittaker and Kaldahl 2001:54). Crushed platforms also comprise 20 percent of the recognized

Figure 6-34. Bifacial chopper #81-10 (bit end up).

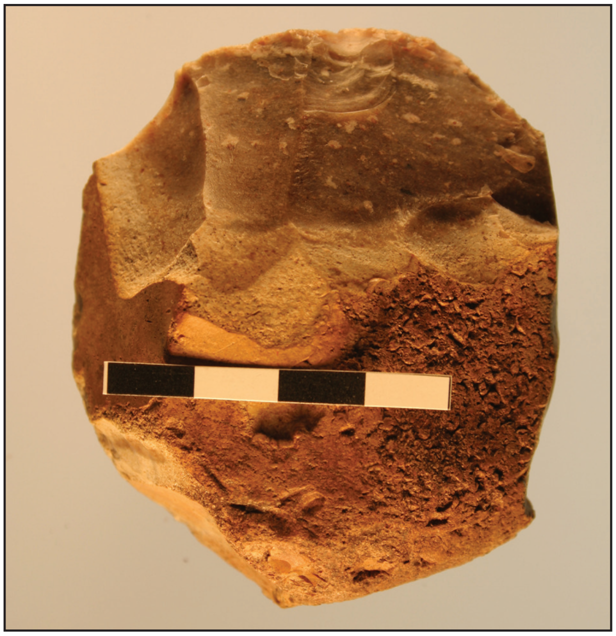


Figure 6-35. Chopper #47-10 with cobble cortex.

platforms and are created quite often when hard-hammer percussion is used. Approximately 13.4 percent of the platform-bearing flakes are cortical (Figure 6-39), representing initial flake detachment from a cortex-covered objective piece (e.g., a rounded river cobble). This is a sizeable percentage considering that cortical platforms are produced in initial cobble reduction which limits number of cortical flakes produced per cobble.

As with cortical platforms, lithic debitage exhibiting cortex on the dorsal face signifies early-stage reduction of objective pieces (Figure 6-40). A large proportion of platform-bearing flakes (28 percent) exhibit cortex. This supports the assertion that initial reduction of raw material packages was done primarily on-site. Therefore, the knapping of raw material at Block 1 appears to have focused on both early-stage cobble reduction and later-stage tool production and reduction.

The horizontal distribution of debitage by count and weight across Block 1 clearly reveals that many higher concentrations were located outside of designated cultural features. The features consisted largely of concentrations of burned rocks that represented two secondary dumps or discard locales, and rocks from four intact heating and/or cooking features.

6.3.3.1 Notching Flakes

Another indication of tool finishing is the recovery of notching flakes that were produced at the very end of the tool making process (Figure 6-41). Notching flakes are distinctive from other flake types in that they have pronounced convexity on the ventral surface at and below the platform, are most often wider than they are long, and have concave platforms that occur from pressure flaking on a concave bifacial edge (notch area). During debitage analysis, 14 notching flakes were identified across Block 1. Four (29 percent) were found within TU 1, with two in Level 4 where the corner-notched biface (#14-10) was recovered. The likelihood that those two notching flakes recovered were associated with biface #14-10 is high as the break type (perverse) and color of the chert pieces supports on-site production. The remaining 10 notching flakes were found in TUs 8, 9, 10, 11, 12, and 15.

Table 6-7. Selected Measurements on Choppers from Block 1.

PNUM	Unit	Level	Max Length (mm)	Max Width (mm)	Max Thickness (mm)	Weight (g)	Raw Material	Completeness	Width to Thickness Stage
44-10	1	4	85.8	69.6	31.3	185.7	Edwards	complete	2
81-10	1	4	90.9	55.5	29.3	135.7	Edwards	complete	2
47-10	12	2	72.9	62.7	40.8	201.8	Edwards	complete	1-2

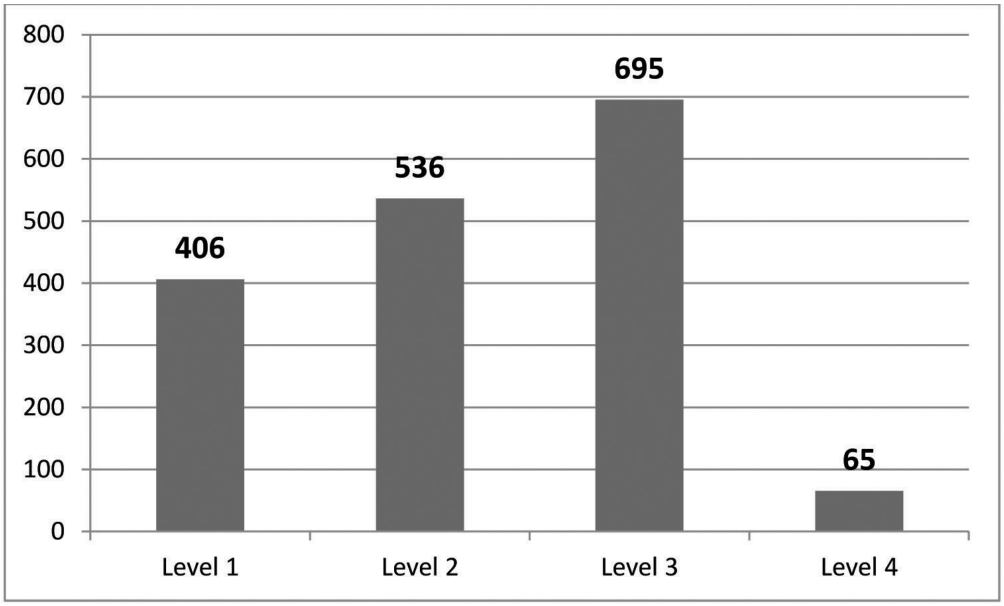


Figure 6-36. Depth range and frequency for lithic debitage from Block 1.

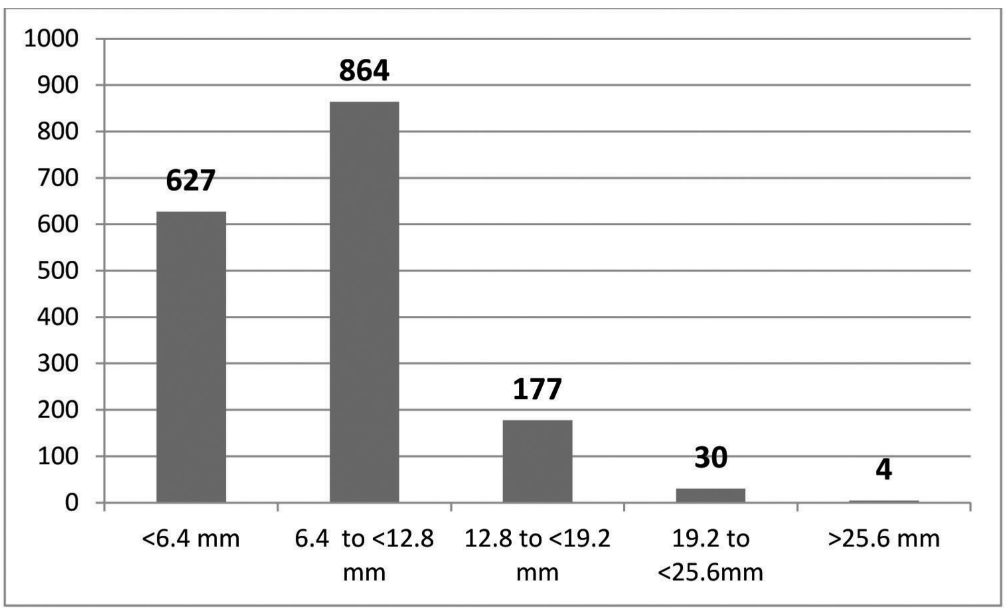


Figure 6-37. Size grade distribution of lithic debitage in Block 1.

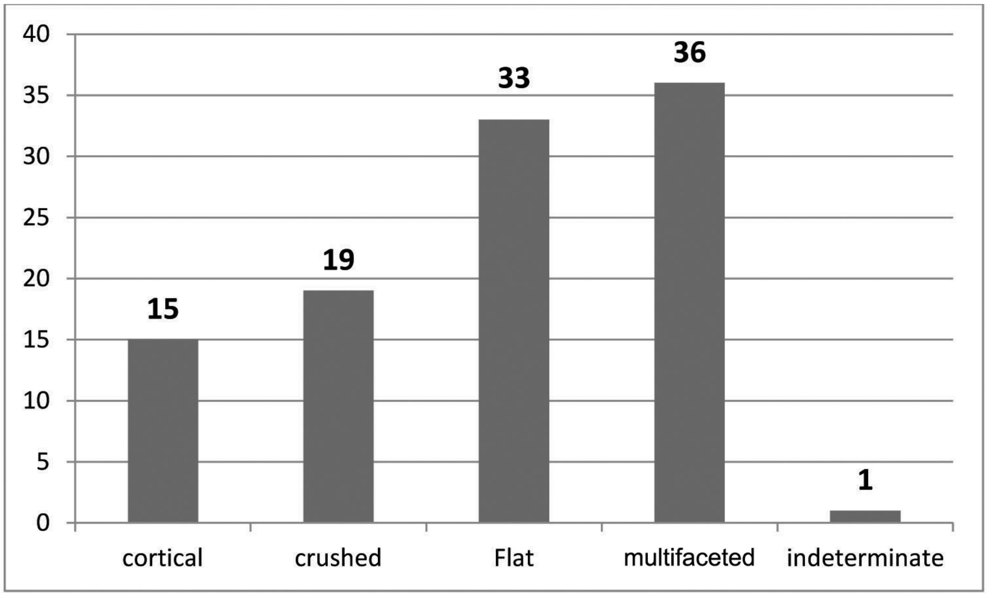


Figure 6-38. Distribution of platform-bearing flakes exhibiting thermal alteration.

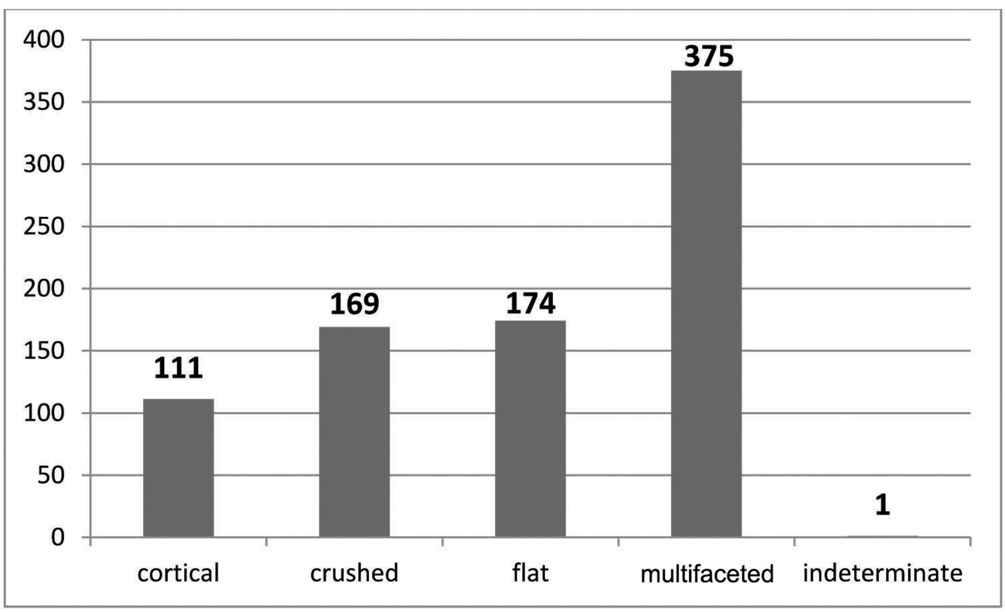


Figure 6-39. Frequency of platform types in Block 1 debitage assemblage.

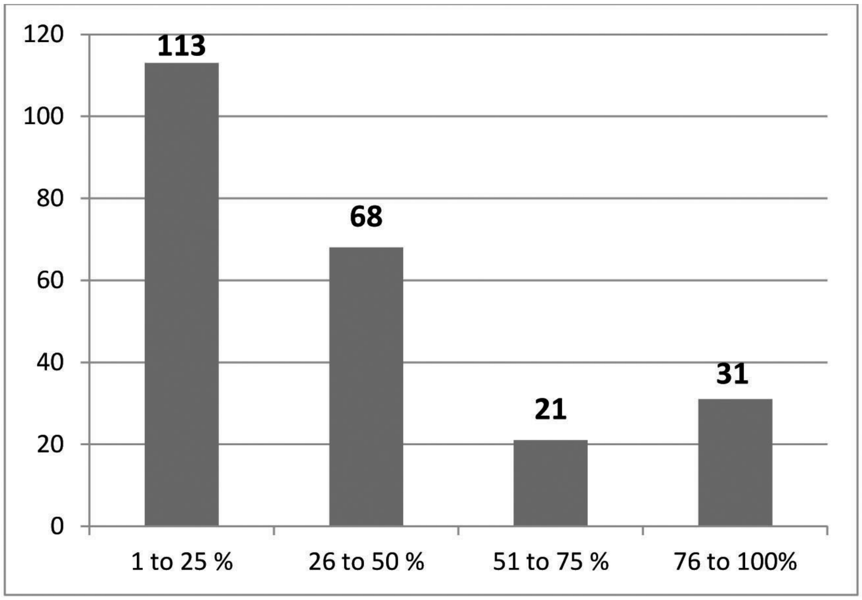


Figure 6-40. Cortex presence on lithic debitage from Block 1.

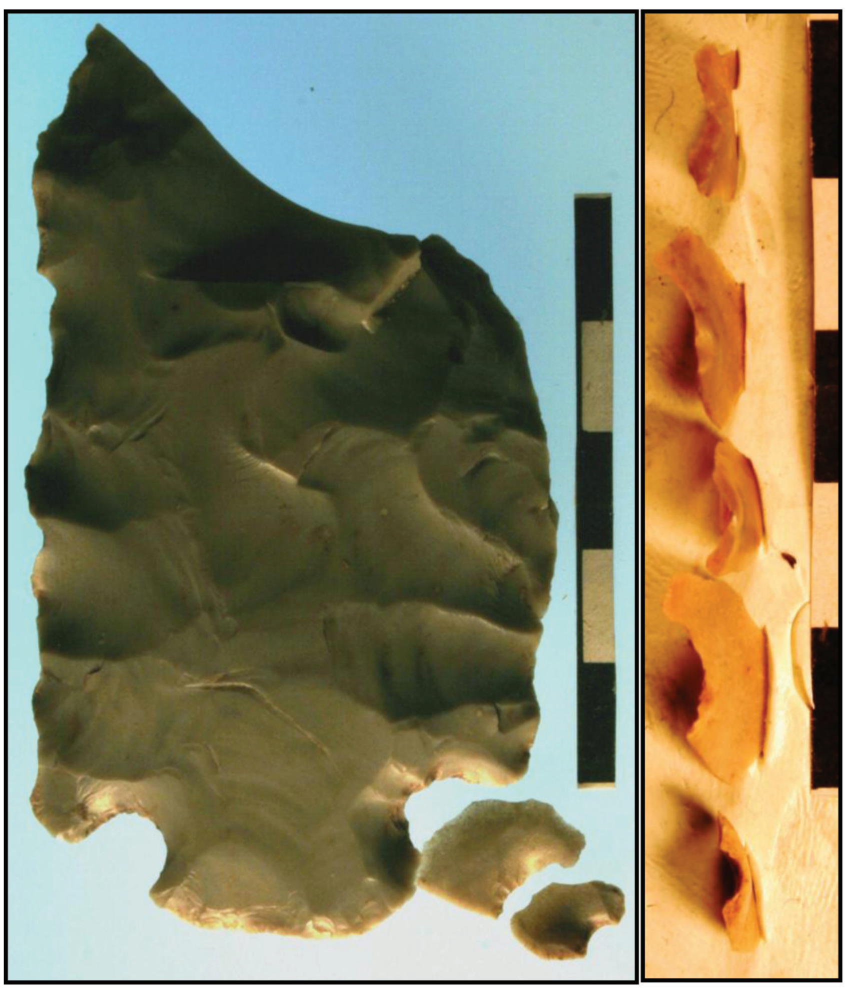


Figure 6-41. Selected notching flakes recovered from Block 1.

6.3.3.2 Summary of Lithic Debitage Analysis

In summary, the lithic debitage reveals clear patterns of local Edwards chert raw material procurement, reduction of cobbles and formal tools, bifacial and flake-tool production, and notching bifaces within Block 1. The high incidence of cortex on platform-bearing flakes suggests on-site initial reduction of smooth, rounded cortexed cobbles (orange-peel surface, brown to dark red in color). The cobbles from which this debris orginated were most likely procured locally from uplands or gravels associated with nearby streams such as Crooked Run Creek or the Colorado River approximately 1 km to the east. However, cortex from nodular clasts also were evident (rough, chalky and orange and white in color).

Furthermore, the relatively restricted incidence of thermal alteration (12.4 percent of platform-bearing flakes) suggests that intentional heat treatment of Edwards chert was not a necessary precursor to material reduction/use. The evident proportion of heat-altered debitage likely represents discard of chert debitage into hot heating features. As a result, it does not appear that the site's occupants employed intentional heat treatment in their lithic reduction strategy.

The large proportion of platform-bearing flakes with two or more facets (47 percent) combined with the 14 notching flakes indicates that bifacial thinning, edge finishing, tool notching, and rejuvenation were the primary source of the flakes produced on site. Core reduction is also indicated at this component by the presence of platform-bearing flakes with only a single facet. Therefore, both bifacial and core forms were reduced on site, although it is unclear by strictly examinating the platform–bearing flakes what proportion of bifacial reduction flakes originated from bifacial cores as opposed to modification of large flakes.

The frequency distribution of lithic debitage across the Block 1 (Figure 6-42) shows a fairly even pattern of disposal near delineated feature boundaries (i.e., burned rock concentrations). The apparent lithic concentrations are interpreted as remnants of reduction locations and/or debris discard areas. In Chapter 7.0, these lithic concentrations will be examined more throughly in relation to the horizontal distribution of other artifact classes in order to gain a greater understanding of discrete activity areas and, by extension, overal site function.

6.3.4 Burned Rocks

A note on TU 1 records indicates that all burned rocks were sandstone unless otherwise noted. It appears that only sandstone was present, as there is no indication of other material types referenced in the records or collected. Statements in various level records mention flat slabs and chunks of sandstone, but no specific counts or weights to accompany these general observations. Burned rocks were also mentioned as being broken *in situ.* It is assumed that this means two rocks side by side fit together.

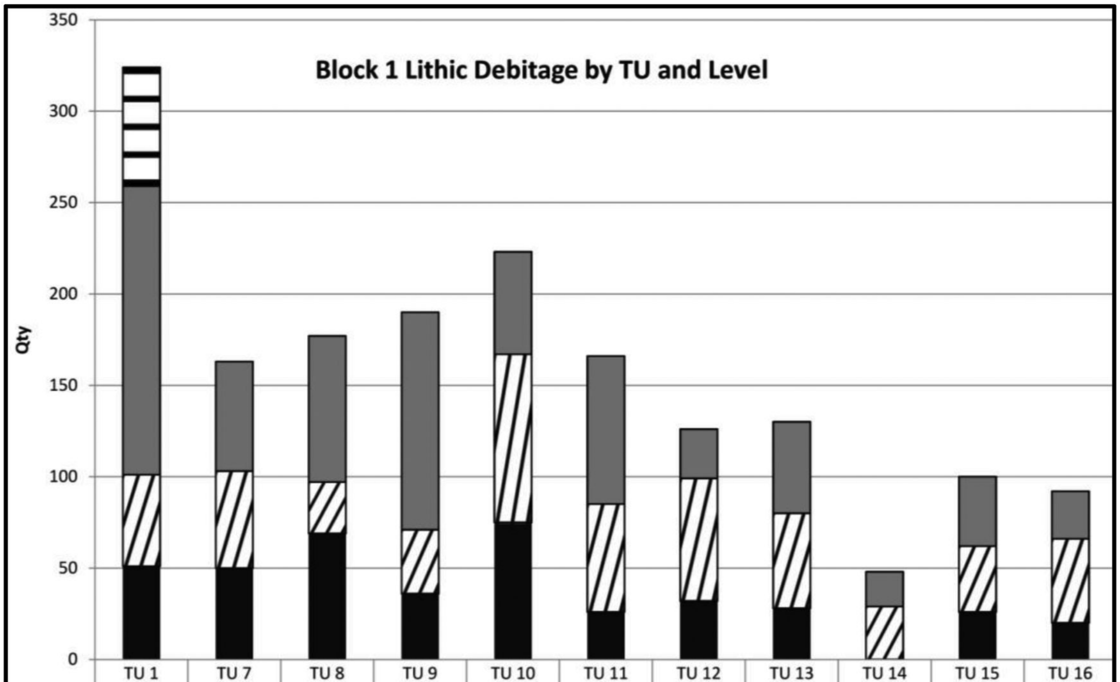
Different sizes of burned rocks were also mentioned but again specific counts and weights by size class were not provided. Sometimes a minimum or maximum size for a level or feature is provided. It is not clear what the total range of sizes were present in most instances. Generally sandstone is relatively soft and small chunks of 1 to 2 cm can often be present. It is not clear what minimum size was recognized as a burned rock or if the smaller sizes were drawn on the maps.

The burned rocks plotted on Block 1 level records totaled 252 pieces. This must be considered a minimum number. The collected burned rocks from the various features in Block 1 were measured and weighed in the TRC laboratory before any rocks were selected for technical analyses (Table 6-8). This small sample may not be a representative sample of the rocks in each of the features.

6.4 UNASSIGNED MATERIALS FROM BLOCK 2

J. Michael Quigg

The following sections present an overview concerning the cultural materials from Block 2. As per TxDOTs direction these materials were not analyzed as TxDOT personnel thought these materials represented mixed components with no diagnostic artifacts or materials for radiocarbon



	TU 1	TU 7	TU 8	TU 9	TU 10	TU 11	TU 12	TU 13	TU 14	TU 15	TU 16
Level 4	65										
Level 3	158	60	80	119	56	81	27	50	19	38	26
Level 2	50	53	28	35	92	59	67	52	29	36	46
Level 1	51	50	69	36	75	26	32	28	0	26	20

Figure 6-42. Frequency distribution by level and unit of lithic debitage in Block 1.

dating, besides the burned rocks. Material classes are presented in the same sequence as for Block 1 starting with a comment on features, followed by the counts of chipped stone tools and debitage, and finally a brief comment on the burned rocks collected from Block 2.

6.4.1 Occupational Features

No cultural features were identified and assigned numbers in excavation Block 2. However, one cluster of burned rocks was recognized and considered a possible feature and discussed in the field notes. That cluster was in Level 5 (57 to 85 cmbgs) of TU 6 and sketched in the notes and drawn on the level record. This cluster was not assigned a feature number, although it could have easily been an intact heating element or discard pile. It appeared as a tight cluster of 13 burned sandstone rocks in an area that measured 34-by-25 cm (Figure 6-43). The two largest rocks as drawn on the level record were about 10 to 12 cm long. The rocks were removed and their depths recorded, which ranged from 73 to 80 cm. These depths appear to indicate a generally flat surface with no obviously tilted or slanted rocks to support the presence of a basin below the rocks or indication that this reflected mixed materials. No observations concerning charcoal, stained soil, or other comments were made in the level record notes. Other burned sandstone rocks were scattered across this same level along with scattered lithic debitage. The artifacts in Level 5 were at or near the bottom of the A horizon and/or rested on top of the B horizon that sloped to the east. This vertical position was generally the same for most cultural materials encountered in Block 1.

6.4.2 Chipped Stone Tools

No formal chipped stone tools were recognized from the five units excavated in Block 2. Examination of the lithic debitage revealed six informal, edge-modified flakes. Four of the five lithic materials represented in the edge-modified flakes are significantly darker

Table 6-8. Burned Rock Data From Block 1, 41MI96.

Block	Unit	Level	Feature	Artifact	Qty	PNUM	BR 4.1-9 cm (Count)	BR 4.1-9 cm (Wt)	BR 9.1-15 cm (Count)	BR 9.1-15 cm (Wt)	BR >15 cm (Count)	BR >15 cm (Wt)	BR Length (cm)	TxDOT Field No.	Comments
1	13	2	2	BR	1	61-1			1.0	378.5			13.5	Fea rock 1	Sent for starch analysis, entire rock sampled
1	13	2	2	BR	1	61-2			1.0	222.0			10.5	Fea rock 2	
1	13	2	2	BR	1	61-3			1.0	139.9			13.0	Fea rock 3	
1	13	2	2	BR	1	61-4			1.0	304.5			13.0	Fea rock 4	Sent for starch analysis, entire rock sampled
1	13	2	3	BR	1	62-5			1.0	579.2			13.5	in Fea 3	Sent for starch analysis, entire rock sampled
1	15	2	3	BR	1	69-6			1.0	941.5			15.0	Fea rock 6	
1	15	2	3	BR	1	69-4			1.0	344.8			12.0	Fea rock 4	
1	15	2	3	BR	1	69-3			1.0	640.4			13.0	Fea rock 3	
1	15	2	3	BR	1	69-2			1.0	404.1			10.0	Fea rock 2	
1	15	2	3	BR	1	69-1					1.0	763.1	17.0	Fea rock 1	
1	7	2	5	BR	1	41-4			1.0	268.8			13.5	Fea rock 4	Sent for starch analysis, entire rock sampled
1	7	2	5	BR	1	41-5	1.0	214.0					8.7	Fea rock 5	
1	7	2	5	BR	1	41-3			1.0	720.8			13.0	Fea rock 3	
1	7	2	5	BR	1	41-1			1.0	355.2			13.0	Fea rock 1	
1	7	2	5	BR	1	41-2			1.0	322.2			10.0	Fea rock 2	
1	7	2	5	BR	1	41-6			1.0	353.6			12.0	Fea rock 6	
1	7	3		BR	1	40	1.0	140.9					7.0		collected as ground stone but is not ground
1	9	3	7	BR	1	49-3			1.0	177.9			12.0	Rock 3	Sent for starch analysis
1	9	3	7	BR	1	49-4					1.0	1047.2	16.0	Rock 5	collected as "metate frag" but not metate
1	9	3		BR	1	49					1.0	6000.0	30.0	Rock 4 @ bottom of	collected as "large basal slab" but not ground
1	9	3	7	BR	1	49-1					1.0	467.3	17.0	Rock 1	
1	9	3	7	BR	1	49-2			1.0	373.8			12.0	Rock 2	Sent for starch analysis, entire rock sampled
1	1	4	4	BR	1	15-2					1.0	2506.6	23.0	Fea rock 2	
1	1	4	4	BR	1	15-3								Fea rock 3	
1	1	4	4	BR	1	15-7			1.0	633.4			12.0	Fea rock 7	
1	1	4	4	BR	1	15-6			1.0	1076.0			15.0	Fea rock 6	
1	1	4	4	BR	1	15-5			1.0	1038.6			13.0	Fea rock 5	
1	1	4	4	BR	1	15-4					1.0	1427.2	18.0	Fea rock 4	
1	1	4	4	BR	1	15-1					1.0	1197.0	18.5	Fea rock 1	
1	1	4	4	BR	1	15-8					1.0	832.1	21.0	Fea rock 8	
Totals					30		2.00	354.90	19.00	9275.20	8.00	14240.50	415.20		

under the shortwave UV light than most chert types currently referred to as Edwards chert. They are generally more orange to light red under the UV light. Only one specimen (#31-11) appears similar in color to the yellowish Edwards chert under the shortwave UV light.

6.4.3 Lithic Debitage

The initial TxDOT field interpretation was that this material was mixed. As per TxDOT instructions, the lithic debitage from Block 2 was not to be analyzed. Table 6-9 provides the counts recovered by unit and level.

6.4.4 Burned Rocks

Flat slabs and chunks of burned sandstone are mentioned in the level records and roughly 350 rocks were drawn on the 22 level records, but again no specific counts or weights were recorded in the field to accompany these general observations and drawings. In short, the total number, size range, and total weight of the burned rocks encountered is not possible to determine. Most burned rock depths were not individually recorded except in Levels 2 and 3 of TU 5 and it appears they were measured from an unspecified datum.

Careful examination of the level records indicates that at least two of the five units encountered only one level of burned rocks with a couple of units showing what appear to be a sloping or dipping zone of burned rocks. If this truly represents what was encountered, these authors believe it is difficult to argue for any significant mixing of components in Block 2, especially if the one cluster of burned rocks was an intact feature.

Different sizes of burned rocks were not mentioned

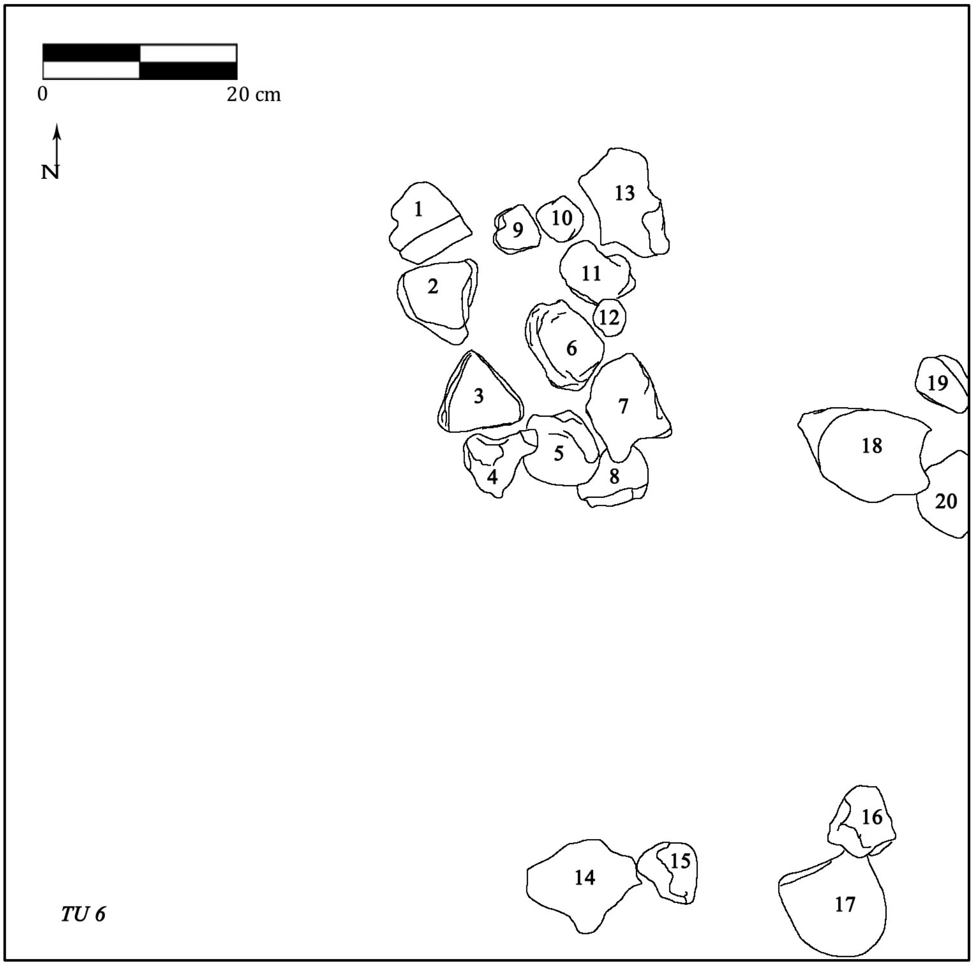


Figure 6-43. Burned rock cluster in Test Unit 6.

for Block 2, but based on what is mapped on the various level records and the rocks drawn were somewhat proportionally to one another, the rocks ranged from about 2 to 15 cm in length. Currently, it is not clear what the total range of sizes were encountered. Generally sandstone is relatively soft and small chunks of 1 to 2 cm can and often occur. It is not clear if these smaller pieces were present or what the minimum size was recognized as a burned rock and then drawn on the level records.

A sample of 44 burned rocks was collected from individual units in Block 2. These collected pieces were measured and weighed (Table 6-10). Since no features were recorded in the field and our focus of analyses was on Block 1, no burned rocks from Block 2 were selected for technical analyses as directed by TxDOT.

Table 6-9. Counts of Lithic Debitage by Unit and Level from Block 2, 41MI96.

Test Unit 2	Level	Count
2	1	120
2	2	60
2	3	47
2	4	12
Total Test Unit 2		**239**
Test Unit 3		
3	1	93
3	2	77
3	3	66
3	4	40
3	5	12
3	(blank)	5
Total Test Unit 3		**293**
Test Unit 4		
4	1	26
4	2	15
4	3	4
4	4	7
4	5	4
Total Test Unit 4		**56**
Test Unit 5		
5	1	4
5	2	90
5	3	58
5	4	59
Total Test Unit 5		**211**
Test Unit 6		
6	1	63
6	2	73
6	3	39
6	4	80
6	5	90
Total Test Unit 6		**345**
Block 2 Total		**1144**

Table 6-10. Data from A Collected Sample of Burned Rocks from Block 2.

Block	Unit	Level	Count	PNUM	Burned Rock No.	Specific Length	4-9 cm Size Count	4-9 cm Size Weight (g)	9-15 cm Size Count	9-15 cm Size Weight (g)
2	2		1	76	130	11.0			1	419.2
2	2	2	1	16		9.0	1	196.9		
2	2	2	1	16		8.5	1	217.9		
2	2	2	1	16		9.5			1	280.2
2	2	2	1	16		10.0			1	260.2
2	2	2	1	16	129	10.5			1	601.1
2	3	2	1	20		8.8	1	302.9		
2	3	2	1	20		6.5	1	140.1		
2	3		1	68	115	13.0			1	397.6
2	3		1	68	116	9.4			1	350.4
2	3		1	68	117	8.6	1	137.7		
2	3		1	68	118	11.0			1	596.3
2	3		1	68	119	6.5	1	128.0		
2	3		1	68	120	6.5	1	137.7		
2	3		1	68	121	8.0	1	144.2		
2	3		1	68	122	7.5	1	132.1		
2	3		1	68	123	14.0			1	654.5
2	3		1	68	124	10.5			1	274.7
2	3		1	68	125	9.5			1	238.6
2	3		1	68	126	10.6			1	522.4
2	3		1	68	127	7.5	1	142.9		
2	3		1	68	128	9.5			1	576.8
2	4		1	86	107	8.0	1	315.5		
2	4		1	77	108	10.0			1	299.9
2	4		1	78	109	11.5			1	325.1
2	4		1	79	110	9.4			1	221.7
2	4		1	80	111	10.0			1	246.6
2	4		1	83	112	10.5			1	562.5
2	4		1	84	113	9.5			1	217.4
2	4		1	85	114	10.0			1	238.4
2	5		1	88	106	13.0			1	600.9
2	5		1	87	105	8.7	1	315.7		
2	5	2	1	30		8.5	1	143.4		
2	5	2	1	30		8.9	1	171.7		
2	5	2	1	30		8.5	1	225.9		
2	5	2	1	30		8.8	1	243.1		
2	6		1	89	100	8.9	1	258.9		

Table 6-10. Data from A Collected Sample of Burned Rocks from Block 2. (cont.)

2	6		1	90	101	4.1	1	68.4		
2	6		1	92	102	6.5	1	84.1		
2	6		1	93	103	8.0	1	192.5		
2	6		1	94	104	10.5			1	529.4
2	3	2	2	20			1	145.9	1	128.9
2	3	2	1	20		11.0			1	366.6
Totals			**44**				**21**	**3845.5**	**23**	**8909.4**

7.0 ADDRESS RESEARCH QUESTIONS

7.1 INTRODUCTION

In Chapter 4.0 above, four research questions were proposed that formulated the strategies for the analyses of burned rocks and lithic debitage recovered from Block 1 at 41MI96. The questions focused on the data from Block 1 as it presented the most appropriate dataset with intact, well-defined burned rock features surrounded by lithic debris. These questions were discussed with and approved by TxDOT prior to initiating analyses. The questions were formulated with the intent of maximizing the information return from the small features by extracting information from the small collection of burned rocks that comprised parts of the intact features to determine what resources were processed in these features and what if any these contributed to understanding feature functions.

To make meaningful contribution, it was first necessary to establish the general age of the features and therefore, this was the first question to be addressed. Once general age was established, feature function was addressed through multiple data sets, followed by establishing the range of resources exploited as determined from microfossils, starch grains and lipid residues, extracted from the burned rocks. The recovered stone tool debris that surrounded the features allowed the question of lithic technology to be examined. Each question is addressed in the following sections.

7.2 QUESTION 1, SITE CHRONOLOGY

J. Michael Quigg and Roberts A. Ricklis

Although small charcoal and bulk matrix samples from some features were collected during TxDOT's 1999 fieldwork, by the time the materials reached TRC in 2012 these samples were no longer available for analyses. Other organic materials such as animal bones, snail shells, and mussel shells that might have served for direct dating were not recovered during TxDOT's excavations. The only means of deriving an absolute radiocarbon date was through dating the organic residues contained within the porous sandstone burned rocks collected. While this is not the standard means of documenting the age of a cultural event, it is not the first time that dating of organic residues within burned rocks has been conducted in Texas (i.e., Quigg 2001, 2003; Quigg et al. 2002a, 2002b, 2008, 2011a). The first major attempt was conducted at the Boiler site (41WB557) and, although variable, some promising results were obtained (Quigg et al. 2002a). Since that time, a limited number of burned rocks have been radiocarbon dated, again with variable results (e.g., Quigg et al. 2002b, 2008, 2011a).

TxDOT personnel collected less than six burned rocks from each of the six features, which severely limited the samples available for analyses. In most instances, a sizable sandstone fragment with visually discolored exterior and often with a darker outer rind was selected for dating. Generally, two rocks per feature were dated, except in the case of Feature 2, for which a single rock was dated. Burned rocks from Feature 1 were not collected, thus none were available for this purpose.

The nine sandstone samples selected by TRC personnel, subsamples of the collected rocks, were carefully processed by Beta Analytic, Inc., who were instructed to target only the darker outer rinds of the submitted samples. The targeted and recovered organic residues were then combusted and AMS dated (see 5.0 Methods section for details of the amounts processed). Table 7-1 provides pertinent data concerning the dates from the various rocks that represent the five features.

The conventional age results indicate that Features 2 and 3, with dates less than 1000 B.P., are the youngest and appear relatively close in time. Although not radiocarbon dated, Feature 1 was less than 2 m south of Features 2 and 3 and appeared at about the same depth as Features 2 and 3. It is believed that these three burned rock features were all constructed and used during the same general time interval. These three features also were clustered towards the western end of Block 1. Feature 4 at the eastern end of Block 1 is the oldest feature at roughly 1430 B.P. and was also the deepest feature investigated. The four radiocarbon dates on rocks from Features 5 and 7 appear to cluster at about the same time between roughly 1120 and 1330 B.P. and indicate at least one

Table 7-1. Summary of Radiocarbon Results from Block 1 at 41MI96.

Block No.	PNUM	Feature No.	Test Unit	Level	Material*	Weight of Material Combusted (g)	Beta Lab No.	Measured Age (B.P.)	$^{13}C/^{12}C$ Ratio (‰)	Conventional Age (B.P.)	2 Sigma Calibration Age
1	61-2c	2	13	2	Burned SS	0.532	323141	NA	NA	910 ± 30	Cal A.D. 1030 to 1210
1	62-5c	3	13	2	Burned SS	1.6	324165	930 ± 30	-22.2	980 ± 30	Cal A.D. 1020 to 1150
1	69-1c	3	15	2	Burned SS	1.1	324166	NA	NA	820 ± 30	Cal A.D. 1160 to 1270
1	15-5c	4	1	4	Burned SS	0.82	324162	NA	NA	1410 ± 30	Cal A.D. 600 to 660
1	15-2c	4	1	4	Burned SS	1.6	321461	1400 ± 30	-21.7	1450 ± 30	Cal A.D. 560 to 650
1	41-2a	5	7	2	Burned SS	2.2	314163	1100 ± 30	-21.4	1160 ± 30	Cal A.D. 780 to 900
1	41-1c	5	7	2	Burned SS	0.184	323140	NA	NA	1330 ± 40	Cal A.D. 650 to 770
1	49-5c	7	9	3	Burned SS	0.410	323139	1060 ± 30	-21.4	1120 ± 30	Cal A.D. 880 to 990
1	49-2c	7	9	3	Burned SS	0.96	314164	NA	NA	1210 ± 30	Cal A.D. 710 to 750

* All material was organic particles in burned sandstone

additional period of site occupation. As far as can be ascertained with available information, Features 5 and 7 are slightly deeper than those younger features at the western end of the block, and at a slightly higher elevation than the older Feature 1 at the eastern end. The nine radiocarbon dates on rocks from five features indicate a basic stratigraphic integrity, despite the limited deposition of sediment that took place between the dated cultural occupations.

The two dates derived from each of the four features are relatively close in time, especially the two dates from Feature 4 and 7, which indicate that the organically enriched margins of the sandstone burned rocks are likely yielding reasonably accurate ages for accumulated organic residues. While these results may be less precise than would be obtained from dating a burned seeds or nut shells from a particular feature, they appear to be sufficiently accurate for assessing the ages of the features in question, and for meaningful chronological interpretations concerning the history of site occupations.

The conventional AMS dates derived from organic residues in the sandstone burned rocks range from 820 to 1450 B.P. (maximum 2-sigma range of cal A.D. 560 to 1270) and indicate a conventional maximum time range of some 630 years or 710 years when the dates are calibrated. This period falls generally towards the latter part of the Late Archaic II period as identified by Johnson and Goode (1994, 1995) and Collins (2004) and into the early part of Late Prehistoric period (Figure 7-1). While the radiocarbon dates thus indicate that 41MI96 was occupied during a time interval (ca. A.D. 600 to 1200) that is often ascribed to the early part of the post-Archaic, or Late Prehistoric, period (i.e., the Austin phase) in central Texas, the lack of corresponding time-diagnostic artifacts, such as Scallorn arrow points, from the site precludes any

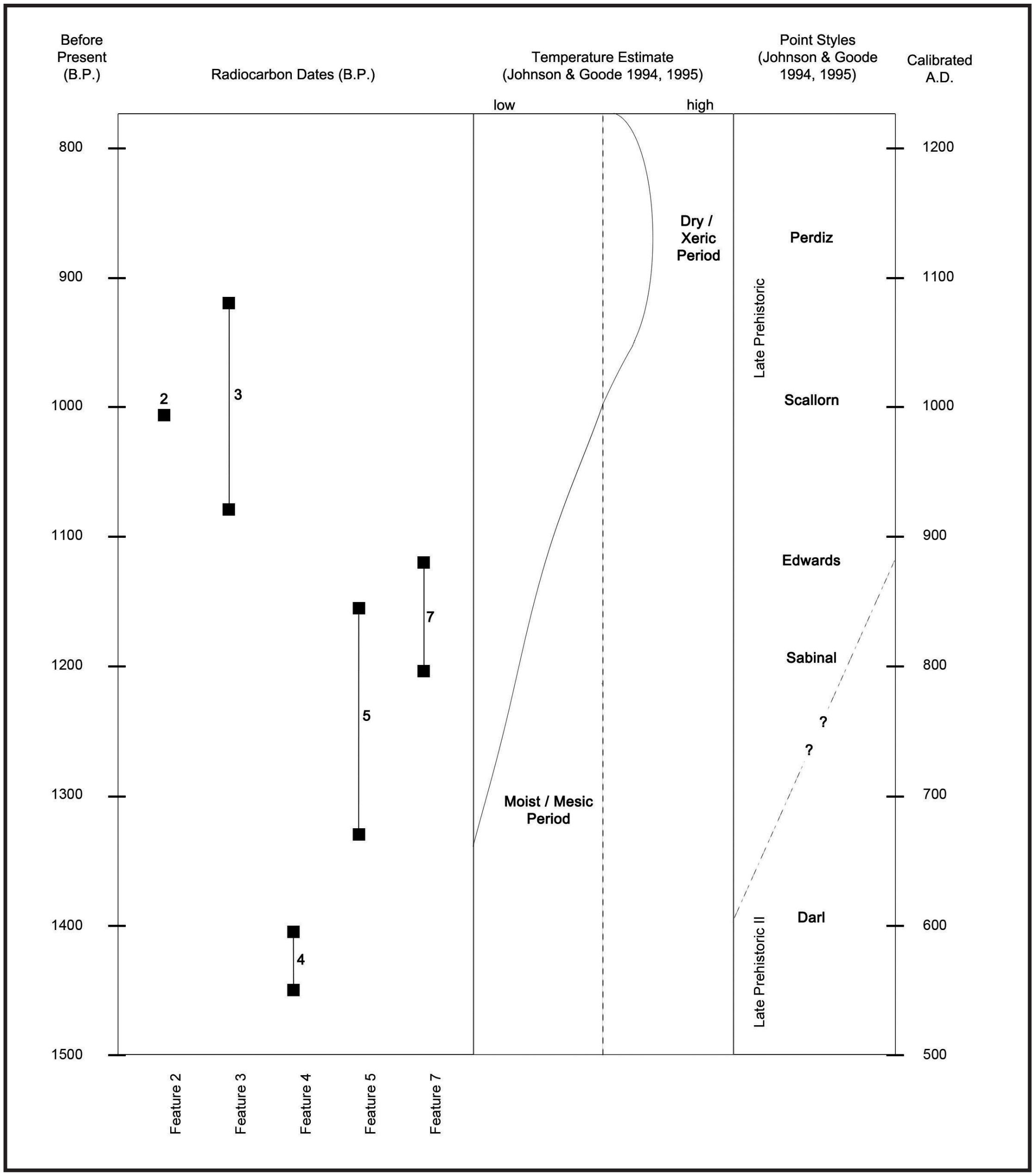


Figure 7-1. Radiocarbon dates from 41MI96 in relation to broad temperature changes and projectile point styles.

confident assignment of the recovered materials to the Austin phase.

However, in terms of environmental conditions and corresponding patterns of human adaptation, this time interval can legitimately be lumped with the Late Archaic II period, as defined by Johnson and Goode (1994, 1995). Those authors stated that the Late Archaic II cultural period corresponded to the relatively moist climatic conditions that followed the earlier dry conditions of their Edwards Interval. That dry period created a more xeric environment during the Late Archaic I, which resulted in an emphasis by those populations towards exploitation/cooking of xerophytic plants that resulted in the intensification of hot rock cooking and major accumulation of burned rock middens (see Chapter 3.0, "Cultural Background"). Aside from the technical shift between the end of the Archaic and the beginning of the Late Prehistoric in central Texas archeology via replacement of dart points by arrow points (and the corresponding replacement of the dart-atlatl weapon system with the bow and arrow), from a cultural-ecological perspective there was probably little appreciable change in either environment or basic human adaptive patterns during this period, justifying its inclusion within the Late Archaic. As noted by Johnson and Goode,

In fact, of all the period boundaries set in the present paper, that for the ending of the Late Archaic II subperiod is the most subjective and bothersome. For one thing, human culture did not change greatly after the beginning of that interval down through the days when Scallorn arrowheads were in vogue. If the informed reader wishes to terminate the Late Archaic period at A.D. 1200, I will not argue. Or if he wants to stop the period at around A.D. 400 (or a bit later), when very small "dart" points of the Darl and Figueroa sort appear in the region, that is another possibility. Those small points may actually represent the first arrowheads to materialize locally. The appearance of small dart points at about this time is also documented for north-central Texas (Prikryl 1990:56) and other regions.

In any case, human life on and just below the eastern Edwards Plateau changed in small ways in the Edwards-Scallorn part of the Post-Archaic Era….

> *The climate continued mesic until around A.D. 1200, when a drought affected at least parts of the Edwards Plateau. Buffalo came back onto the plateau soon thereafter and stayed, even after climatic conditions may have reverted to the region's near-mesic norm between A.D. 1300 and 1400. The Archaic-seeming life style of the Scallorn folk was replaced by buffalo hunting and foraging by smallish groups of Toyah-culture people [Johnson and Goode 1994:40-41].*

In light of these observations, and in the absence of diagnostic artifacts that would indicate otherwise (e.g., Scallorn arrow points), we believe it is appropriate to interpret 41MI96 occupations as representative of the terminal centuries of the Late Archaic I period, as defined by Johnson and Goode (1994, 1995), and to view the site's features and other materials as reflecting patterns of human adaptation during that cultural period.

7.3 QUESTION 2, FEATURE FUNCTION

J. Michael Quigg

7.3.1 Introduction

Small burned rock features- those generally less than about 2 m in diameter- have not often been critically evaluated as to function in archeological investigations. In some reports, small burned rock features have been assigned to inferred functional groupings such as cooking and/or heating features or "other" types (i.e., Prewitt 1981; Kleinback et al. 1995; Abbott et al. 1996). Frequently, small concentrations or clusters of burned rocks have been defined as a 'hearth' solely on the basis of the presence of the burned rocks in more or less tight clusters. Often these small features are described in various ways and illustrated by means of photographs and/or drawings, but are not identified according to function on the basis of any empirical evidence. This type of presentation is often a reflection of loose associations with other classes of artifacts such as animal bones, lithic debitage, mussel shells, and/or carbonized organic remains. Sometimes the lack of identification of function is the reflection of poor recording in the field, poor preservation, or a basic lack of interest in burned rocks. There has also been a near absence of technical studies directed towards microfossils directly associated with the features, and this has severely hampered reliable understanding of the possible range of uses for small burned rock features. Effectively, the paucity of in-depth analysis leaves the interpretation of the function(s) of small burned rock features at the level of an untested assumption. Black (2003) has provided "a partial roadmap for systematic data collection from the hearths of the greater Edwards Plateau" to help address this reoccurring problem.

Burned rocks have been explicitly recognized as a means of transferring heat from a fire to a target substance in prehistoric methods of food preparation. Ellis (1997:47) states that "burned rock features … are facilities (or the remains thereof) that represent fire-oriented technologies. Heated rocks provide a simple, yet effective, means of controlling the release of heat and function as heat reservoirs that reduce the level of energy expended to gather fuel and minimize heat dissipation". The presence of burned rocks is thus considered an obvious physical remnant of cooking and heating activities, and discrete clusters of burned rocks therefore assumed to reflect specific human behavior involving cooking, heating, and related activities.

Despite the lack of critical evaluation of small burned rock features, increased attention has been devoted to empirical studies of the major constituents of small burned rock features- the actual burned rocks. Over the last 25 years considerable advancement has been made towards understanding burned rocks through a variety of analytical approaches (e.g., House and Smith 1975; Witkind 1977; Tennis et al. 1997; Bond 1978; Lucas and Frederick 1978; Jones 1981; Lintz 1989; Collins et al. 1990; Duncan and Doleman 1991; Loy 1994; Ellis 1997; Stark 1997; McPaland 1977; Leach et al. 1998; Mauldin and Tomka 2011; Jackson 1998; Dering 1999; Gose 1999; Quigg 2001, 2003; Quigg and Cordova 2000; Quigg et al. 2000, 2001, 2002a, 2000b, 2003; Thoms and Mandel 2007; and Thoms 1986, 2003, 2008).

In order to reconstruct activities at a particular site, it is necessary to understand the specific tasks that are represented by burned rock features. Common questions that arise in attempting behavioral reconstructions are: is the cluster *in situ*? Did it serve as a cooking device, and was the method of cooking stone boiling, grilling, roasting, or parching? Or, is it a heating element that was used for something besides cooking? Alternatively, does the feature reflect a secondary activity such as clean out of a primary facility and dumping or discard of rocks no longer desired to transference heat. Identifying the specific function of a burned rock cluster depends on the combination of accurate observations recorded in the field, coupled with subsequent laboratory analyses of the rocks and associated artifacts and ecofacts. Field observations on a particular feature such as size, shape, presence or absence of a basin, any associations of charcoal, ash, burned sediment, lithic, bone, and other artifacts, combined with rock material types, rock sizes, rock shapes, and overall patterning of the rocks within the feature all contribute to the data required for functional interpretation.

Small burned rock features have yielded a variety of carbonized plant remains such as nuts, hackberry nutlets, bulbs, etc., that indicate that these small features were used for cooking of edible plants and not solely to produce heat (e.g., Schroeder and Oksanen 2002; Brownlow 2004; Karbula et al. 2001, 2011). In Texas, such features have been found to extend back at least to Late Paleoindian times at the Wilson-Leonard site (41WM235), radiocarbon dated to 9500 to 10,000 B.P. (Collins 1998, 2004), at the Armstong site (41CW54), dated to 8,500 B.P. (Schroeder and Oksanen 2002; Schroeder 2011), and at the Richard Beene site (41BX831), with dates from 8640 to 8900 B.P. (Thoms 2007; Thoms and Clabaugh 2011). Additionally, charred bulb fragments have been identified in small rock features that pertain to the long-lived Archaic stage in Texas (e.g., Collins 1998, 2004; Schroeder and Oksanen 2002:23; Dering 2003; Mehalchick et al. 2004; Mehalchick and Kibler 2008; Dixon and Rodgers 2006; Schroeder 2011; and Karbula et al. 2011). A particularly informative and recently studied example was documented for the Early Archaic period at the Berdoll site in Travis County, where an *in situ* rock oven with a deep basin (Feature 11), approximately 2 m in diameter, yielded three charred bulb fragments (Karbula et al. 2011).

The large burned rock middens and mounds have been discussed at length in the Texas archeological literature (e.g., see Hester 1991 and Black et al. 1997) and have been documented to be primarily associated with cooking Agavaceae such as sotol and lechuguilla, roots, and/or geophytes including eastern camas (*Camassia scilloidies*), onion (*Allium* spp.), and false garlic (*Nothoscordum* bivalue). All of these plants can be gathered in large quantities and require extensive cooking times (e.g., Dering 1997, 1998; Black et al. 1997; Wandsnider 1997; Collins 1998, 2004; Brownlow 2003; Mauldin et al. 2003; Boyd et al. 2004:216, Figure 9.5; Quigg et al. 2011b).

In a three-county area surrounding 41MI96, including Mills, San Saba, and Lampasas counties, there are relatively few recorded archeological sites (ca. 330 in total); the majority are known only as surface exposures, of those, at least 25 (7.5 percent) are recorded as burned rock middens. In contrast, only eight (2.4 percent) of the sites were documented as containing 'hearths' or 'possible hearths'. The broader region surrounding these three counties also has large burned rock middens and smaller burned rock features. The extensive McCann site (41LM3), in Lampasas County, was excavated and yielded at least five burned rock 'hearths' and a large burned rock midden (Preston 1969). Significant testing at 41SS164, in San Saba County, yielded a large sheet midden and a small hearth (Bonine et al. 2008). The immediate surrounding area has recorded evidence of both small burned rock features and much larger concentrations of burned rock, designated as burned rock middens. Obviously the assumed processing of food resources through these different size burned rock features was conducted throughout the region and is therefore likely to have been conducted by the occupants of 41MI96.

7.3.2 Assessment of Six Burned Rock Features in Block 1

From the 1999 TxDOT field notes, level records, and feature drawings of the six recognized burned rock features in Block 1, the authors have assessed the recorded data and assigned them to two different basic groups. Using L. Ellis' (1997) discussion as a guide, Features 1 through 4 best reflect *in situ* heating elements, with Features 2, 3, and 4 having had discernible basins immediately beneath the rocks. The occurrence of basins in these three features indicates they were *in situ* facilities, but exactly how the rocks or the feature functioned is not clear from field data alone. A number of possibilities exist, such as, but not limited to: heating elements for warming, fires to heat stones, or actual *in situ* cooking facilities. Since field observations are not sufficient for defiing the specific function of the feature, analyzing selected attributes of the features, the burned rocks, through two types of technical analyses was our strategy for determining how these features may have functioned.

Here, starch grain and lipid residue analyses have targeted a couple of selected rocks from each of the five features, and these have yielded positive results that indicate that both plant and animal foods were cooked using these rocks. It is clear that rocks from these features functioned as part of the food cooking process as most contain food residues. The absence of mussel shells in or around these features indicates that mussels were not a targeted food resource. The absence of vertebrate faunal remains is likely the result of preservation and is not interpreted to reflect an on-site absence of animal products acquired through hunting. Although it has been demonstrated through these two analyses that multiple kinds of food (i.e., grass seeds, maize, and animal products) were cooked by the rocks, the exact method of cooking (e.g., grilling, roasting, and stone boiling) remains unclear. Gelatinization of two identified starch grains (one grass and one maize), the distortion of normal grains resulting from contact with heat and water, indicate that boiling was likely carried out in at least some instances.

These small *in situ* rock facilities combined with the food residues detected on selected burned rocks, and the absence of final cleaning or nearby burned rock discard piles indicate the occupants were likely present for short time, constructed or used existing facilities for heating and/or cooking, and then abandoned the features. None of these four features appeared to have had materials raked out or disturbed from reuse. Feature 1, which lacked a detectable basin, may have served as a heating element for rock, or used as griddle, or possibly a discard pile. The lack of collected burned rocks from Feature 1 for analyses prevented investigation of its specific function.

The presence of small informal cooking/heating and discard features here and radiocarbon dated to different times indicate peoples repeatedly occupied this spot in highly redundant manner for the purpose of carrying out the same or very similar activities during each visit.

Features 5 and 7 appear to represent discard piles or dumps of burned rocks no longer desired following their use in cooking and/or heating foods that include plant and animal products. These dumps involved a decision by the operators that the primary heating element or cooking facility needed to be cleaned and thus the rocks and likely other associated materials removed from the primary feature and discarded. Both Features 5 and 7 have yielded radiocarbon dates that indicate they are not contemporaneous with the other *in situ* features, so it appears most likely that they came from primary features not represented in Block 1. Discard features indicate that the occupants were present at this particular spot long enough to use and then need/desire to clean a primary *in situ* facility for reuse. This process of cleaning and discarding materials potentially indicates a slightly longer stay than represented by features that were not cleaned.

Consequently, the small excavated area in Block 1 documents the *in situ* cooking and disposal area from multiple cooking events that occurred during at least three separate occupations based on the obtained radiocarbon dates, short duration occupations, that occurred over a span of roughly 700 years. These features were well-preserved and were associated with various knapping activities in a slowly aggrading alluvium. These activities occurred from ca. 820 to 1450 B.P. (cal A.D. 560 to 1270) during the period of transition from the Late Archaic II to the early part of the Late Prehistoric period.

7.4 QUESTION 3, RANGE OF RESOURCE EXPLOITATION

J. Michael Quigg and Roberts A. Ricklis

7.4.1 Introduction

As previously discussed, rocks from five intact burned rock-dominated features and lithic tools collected from Block 1 were targeted for technical analyses directed towards identifying the resources cooked by the rocks in those features and the resources processed by means of stone tools. Below, the starch grain and lipid residue results are presented for rocks analyzed from the five sampled features. The analyzed rocks were selected from those few collected in the field by TxDOT personnel from each feature, which were likely randomly selected (see the feature drawings for the positions of the rocks selected and analyzed). It is presumed that the early inhabitants heated the rocks in a fire to transfer heat and cook various food resources (see L. Ellis 1997 for in depth discussion). Given these presumptions, the authors anticipated that these two specific technical analyses would shed light on what resources were heated and/or cooked, and potentially how they were cooked (i.e., boiled, etc.). Following the discussions concerning the results from starch and lipid analyses on burned rocks, the identifications of resources manipulated by chert tools detected from the high-powered microscopic use-wear and residue identifications, and starch analysis are presented.

7.4.2 Starch and Lipid Results from Feature Rocks

Since rocks from Feature 1 were not available for analysis, the food resources that may have been heated and/or cooked in this feature remain unidentified. However, considering its position next to Features 2 and 3, that it rested at approximately the same elevation, and was of the same approximate age, it is probable that similar food resources were processed in this feature as in Features 2 and 3. The absence of a recognized basin may indicate that Feature 1 did not function as a cooking facility, but was used to heat rocks for use in the adjacent cooking facilities.

Four subsets of burned rock fragments (#61-1 through #61-4) from Feature 2 were analyzed for starch grains and pieces of those same rocks were subjected to lipid analysis. In general, the lipid residue analysis revealed traces of animal products, but mostly plant lipids (Table 7-2; Appendix D). The starch grain analysis produced positive results from three of the four rock fragments (Table 7-3 Appendix C). One rock fragment yielded a lenticular grain (likely of little barley [*hordeum pusillum*] or wildrye [*Elymus canadensis*]), one rock

Table 7-2. Lipid Residue Results from Burned Rocks in Block 1.

Feature No.	Test Unit	Level	TxDOT Burned Rock No.	Final PNUM	Wt. (g) of Piece Analyzed	Malainey's Lab No.	Lipid Residue Results and Interpretations
2	13	2	BR #1	61-1b	55.7	12MQ5	Plant, traces of animal products, conifer products
2	13	2	BR #2	61-2b	38.7	12MQ6	Plant, traces of animal products
2	13	2	BR #3	61-3b	14.9	12MQ7	Plant, traces of animal products
2	13	2	BR #4	61-4b	92	12MQ8	Plant, traces of animal products, conifer products
3	13	2	BR #5	62-5b	30.7	12MQ9	Plant, traces of animal products
3	15	2	BR #1	69-1b	58.6	12MQ10	Large herbivore, plant and animal products
3	15	2	BR #2	69-2b	104	12MQ11	Traces of plant and animal products, conifer products
3	15	2	BR #3	69-3b	44.1	12MQ13	Traces of plant and animal products
4	1	4	BR #2	15-1b	90.4	12MQ1	Plant seed oils, animal products, conifer products
4	1	4	BR #3	15-2b	109.5	12MQ2	Traces of plant and animal products, conifer products
4	1	4	BR #6	15-4b	94.4	12MQ3	Plant and animal products, conifer products
4	1	4	BR #8	15-5b	102.1	12MQ4	Plant and animal products, conifer products
5	7	3	BR #1	41-1b	57.3	12MQ13	Plant and animal products, conifer products
5	7	2	BR #3	41-3b	54.2	12MQ14	Plant and animal products
5	7	2	BR #4	41-4b	51.6	12MQ15	Plant and animal products, conifer products
5	7	2	BR #6	41-6b	40	12MQ16	Traces of plant and animal products, conifer products
7	9	3	BR #1	49-1b	103.4	1MQ17	Plant seeds, traces of animal products
7	9	3	BR #2	49-2b	103.9	12MQ18	Plant and animal products
7	9	3	BR #3	49-3b	49.6	12MQ19	Plant seed residues, trace of animal products, conifer products
7	9	3	BR #5	49-4b	94.9	12MQ20	Plant and animal products

revealed maize (*Zea mays*) grains and an unknown grass; with another yielding an unidentifiable grass grain (Appendix C). The lenticular grass grain was damaged from processing and cooking, displaying both grinding and gelatinization. The latter meaning it was distorted by contact with heat and water, most likely representative of stone boiling.

Pieces of four individual burned rocks (#69-1 through #69-3 and #62-5) from Feature 3 were also subjected to both starch grain and lipid residue analyses. The lipid residue analysis yielded mostly traces of plant and animal products (see Table 7-2). One rock (#69-1) revealed residues indicative of large herbivore (i.e., deer or bison) along with other animal and plant products. Starch analysis revealed two rocks with maize and two rocks with unidentifiable grains (see Table 7-3; Appendix C). One maize grain was gelatinized, meaning it was distorted by contact with heat and water, most likely representative of stone boiling.

The fragments of four burned rocks analyzed (#15-1, #15-2, #15-4, and #15-5) from Feature 4 yielded

Table 7-3. Starch Grain Results from Burned Rocks in Block 1.

Feature No.	Test Unit	Level	TxDOT Burned Rock No.	Final PNUM	Wt. (g) of Piece Analyzed	Lenticular Grass Starch	Other Grass Starch	Unidentified Starch	Maize Starch	Damaged Starch *
2	13	2	BR #1	61-1	322.4					
2	13	2	BR #2	61-2a	127.6	1				GL, GD
2	13	2	BR #3	61-3a	99.8		1		1	
2	13	2	BR #4	61-4	208.6				1	
4	1	4	BR #2	15-1a	416.2					
4	1	4	BR #3	15-2a	380.9	1				H
4	1	4	BR #6	15-4a	656.7		1	1		
4	1	4	BR #8	15-5a	339.9		1			GL
3	13	2	BR #5	62-5	325.6				1	GL
3	15	2	BR #1	69-1a	290.6					
3	15	2	BR #2	69-2a	144.3			1	1	
3	15	2	BR #3	69-3a	433.4			1		
5	7	2	BR #1	41-1a	203.6					
5	7	2	BR #3	41-3a	585.1					
5	7	2	BR #4	41-4	216.8					
5	7	2	BR #6	41-6a	169.4					
7	9	3	BR #1	49-1a	323.4	4		1		1 GD
7	9	3	BR #2	49-2	196.1					
7	9	3	BR #3	49-3	125.7					
7	9	3	BR #5	49-4a	813.2					

* GL = gelatinized, GD = ground, H = heated,

informative results from both lipid and starch analyses. Animal and plant (including seed oil) lipid residues were found on rock #15-1 (see Table 7-2; Appendix D). Starch grains from grasses were identified along with one unidentified grain. One lenticular grass grain had heat damage and another had been damaged by grinding (see Table 7-3; Appendix C).

From Feature 5, parts of four separate burned rocks (#41-1, #41-3, #41-4, and #41-6) were analyzed for starch grains, and portions of those same four rocks were analyzed for lipid residues. Plant and animal lipid residues were again present in all four samples (see Table 7-2; Appendix D). Starch grain analysis was negative for these four burned rocks (see Table 7-3; Appendix C).

Portions of four burned rocks (#49-1 through #49-4) from Feature 7 were subjected to the same technical analyses as rocks from the other features. The lipid residue results reveal plant and animal products present with some residues representing seed oils (see Table 7-2; Appendix D). Starch grains were only on one rock and these included four lenticular grass grains and one unidentifiable grain. One of the grains had been damaged by grinding (see Table 7-3).

7.4.3 Starch Grain and Use-Wear Results from Chipped Stone Tools

Starch grain analysis was also conducted on 20 chipped stone tools (17 edge-modified flakes, 2 chert choppers, and 1 biface fragment). Positive results were obtained on nine (45 percent) of the tools (Table 7-4; Appendix D). Those nine tools yielded 15 grains in a similar frequency per artifact as recovered from the burned rocks. Seven grains were lenticular and likely represent little barley (*hordeum pusillum*) or wildrye (*Elymus* spp.) grass seeds. One grass grain was unidentifiable as it was damaged through heat alteration. Five other unidentifiable grains were also detected. Two tools, an edge-modified flake and a biface fragment, each yielded one maize (*Zea mays*) starch grain. The documentation of definite plant starches on the edge-modified flakes and a biface

Table 7-4. Starch Analysis Results on Stone Tools.

Feature No.	Test Unit	Level	TxDOT Burned Rock No.	Final PNUM	Conventional Radiocarbon Ag`e (B.P.)	Lipid Residue Results and Interpretations	Lenticular Grass Starch	Other Grass Starch	Unidentified Starch	Maize Starch	Damaged Starch *
2	13	2	BR #1	61-1b		Plant, traces of animal products, conifer products					
2	13	2	BR #2	61-2b	910 ± 30	Plant, traces of animal products	1				GL, GD
2	13	2	BR #3	61-3b		Plant, traces of animal products		1		1	
2	13	2	BR #4	61-4b		Plant, traces of animal products, conifer products				1	
3	13	2	BR #5	62-5b	980 ± 30	Plant, traces of animal products				1	GL
3	15	2	BR #1	69-1b	820 ± 30	Large herbivore, plant and animal products					
3	15	2	BR #2	69-2b		Traces of plant and animal products, conifer products			1	1	
3	15	2	BR #3	69-3b		Traces of plant and animal products			1		
4	1	4	BR #2	15-1b		Plant seed oils, animal products, conifer products					
4	1	4	BR #3	15-2b	1450 ± 30	Traces of plant and animal products, conifer products	1				H
4	1	4	BR #6	15-4b		Plant and animal products, conifer products		1	1		
4	1	4	BR #8	15-5b	1410 ± 30	Plant and animal products, conifer products		1			GL
5	7	3	BR #1	41-1b	1330 ± 40	Plant and animal products, conifer products					
5	7	2	BR #2	41-2a	1160 ± 30	NA					
5	7	2	BR #3	41-3b		Plant and animal products					
5	7	2	BR #4	41-4b		Plant and animal products, conifer products					
5	7	2	BR #6	41-6b		Traces of plant and animal products, conifer products					
7	9	3	BR #1	49-1b		Plant seeds, traces of animal products	4		1		1 GD
7	9	3	BR #2	49-2b	1210 ± 30	Plant and animal products					
7	9	3	BR #3	49-3b		Plant seed residues, trace of animal products, conifer products					
7	9	3	BR #5	49-4b		Plant and animal products					
7	9	3	BR #4	49-5c	1120 ± 30	NA					

* GL = Gelatinized, GD = Ground, H = Heated

demonstrates that both tool classes were used in plant processing. No starches were found on the two choppers.

Fifteen stone tools of the previous 20 were also subjected to high-powered microscopic use-wear analysis. Results revealed contact with various materials, which included; wood, unidentified plants, bone, and animal hair (Table 7-5; Appendix B). Both choppers revealed visible residues, one of wood and the other plant fibers, and the absence of starch grains on these two tools indicates they were used on non-starchy, woody/fibrous plant parts. One biface fragment also revealed plant fibers. Wood residues were present on five specimens, plant fibers were on four specimens, and animal hair was on three specimens. The observed use-wear indicates that these 15 tools were used for cutting hard, high silicate materials, cutting wood and plants, scraping and/or whittling wood and bone, and/or cutting soft materials and hides (Appendix B).

7.4.4 Summary

The 20 burned rocks from five features subjected to lipid and starch analyses yielded positive, important, and interesting results, as did the starch analysis on 20 stone tools and high-powered microscopic use-wear analysis on 15 tools analyzed. These results provide information that contributes to understanding what food resources were processed by means of these five burned rock features at this particular site.

Ten burned rocks yielded 17 grains, or 53 percent of the total starches, from the two classes of artifacts. The starch analysis on the burned rocks revealed at least nine grass starches, with five lenticular grains (either little barley or wildrye) and at least three unidentifiable grass grains, plus three other unidentifiable grains (Appendix C). Grass starch was in rocks from Features 2, 4, and 7. At least one grass starch revealed it was heated, another two were ground with at least one gelatinized. This indicates that grasses were procured, likely heated in a parching process, then ground, and finally cooked. Maize starch was identified in Features 2 and 3 with at least one grain gelatinized.

The results of starch analysis on the 20 stone tools document plant processing through 7 grains that represent multiple grass species, which include little barley and/or wildrye and others. Also present are two grains of maize starch on edge-modified flakes. Additionally, five grains were unidentifiable. At least two grains damaged from heating were observed on two edge-modified flakes. The starch analysis on the 20 burned rocks and 20 chipped stone tools documents an extensive use of multiple grasses in apparent association with Features 2, 4, and 7 and on at least 4 edge-modified flakes.

In general, the majority of the lipid residues is interpreted to reflect cooking and/or heating both plant (dominant) and animal (minor) products. Large herbivore residue (probably deer in this instance) is reflected in one rock from Feature 3, whereas oily seeds (i.e., sunflower, sumpweed) are reflected in at least three rocks, two from Feature 7 and one from Feature 4. These results are not unexpected, but they reveal that the use of similar food resources did not radically change over the some 700 years represented by these features, until the addition of maize during the most recent occupation.

Highly significant, and quite unexpected, is the presence of maize starch grains on rocks from Features 2 and 3, as well as on two edge-modified flakes. The multiple occurrences of maize in direct association with these cultural items, including the rocks from two dated features, almost certainly indicates the integration of this plant domesticate into the range of subsistence resources between ca. 820 and 1210 B.P. (cal A.D. 710 and 1270) in central Texas. Specifically, burned rock #62-5 from Feature 3 with maize starch present was directly dated to 980 ± 30 B.P. (cal A.D. 1020 to 1150). While at least the occasional use of maize by central Texas hunter-gatherers has been documented for the subsequent Toyah phase between ca. A.D. 1300 through 1700 (e.g., Jelks 1962; Harris 1985; Prewitt 1985; Story 1990: 253-255), these findings at 41MI96 indicate, for the first time in central Texas, that this cultigen was in use in this area during the preceding period. This is a new and provocative discovery, given that only one or two examples of maize cobs have been reported in the literature from central Texas and these in later Toyah contexts. Generally, the present of maize cobs has been taken to indicate that maize was traded into these central Texas

Table 7-5. High-Powered Microscopic Use-Wear Results.

PNUM	Unit	Level	Feature	Tool Type	Residues	Use-Wear	Function *
13-10	1	3		Edge Modified	NA	Striae, edge rounding	Cutting HHS material
13-11	1	3		Edge Modified	wood, plant fibers	HHS	Cutting wood
14-10	1	4	4	Hafted Biface	wood	NA	Unknown/unused
14-11	1	4	4	Biface fragment	NA	soft polish, striae	Cutting plant
14-12	1	4	4	Edge Modified	Plant fibers	HHS polish, striae	Cutting plant
14-13	1	4	4	Edge Modified	NA	Straiae, HHS polish	Wittling HHS material
44-10	9	1		Chopper	Wood	HHS polish, striae	Scraping wood
44-11	9	1	7	Edge Modified	NA	HHS polish	Cutting HHS mateial
45-10	9	2		Edge Modified	Bone, hair	HHS polish edge damage	Scraping bone/hide
54-10	12	2		Thick Wedge	Hair	Striae, edge rounding	Cutting hide
57-10	13	2		Edge Modified	NA	soft polish, striae	Sutting soft material
59-10	14	1		Edge Modified	Wood plant fibers	soft polish, striae	Whittling wood
60-10	14	2		Edge Modified	Wood	HHS polish	Cutting wood
81-10	14	3		Chopper	Plant fibers	NA	Unknown/unused
65-10	16	1		Edge Modified	Hair	Soft Polish, HHS polish, striae	Cutting hide & HHS material

* HHS = hard/high silica

populations or region from outside sources. The most likely originating sources would have been the Caddoan populations to the northeast. This may mean the pattern of interaction between east Texas Caddo and central Texas hunter-gatherers was in operation considerably earlier than previously believed. The Caddo populations to the northeast are known to have been cultivating maize, squash and native seed plants during the period of ca. A.D. 1000 through 1200 (Perttula 2004, 2008). However, further starch grain analysis of burned rocks from this northeastern portion of the greater central Texas area may ultimately indicate that maize was more ubiquitous than is presently assumed, with the implication that local residents may have practiced some limited form of maize horticulture. We believe that this is a significant question worthy of further investigation, and that the development of maize agricultural practices in prehistoric Texas, and effects on regional subsistence practices, can be further elucidated by additional application of starch grain analysis in future archeological investigations in central and east-central Texas.

For the present, we assert that without these technical analyses we could not have identified the resources cooked in these small rock features and processed by the various chipped stone tools. Even without the presence of ground stone tools, evidence for grinding grass grains was documented due to characteristic damage to starch grains. Evidence was exhibited, through the presence of at least three gelatinized grass grains, to indicate boiling as a means of cooking was employed. These three techniques of starch grain, lipids, and use-wear analyses have documented in some instances specific resources and in specific instances cooking techniques, along with the diversity of resources that contributed to the diet of the populations at this locality over a roughly 700 year period.

7.5 QUESTION 4, LITHIC TECHNOLOGIC ORGANIZATION

Paul M. Matchen

Question 4: Using the Protocol for Lithic Analysis developed by TxDOT (2010), we propose to identify the general stage of lithic tool production conducted at this locality as well as the kinds of tools that were the preferred outcome of lithic reduction activities. Further, we also propose to determine whether or not locally available cherts were the preferred materials in use, through instrumental neutron activation analysis (INAA) of the chemical constituents of debitage recovered from block 1 and chert materials from the off-site locations in the area immediately surrounding the site. (Note: the INAA analysis was not supported by TxDOT for implementation.)

As presented previously (Chapter 6, this volume), the chipped stone tool assemblage recovered from Block 1 was analyzed using the Protocol for Lithic Analysis developed by TxDOT (2010). There were surprisingly few formal tools recovered (0.3 percent) and small group of informal flake tools (4.2 percent; Table 7-6). A majority of the lithic artifacts (95 percent) were classified as debitage. Within this class, specimens were size graded and sorted into flake (platform-bearing) and shatter (no-platform) categories. Raw material attributes were recorded and flakes were sorted from non-flakes by platform type.

Table 7-6. List of Artifact Types and Frequencies in Block 1.

Block	Artifact Classes	Count (*N*)
1	Bifaces	3
1	Edge-Modified Flakes	76
1	Scraper/Wedge	1
1	Choppers	3
1	Debitage	1702
Total		**1785**

Aspects of Lithic Procurement and Tool Reduction

As discussed previously, the site is situated near the boundary between the Cretaceous limestone bedrock of the Edwards Plateau and the older sandstone bedrocks that underlie the Rolling Plains. Raw material procurement focused on locally available sources of Edwards chert from both nodular and water-worn cobbles likely procured locally from uplands or gravels associated with nearby streams such as Crooked Run Creek or the Colorado River approximately 1 km to the east. The high incidence of cortex on platform-bearing flakes suggests on-site initial reduction of mostly smooth, rounded cobbles.

Furthermore, the relatively restricted incidence of thermal alteration (12.4 percent of platform-bearing flakes) suggests that intentional heat treatment of Edwards chert was not a necessary precursor to material reduction/use. The evident proportion of heat-altered debitage likely represents discard of chert debitage into hot heating elements/features. As a result, it does not appear that the site's occupants employed intentional heat treatment in their lithic reduction strategy.

The incidence of multi-platform flakes (47 percent) combined with the 14 notching flakes indicates that bifacial thinning, edge finishing, tool notching, and rejuvenation were the primary source of the flakes produced on site. Core reduction is also indicated at this component by the presence of platform-bearing flakes with only a single facet. Therefore, both bifacial and core forms were reduced on site, although it is unclear by strictly examinating the platform–bearing flakes what proportion of bifacial reduction flakes originated from bifacial cores as opposed to bifacial reduction of large flakes.

The frequency distribution of lithic debitage across the Block 1 shows a fairly even pattern of disposal near delineated feature boundaries (i.e., burned rock concentrations). The apparent lithic concentrations are interpreted as reflective of reduction locations and/or debris discard areas.

Comments on Tool Technology

Given the diversity of flake assemblage, it is evident that both core and biface reduction were carried out on site using both stream-cobble and nodular-chert matierals. Small numbers of bifacial tools (*N* = 3), bifacial choppers (*N* = 3), a wedge/scraper (*N* = 1), and edge-modified flake tools (*N* = 76) were recovered from the site. All of the bifaces were broken (two perverse fractures and one transverse fracture) during manufacture. As a whole, most of the tools recovered from Block 1 are expediently produced, with the exception of the bifaces and choppers. This implies that the majority were made on an asneeded basis without much preparation. Those tools that did involve some planning to produce (bifacial tools) were evidently made or at least thinned and finshed on-site, given the presence of bifacial thinning flakes and notching flakes (Figure 7-2) .

The relationship between chipped stone tools and flake debris in Block 1 can be summarized by stating that the small diversity in tool classes and frequency are adequately represented in the range of flake debris examined. The materials recovered support on-site production of modest numbers of formal and informal tools, ranging from initial reduction of locally available nodular clasts and water-worn cobbles to tool production and finishing. Thermal alteration of material was evident but seems to have been due to post-production inclusion in hot thermal features, rather than intentional heat-treating of raw material.

7.6 SUMMARY

J. Michael Quigg

Limited hand-excavations at 41MI96 revealed multiple occupations in compressed stratigraphy, a restricted range of materials from two block excavations (burned rock and lithic debitage) that lacked diagnostic projectile points, plus six small intact burned rock features surrounded by moderate quantities of lithic debitage were encountered in Block 1. The materials from Block 1 were targeted to extract information from as those in Block 2 were considered mixed.

The near absence of charcoal did not prevent documenting the ages of the multiple events, which were determined through nine dates obtained from organic residues in the burned rocks from five features. The nine dates document multiple occupations from 820 to 1450 B.P. (cal A.D. 560 to 1270), during the Late Archaic II and likely into the Late Prehistoric period. The very close correspondence of paired radiocarbon sample results on organic residues showed excellent results. These tightly clustered pairs reveal considerable promise in providing realistic dates as to when the rocks were used. The reliability of dates derived from burned rocks may vary with the type of rocks used in features, but at least at the present time sandstone provides a very positive medium in which organic residues can be trapped during use and subsequently directly dated if used in cooking activities.

Multiple technical analyses that targeted the burned rocks from five features provide meaningful insights into prehistoric human adaptations in central Texas during this period. Starch grain and lipid residue analyses on the burned rocks yielded new, important, and provocative data concerning foods cooked by the rocks and food processing activities (Table 7-5).

The lipid residue analysis combined with the presence of specific chemical biomarkers on 20 burned rocks from five features also yielded positive and informative results. The results indicate that both animal and plant products were cooked and/or heated by these rocks with some residues indicating the presence of oily seeds (e.g., sunflower, sumpweed, etc.) and large herbivores (probably deer in this instance). Apparently plant foods were the more dominant residues cooked with the feature rocks. These same general food products were found in each feature rock and document a stable and consistent use of multiple food resources over the roughly 700 year use period. Not only were general food classes identified (plant and animal), but chemical residues from conifer products were detected, which likely indicate the wood used to heat the rocks. This wood product is probably juniper in this instance.

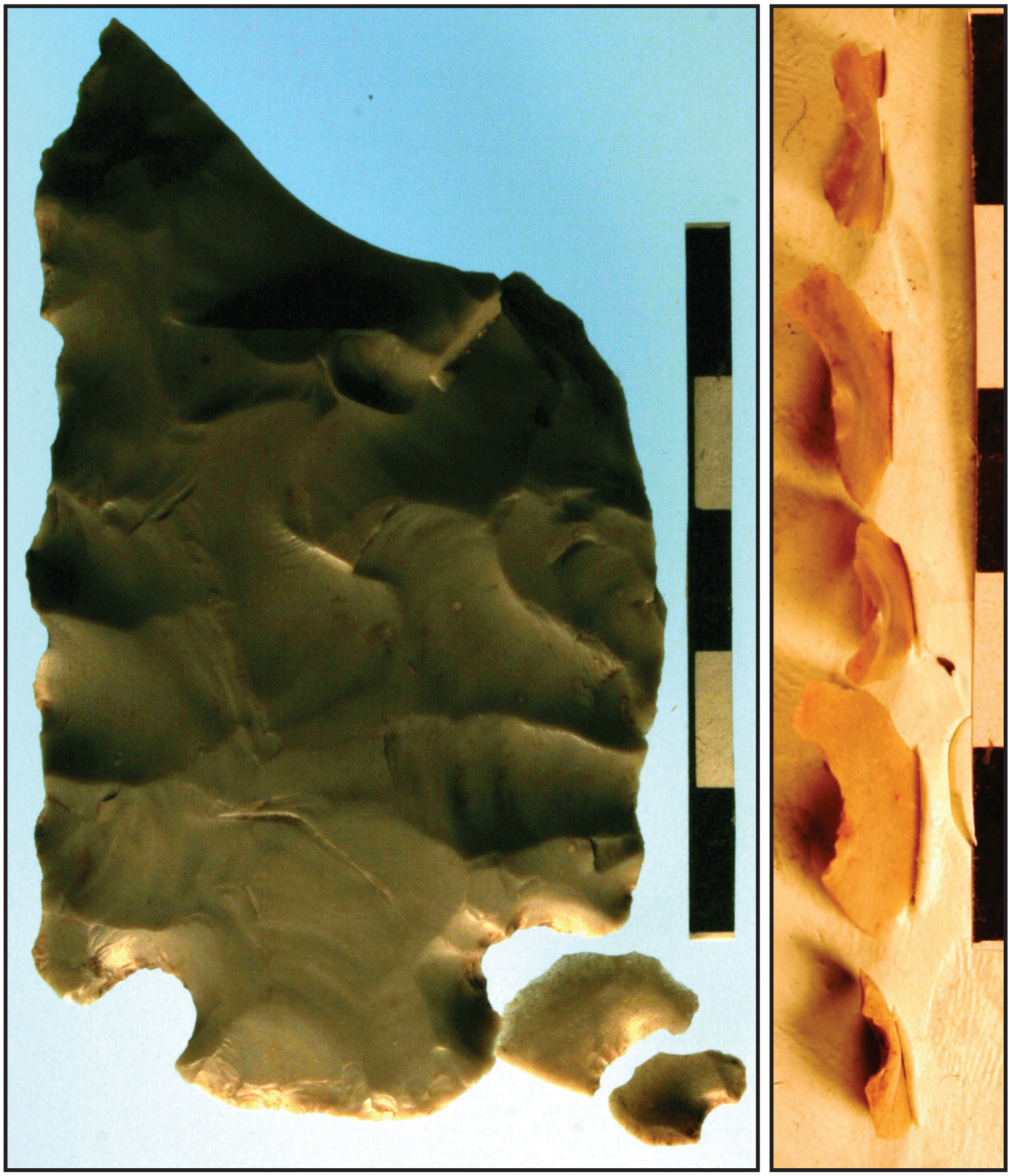


Figure 7-2. Biface #14-10 and potentially associated notching flakes, an example of on-site formal tool finishing for future hafting.

Table 7-7. Summary of Technical Analyses on Burned Rocks From Features.

Feature No.	Test Unit	Level	TxDOT Burned Rock No.	Final PNUM	Conventional Radiocarbon Age (B.P.)	Lipid Residue Results and Interpretations	Lenticular Grass Starch	Other Grass Starch	Unidentified Starch	Maize Starch	Damaged Starch *
2	13	2	BR #1	61-1b		Plant, traces of animal products, conifer products					
2	13	2	BR #2	61-2b	910 ± 30	Plant, traces of animal products	1				GL, GD
2	13	2	BR #3	61-3b		Plant, traces of animal products		1		1	
2	13	2	BR #4	61-4b		Plant, traces of animal products, conifer products				1	
3	13	2	BR #5	62-5b	980 ± 30	Plant, traces of animal products				1	GL
3	15	2	BR #1	69-1b	820 ± 30	Large herbivore, plant and animal products					
3	15	2	BR #2	69-2b		Traces of plant and animal products, conifer products			1	1	
3	15	2	BR #3	69-3b		Traces of plant and animal products			1		
4	1	4	BR #2	15-1b		Plant seed oils, animal products, conifer products					
4	1	4	BR #3	15-2b	1450 ± 30	Traces of plant and animal products, conifer products	1				H
4	1	4	BR #6	15-4b		Plant and animal products, conifer products		1	1		
4	1	4	BR #8	15-5b	1410 ± 30	Plant and animal products, conifer products		1			GL
5	7	3	BR #1	41-1b	1330 ± 40	Plant and animal products, conifer products					
5	7	2	BR #2	41-2a	1160 ± 30	NA					
5	7	2	BR #3	41-3b		Plant and animal products					
5	7	2	BR #4	41-4b		Plant and animal products, conifer products					
5	7	2	BR #6	41-6b		Traces of plant and animal products, conifer products					
7	9	3	BR #1	49-1b		Plant seeds, traces of animal products	4		1		1 GD
7	9	3	BR #2	49-2b	1210 ± 30	Plant and animal products					
7	9	3	BR #3	49-3b		Plant seed residues, trace of animal products, conifer products					
7	9	3	BR #5	49-4b		Plant and animal products					
7	9	3	BR #4	49-5c	1120 ± 30	NA					

* GL = Gelatinized, GD = Ground, H = Heated

Starch grain analysis yielded relatively few starch grains (*N* = 32), with 59 percent positively identified. Grass grains from little barley (*Hordeum pusillum*) and/or wildrye (*Elymus* spp.), plus some unidentifiable grass grains were recognized. Surprisingly, maize (*Zea* spp.) starch was also identified on at least four burned rocks from Features 2 and 3. Not only were positive identifications made to types of plants cooked, but cultural damage to various grains indicates multiple processing techniques were applied to these food resources. Grinding was evident on at least two grass grains, heating was evident on at least three grass grains, and gelatinization was identified on three grains, two of which were grass and the other maize. Fifty-three percent of the starch grains were from the 20 burned rocks analyzed. Forty-seven percent were on 45 percent of the stone tools analyzed. Obviously both classes of artifacts provide evidence of plant use by these populations. The documentation of maize at this early time, between ca. 820 and 1210 B.P. (cal A.D. 710 and 1270) has profound effect concerning trade networks and agricultural practices across the region. The pursuit of these practices is extremely important and deserves to be targeted in future investigations.

High-powered microscopic use-wear analyses on 15 chipped stone tools revealed use in woodworking, plant processing, and butchery. This broad range of functions is not unexpected, but does specifically demonstrate different functions, which included cutting, scraping, and whittling were mostly evident from various polishes and striations present in combinations with wood and plant fibers, and hair fragments that remain on these edge-modified flakes and other common tools.

The lithic assemblages from Block 1 that appeared generally associated with the six identified features that date to 820 to 1450 B.P. (cal A.D. 560 to 1270) were targeted for detailed analysis that employed the Protocol for Lithic Analysis developed by TxDOT (2010). Although the assemblages could not be separated into specific time units the analysis provides a broad understanding of general tasks associated with the burned rock features. The debitage recovered supports on-site production of modest numbers of formal and informal tools, with production that ranges from initial reduction of locally available nodular clasts and water-worn cobbles to the final product. Minimal thermal alteration of material was evident but was due to post-production inclusion in hot thermal features, rather than intentional heat-treating of raw material to inhanse workability.

Further use of microfossil studies on burned rocks will more than likely continue to enlighten researchers as to not only the type and diversity of foods cooked with the rocks, possible processing techniques employed, but also contribute to help document how these small burned rock concentrations functioned. Given the high frequency of similar features at archeological sites across Texas, the continued employment of these technical analyses combined with phytolith and diatom studies will likely provide valuable insights into past selection and use of food resources and related human processing behaviors. The high-powered microscopic use-wear analysis on stone tools also provides a much greater understanding on what tools were used for and on, how they actually functioned, and reveal the actual activities apparently associated with the features.

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8.0 SUMMARY AND RECOMMENDATIONS

J. Michael Quigg

8.1 SUMMARY

In 1999, TxDOT staff archeologists conducted an initial environmental review, followed by an in-field archeological impact evaluation, with subsequent data recovery excavations in May 1999 at prehistoric site 41MI96 in Mills County, Texas. These investigations were necessary prior to TxDOT proposed bridge replacement and realignment impacts to a county road (CSJ: 0923-23-011).

The data recovery excavations were carried out on the northwestern side of the project area within the TxDOT right of way. Investigations included the excavation of 4 mechanical trenches across 2 creek terraces (T_1 and T_2), and 5.5 m^3 of hand-excavations in 16 total 1 by 1 m units, in 2 small blocks of 11 m^2 units (Block 1) and 5 m^2 (Block 2). Hand-excavations in both blocks were initiated from the bottom of backhoe scrapings to target newly discovered burned rock concentrations. Cultural materials encountered included a minimum of 602 burned rocks, 2,846 pieces of lithic debitage, 89 formal and informal tools (no diagnostics) and 6 small, intact burned rock features identified in Block 1, but no diagnostic artifacts, charcoal, or faunal remains.

TRC was contracted in 2012 to conduct artifact processing, perform analyses of materials, and report the findings from both the 1999 TxDOT field excavations and TRC analyses. Four technical analyses targeted five of six intact features with associated lithic debitage from Block 1 in the T_2 terrace. These analyses included radiocarbon dating of organic residues in 9 burned sandstone rocks, lipid residue and starch grain analyses on the same 20 burned rocks, and high-powered microscopic use-wear and residue analyses on a suite of 15 chipped stone tools. Because TxDOT archeologists believe that the burned rocks and lithic debitage in Block 2 were scattered and mixed, these materials were not analyzed and only documented through summary tabulations and generic descriptive discussions.

The conventional AMS dates derived from organic residues in the nine sandstone burned rocks from five *in situ* features in Block 1 range from 820 to 1450 B.P. (maximum 2-sigma range of cal A.D. 560 to 1270) and indicate a conventional maximum time range of some 630 years, or 710 years when the dates are calibrated. This period falls generally towards the latter part of the Late Archaic II period as identified by Johnson and Goode (1994, 1995) and Collins (2004), and into the early part of Late Prehistoric period. The radiocarbon dates indicate that 41MI96 was occupied during a time interval (ca. cal A.D. 560 to 1270) often ascribed to the Late Archaic and into the early part of the post-Archaic, or Late Prehistoric, period (i.e., the Austin phase) in central Texas. However, the lack of corresponding time-diagnostic artifacts from the excavations, such as Scallorn arrow points, precludes any confident assignment of the recovered materials to this phase.

A detailed analysis of the chipped stone tool assemblage from Block 1 reveals evidence for the full range of bifacial tool and flake tool production. The initial reduction of Edwards chert cobbles and nodular clasts is indicated by decortication flakes that exhibit more than 50 percent dorsal face coverage. Other debitage, including larger secondary and tertiary flakes, represent the continuation of this reduction process. The relatively limited incidence of heat-altered debitage likely represents discard of chert debitage into hot heating features. As a result, it does not appear that the site's occupants employed intentional heat treatment in their lithic reduction strategy. Large proportions of platform-bearing flakes with two or more facets, combined with notching and finishing flakes, indicate that bifacial thinning, edge finishing, tool notching, and rejuvenation were prominent on-site. Core reduction is also indicated at this component by the presence of platform-bearing flakes with only a single facet. Therefore, both bifacial and core forms were reduced on site.

High-powered microscopic use-wear analyses on 15 chert tools (11 small edge-modified flakes, 2 biface fragments, and 2 complete choppers) revealed their use in processing wood, plants, bone, and hide as well as unspecified soft and hard materials. These results provide clear evidence that multiple tasks were conducted during most if not all these short-term occupations.

Lipid residue analysis on parts of 20 burned rocks from those five dated features yielded residues in 100 percent of the samples. The results indicate that both plant and animal products were present on all 20 rocks, although plant products dominated. Large herbivore lipids (likely bison or deer) were present on at least one rock, and oily seed lipids (i.e., sunflower, sumpweed) on at least three rocks. Residues from conifer wood products, probably juniper trees, were present on 60 percent of the rocks, and indicate at least one specific wood species, likely used to heat the rocks.

Starch grain analysis on subsets of the same 20 burned rocks used in the lipid analysis from five features in Block 1, and on 15 chipped stone tools recovered from around those features, yielded positive results from 47.5 percent of the specimens. In addition to the documentation of multiple grass species that include either wildrye (*Elymus* spp.) or little barley (*Hordeum pusillum*), the presence of grains of the tropical cultigen maize (*Zea mays*) are of considerable interest. Previously in Texas, wildrye grass has been positively documented in Late Archaic components in the Texas panhandle near Amarillo at the Landis Property (Quigg et al. 2010) and in north-central Texas at Root-Be-Gone (41YN452; Quigg et al. 2011a). Little barley has been identified in two Plains Village period components at Long View (41RB112) in the Texas panhandle (Quigg et al. 2013). It appears that these grasses are one of the major subsistence resources, although they are just recently being identified.

Highly significant and quite unexpected is the documentation of multiple grains of maize, specifically on burned rocks from Features 2 and 3 (two from each), plus on two edge-modified tools in the vicinity of those two features. One specific burned rock with a maize starch grain on it was directly AMS dated to 980 ± 30 B.P. or cal 2 sigma range A.D. 1020 to 1150. Some identified maize starch grains had been damaged through grinding, heating, and/or boiling- direct evidence of processing as a food resource. This indicates use of maize as a food resource in central Texas by apparent hunter-gatherers many centuries earlier than previously suspected. This is a new and provocative discovery, given that only two examples of maize cobs have been reported in the literature from central Texas in late Toyah contexts (e.g., Jelks 1962; Harris 1985). If one is looking for potential sources for this early maize, it may have arrived from the northeast, as currently documented the Caddoans began cultivating maize, squash and native seed plants ca. A.D. 1000 through 1200 (Perttula 2004, 2008). Looking to the west or northwest in Texas little data is currently available to draw upon for possible sources of maize.

The varied and informative results yielded important information concerning the age of the burned rock features, the plant and animal foods cooked by use of heated rocks, and information on cooking techniques employed during the multiple short-term occupations spanning the time range from the end of the Late Archaic to the early part of the subsequent Late Prehistoric period (820 to 1450 B.P., maximum 2-sigma range of cal A.D. 560 to 1270).

8.2 RECOMMENDATIONS

In June 1999, immediately following the fieldwork at 41MI96, TxDOT archeologist Lain Ellis submitted a four-page letter to the THC requesting concurrence from THC that: 1) sufficient excavations had been performed; 2) the deposits that could be affected by construction do not contribute to the site's eligibility for inclusion in the National Register of Historic Places or for designation as a State Archeological Landmark; 3) the proposed undertaking should have no effect on archeological historic properties or State Archeological Landmarks; and 4) the proposed undertaking should proceed with no further consultation with the THC (Ellis June 1999). That letter was stamped with "CONCUR" by the THC and signed in June 1999. Consequently, the THC has already determined the outcome of this data recovery project.

In light of the cultural materials uncovered in the mechanical trenches and the discrete depth range of the cultural deposits, especially in BT 4 and Block 1 at 41MI96, combined with the positive and informative outcomes of the technical analyses performed by TRC, it is now apparent that other significant *in situ* cultural data may exist immediately adjacent to the current TxDOT right-of-way. Consequently, any further expansion of the current right-of-way west of the bridge would negatively impact these valuable non-renewable cultural resources, and it is therefore recommended that any expansion or development west of the bridge and beyond the current 2012 right-of-way be further evaluated for cultural resources prior to any development activities.

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10.0 GLOSSARY OF TECHNICAL TERMS

A Horizon: The near surface horizon of a natural soil. This is a carbon rich soil horizon characterized by an accumulation of partially decomposed to decomposed organic matter and eluvial loss of constituents such as clays and carbonates, which tend to accumulate in the deeper B horizon. The A horizon represents the upper solum of a soil. Lower case letters with the upper case letter A indicate specific characteristics of that A horizon. An Ab designation indicates the A horizon is buried. An Ap designation indicates a disturbed or anthropically modified soil such as in a plow zone.

Accelerated Mass Spectrometry (AMS): Laboratory technique that separates and identifies ions based on their mass to charge ratios. This technique is used in radiocarbon dating tiny particles of carbon in organic remains and residues.

Acidic: Containing acid bearing pollutants.

Acryloid B-72: This is a conservation material used to stabilize or glue artifacts together. It is an ethyl methacrylate copolymer.

A.D.: Anno domini in Latin. "In the year of our Lord." For example, A.D. 1000 is 1,000 years after Christ. This is generally used when a B.P. radiocarbon date is calibrated to the tree ring results with a calibration formula.

Agavaceae: A plant family name that refers to fiber, vascular bundle, or the central stem sections that cannot be specifically identified as agave (*Agave*), yucca (*Yucca*) or sotol (*Dasylirion*).

Allostratigraphic Unit: Depositional unit made up of sediments dating to a similar period of deposition.

Alluvium: Clastic sediments, such as sand, silt, or clay deposited by a flowing stream, either in the channel or outside the channel during overbank flooding.

Argillins: These are clay coatings on ped- or pore surfaces.

Azelaic Acid: This is a chemical biomarker in lipid residue analysis and a short chain dicarboxylic acid associated with the oxidation of unsaturated fatty acids. Its presence may indicate plant seed processing.

B.C.: The abbreviation for Before Christ, in contrast to After Christ (A.D.).

Biface or Bifacial: A stone tool that has two distinct sides or faces, both of which have been substantially worked and/or flaked. The biface may take the form of many shapes and sizes and used in diverse activities.

B Horizon: The lower solum of a natural soil. A B horizon is a mineral soil horizon characterized by an accumulation of constituents such as clays, carbonates or salts, or organic complexes that have been translocated from the A horizon. Common subordinates include lowercase letters such as t as Bt, which indicates accumulation of illuvial clays. The lowercase k (Bk) indicates accumulation of carbonate. The lower case w indicates structural or color changes with no significant accumulations of alluvial material.

Biomarker: This is in lipid residue analysis, a molecular associated with a narrow range of substances, or the presence and distribution of certain types of lipids that enables a residue to be identified with a high degree of precision.

Bioturbation: The churning and mixing of sediments by living organisms, including burrowing rodents, insects, worms, and plant roots.

Biplot: A biplot is a special type of graph following from principal component analysis on which both the samples and elements are displayed. Examination of a biplot from the principal component analysis of ceramic specimens often leads to identification of the analyzed elements responsible for differentiating groups of specimens from one another.

B.P.: An abbreviation for before present, which in radiocarbon dating is referenced to the standard year A.D. 1950, which is considered "present". Generally B.P. dates have not been tree ring corrected using one of the calibration formulas.

β-sitosterol and Stigmasterol: These are sterols associated with plant products, which can be detected during lipid analysis. Its presence indicates plant residues.

Burned Rock Dump: A loose cluster of previously heated rocks that exhibits no horizontal patterning to the positions of the rocks and lacks indications of *in situ* heating/burning, such as a prepared basin, lenses of charcoal or ash, and/or the absence of an oxidation rim. Scattered charcoal or other cultural items may be present between or around the burned rocks.

Burned Rock Midden: An accumulation of a large quantity of discarded burned rocks previously employed in multiple cooking activities. These accumulations were the results of long extensive cooking episodes generally in association with rock ovens.

C_3 Plants: A photosynthetic pathway that most trees and flowering bushes use to assimilate carbon dioxide into their systems. The average carbon isotope of C_3 matter is -26.5‰ with a range from about -19.0‰ to -34.0‰.

C_4 Plants: A photosynthetic pathway used by most arid (xeric) grasses and maize (corn) to assimilate carbon dioxide into their systems. The average carbon isotope of C_4 matter is -12.5‰ with a range of -6‰ to -19‰. These plants are more resistant to stress due to lack of water, but more susceptible to cold temperatures.

C Horizon: Weathered, but relatively unaltered parent material at the base of a soil profile, generally below the B horizon. This term is roughly synonymous with subsoil, although the latter term is often used to encompass the lower B horizon.

Calcareous: Rocks, minerals, or sediment containing calcium carbonates.

Calcite: A mineral consisting only or mainly of calcium, the principal mineral of limestone and marble.

Calcium: A chemical element with the symbol Ca and atomic number 20. Calcium is a soft gray alkaline earth metal, and is the fifth most abundant element by mass in the Earth's crust. Calcium is also the fifth most abundant dissolved ion in seawater by both molarity and mass, after sodium, chloride, magnesium, and sulfate.

Caliche: A more or less cemented deposit of calcium carbonate in soils of warm-temperate, subhumid to arid areas. Caliche, normally white, occurs as soft, thin layers in the soil or as hard, thick beds just beneath the solum, or it is exposed at the surface by erosion.

CAM Plants: A photosynthetic pathway for assimilating carbon dioxide into plants that can change from C_3-like to C_4-like pathways depending on the diurnal (day or night) cycle. Most succulent plants such as cactus have crassulacean acid metabolism (CAM) pathways. The carbon isotope values of most CAM plants in Texas such as *Agave lechuguilla* and *Opuntia englmannii* are similar to the values in C_4 plants (see Eickmeier and Bender 1976).

Campesterol: This and stigmasterol and sitosterol are sterols found in plant tissue, which can be detected during lipid analysis. Its presence indicates that plants were processed.

Carbonates: These are rock or mineral classes that include limestone, calcite, ooids, and bioclasts. White carbonate filaments are often observed in C horizons of soils.

Chalcedony: A cryptocrystalline variety of quartz or chert. Chalcedony is often a component of other cherts. It may be translucent or semitranslucent, has a wax-like luster, and generally is white, pale blue, gray, blown, or black in color.

Cheno-am: A term used in botanical classification that includes the plant family of Chenopodiaceae (goosefoot) and the genus *Amaranthus* (pigweed), with tiny charred seeds that are indistinguishable from each other.

Cholesterol: This is the major sterol in animal tissue, which can be detected during lipid analysis. Its presence indicates animal residues.

Clast: Any detrital particle of sediment created by the weathering and disintegration of a larger rock mass and transported by water, wind, or ice. Clasts also include discrete particulates created and deposited by volcanic action.

Clay: This is mineral sediment particles less than 0.002 millimeters in diameter. As a soil textural class, soil mineral that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Cluster Analysis (CA): A type of numerical classification that uses the value of attributes to cluster data. Clustering is the classification of objects into groups so that objects from the same cluster are more similar to each other than to objects from different clusters. Often similarity is defined according to a distance measure. Clustering is a common technique for statistical data analysis, which is used in many fields, including data mining, pattern recognition, image analysis and bioinformatics.

Colluvium: Soil material, rock fragments, or both, moved by creep, slide, or local wash that is deposited at the base of steep slopes.

Complex: A group of archeological sites that date to the same time period and that contain similar artifacts. This term expresses a relationship of common cultural or technological traits in assemblages within widespread geographic area.

Component: An archeological site or portion of a site that is spatially and chronologically discrete from other accumulations of artifacts. These can be horizontally or vertically differentiated.

Conifers: Any member of the order Pinales, woody plants that bear their seeds and pollen on separate, cone-shaped structures. They constitute the largest division of gymnosperms, with more than 550 species. Most are evergreen, upright trees and shrubs. They grow throughout North American and prefer temperate climate zones. Conifers include the pines (*Pinus*), junipers (*Juniperus*), spruces (*Picea*), hemlocks (*Tsuga*), firs (*Abies*), larches (*Larix*), yews (*Taxus*), cypresses (*Cupressus*), bald cypresses (*Taxodium*), Douglas firs (*Pseudotsuga*), and related groups. The trees are the source of resins, volatile oils, turpentine, tars, and pharmaceuticals.

Context: The association and position of artifacts, materials, and cultural features that are used by archeologists to interpret space, time, and culture.

Cumulic Soil: A soil formed in a setting experiencing relatively slow deposition, so that freshly introduced sediment is incorporated into the A horizon, leading to overthickening of the surface horizon. Cumulic soils are common in alluvial overbank and colluvial settings.

Dehydroabietic Acid: This is a biomarker that indicates the presence of conifer products, which may have been introduced from firewood, resins or other conifer products. This acid can be detected in lipid residue analysis.

Dendrite: An oxide of manganese that has crystallized in a branching pattern as in the dark inclusions in moss agate.

Deposition: The accumulation of sediments or gravels laid down by natural agencies such as moving water, or artificial agencies such as dumping.

Eraillure Scar: A small enigmatic flake formed between the bulb of force and the bulbar scar.

Erosional Unconformity: A significant break or gap in the geological or depositional record, indicative of removal of the older unit prior to renewed deposition.

Ester: This is an organic compound that contains a carbonyl group linked to an alkyl group through an oxygen atom; organic compounds synthesized from a carboxylic acid and an alcohol in the presence of water.

Facies: A definable subdivision of a formal or informal stratigraphic unit.

FAMES: This is an abbreviation for fatty acid methyl esters (FAMES) and is prepared by treating the dry lipid with 3 mL of 0.5 N anhydrous hydrochloric acid in methanol (68oC; 60 min). This is part of the lipid residue analysis.

Fatty Acids: The major constituents of fats and oils (lipids) that occur in nature in plants and animals. They are insolubility in water and relatively abundant compared to other classes of lipids. Fatty acids may be absorbed into porous archeological materials during cooking, including heated rocks and ceramics, or ground into manos, metates, or mortar holes. Some of the major fatty acids are referred to as C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11, C18:2.

Floodplain: A nearly level alluvial plain that borders a stream or river and is subject to periodic flooding.

Gas Chromatography (GC): This highly technical measuring instrument that separates and measures the amount of elemental components of a specific sample by the measurement of light passed through gas at regulated temperatures, which allows the detection of fatty acids at the nonogram (1×10^{-9} g) level. High temperature gas chromatography is used to separate and assess a wide range of lipid components, including fatty acids, long chain alcohols and hydrocarbons, sterols, waxes, terpenoids and triacylglycerols (Evershed et al. 2001). The molecular structure of separated components is elucidated by mass spectrometry (Evershed 2000).

Gas Chromatography-Mass Spectrometry (GC-MS): This is an analytical technique that enables the mass analysis and identification of components separated from a sample by gas chromatography; an analytical technique that combines gas chromatography with mass spectrometry.

Gelatinization: In regards to starch grains this is a morphological change (distortion of the original shape) in the grain caused by the exposure to heat and water when starches are cooked.

Geomorphology: That part of geography concerned with the form and development of the landscape.

Geophytes: These are plants with underground storage organ such as bulbs (i.e., onions, camas, and false garlic), tubers, roots, and rhizomes that are a reserve of carbohydrates, nutrients, and water. These storage organs can be collected, cooked, and eaten as part of the human diet. The study of these geophytes from an archeological site aids in determining the diet of the past occupants.

Glume: Pertains to small dry membranous chaffy bract found at the base of a grass spikelet or each flower in a sedge or related plant.

Gorget: These are usually a polished stone, sometimes of shell or limestone, with holes drilled in it. These are presumably worn as jewelry by natives.

Graticule: A device used in the microscope to measure the size of items under magnification.

Hard/High Silica Polish: This is a residue that comes from the material that a stone tool came in contact with. This type of polish is generally produced when processing soft plants with high silica content in the plant tissues such as grasses, wood, reeds, and potentially soil. This polish was detected during high-powered microscopic use-wear studies conducted during stone tools analysis.

HCL: Hydrochloric acid, which is the solution of hydrogen chloride (HCl) in water. It is a highly corrosive, strong mineral acid and has major industrial uses.

Heating Element: This is an intentional, intact and localized spot were a human created a fire in an archeological site or component. This is generally evidenced by quantities of wood charcoal, prepared basin, lenses of charcoal or ash, and possibly an oxidation rim often accompanied by intentionally placed rocks, either lining the margins or directly amongst the charcoal. The function of this fire may reflect many different things, such as for heat to warm a person, to cook on, or to heat rocks for other uses. The specific contents may provide clues as to a more specific function or length of use.

Hilum: The scar on a seed, such as a bean, indicating the point of attachment to the funiculus. The nucleus of a starch grain.

Holocene: Geological time period spanning roughly the last 10,000-years before present. The Holocene is roughly equivalent to the Post-glacial period, and often referred to as the “Recent” period in geology. Many investigations consider the Holocene to be an interstadial in the ongoing Pleistocene epoch.

Horizon: A discrete, relatively uniform layer in a soil profile that is typically parallel with the surface and formed as the result of pedogenic process.

Humates: These are substances formed from the biological and chemical breakdown of animal and plant life over time. Humates are made up of compounds and materials that plant life on earth absolutely needs for growth. Humates contain a mixture of organic acids, including humic acids, fulvic acids, macromolecules of amino acids, amino sugars, and peptides. The chemistry of humate is so complex it can’t really be broken down.

Humus: A dark, organic-rich substance consisting of decomposed organic material (animal or vegetable) and is found in the soil.

In Situ: An artifact in its original position that was placed or deposited within the landscape.

Integrity: This refers to the degree of intactness of archeological deposits, components, features, or artifacts.

Inulin: This is a carbohydrate, a fructan is not digestible via acid hydrolysis, the typical way we digest carbohydrates such as starch.

Isomers: These are compounds with the same molecular formula that differ with respect to how the atoms are joined. Structural isomers differ with respect to the order in which atoms are joined. Stereoisomers differ with respect to the arrangement of atoms in space but the order in which the atoms are attached is identical.

Isotope: An atom of an element. One of two or more forms of a chemical element, differentiated by the number of neutrons contained in the nucleus.

Jasper: A dense, cryptocrystalline, opaque to slightly translucent variety of chert associated with iron oxide impurities that give the rock various colors. Most often red, but can be yellow, green, grayish-blue, brown, or black.

Knapping: A term used to describe the manufacturing of prehistoric chipped stone tools using different techniques, such as pressure and/or percussion methods, to chip/flake a target mass of material to form a useful tool.

Lamellae: This is a thin plate-like structure, often one amongst many lamellae very close to one another, with open space between.

Legume: A plant that produces a bean or seedpod in various forms consisting of one cell and/or two valves. Common legume plants across Texas include such plants as; mesquite, Texas ebony, various acacia, retama, *Dalea* sp., mimosa, and rattlebush.

Lipids: These are hydrophobic constituents of living tissues including fatty acids, alcohols, triacylglycerols, sterols, bile acids, and waxes. Lipids are present in tissues of all living organisms in varying proportions. These are insoluble in water, relatively easy to extract, and are readily amenable to separation and characterization.

Lithic: Means “of stone”. This term is used by archeologists to refer to stone artifacts and the debris that result from the manufacture of stone artifacts.

Lithology: The scientific study and description of rocks, especially at the macroscopic level, in terms of their color, texture, and composition. The gross physical character of a rock or rock formation.

Little Barley: This is a short winter annual bunch grass with a scientific name of *Hordeum pusillum* in the Poaceae grass family. It has a rapid growth period with a brown seed that develops after spring and is available in the early summer. The seed head consists of flattened spikes. It is considered low in protein and is intolerant to shade. This grass has a low drought tolerance but can grow with only 10 inches of rain per year. It is considered a C_3 grass (-26.7‰; Smith and Brown 1973) adapted to fine and medium soil (http://plants.usda.gov 2011).

Loam: This is soil composed of sand, silt, and clay in relatively even concentration (about 40-40-20% concentration respectively). Loam soils generally contain more nutrients and humus than sandy soils, have better drainage and infiltration of water and air than silty soils, and are easier to till than clay soils.

Macrobotanical: These are remains of plant tissues, such as wood, charcoal, and seeds that one can see with the naked eye.

Maize or *Zea Mays*: The scientific name for corn, which is a water-efficient C_4 plant with a shallow root system. The corn cob is also known as a rachis, which have alignments of cupules that are weakly jointed. The term Indian corn now generally refers specifically to multi-colored "field corn" (flint corn) cultivars. There are many forms of maize, such as flint corn, popcorn, Dent corn, sweet corn (modern), and others.

Mano: This is a hand-held stone, usually sandstone or quartzite, used to grind plants such as corn, nuts, seeds, or other vegetable matter and sometimes other rocks. It is used in conjunction with a stone metate that plants are placed on to perform the grinding.

Manuport: An object, usually a rock, that was transported by humans to the place it was recovered, but its macroscopic appearance does not indicate it had been artificially altered to form a specific tool or other kind of artifact.

Mass Spectrometer: This is an instrument used to produce molecular and elemental ions, sort them according to mass and detect abundances to establish the composition, determine molecular structure or measure isotopic ratios of specific elements.

Matrix: Refers to the sediments in which the artifacts at an archeological site are encased, or surrounds.

Mesic Condition: A relatively moist interval of time generally used in the context of climatic conditions.

Metate: A slab of rock in which vegetable matter is placed upon for the purpose of grinding. The natural surface becomes polished and a concave depression forms on the metate surface from continued grinding. The grinding stone used with the metate is called a mano.

Microdebitage: Any stone or lithic material from the manufacture of stone tools that is less than 4.0 mm in diameter. Microdebitage is often recovered in sieving or floating sediments from archeological deposits.

Microfossils: These include a variety of very tiny residues including such things as starch grains, diatoms, phytoliths, pollen, and organic remains that are only detectable and visible under high-powered microscopes.

Midden: This is somewhat of a catch-all term. It generally refers to an accumulation of cultural material such as a zone of burned rocks, and it is often used to refer to a thick accumulation of mixed cultural material in a vertical zone.

Migmatite: This is a rock at the beginning between igneous and metamorphic rocks. These rocks form under extreme temperature conditions during volcanic activity, prograde metamorphism.

Organic: Compounds that contain carbon and are associated with living organisms. Materials or objects that contain organic carbon can be radiocarbon dated.

Overbank Deposits: The deposition of fine silts and clay particles that are left on terrace tops and banks when water in creeks exceeds the capacity of the channel and drops the suspended sediments in the lower energy environment. Overbank depositional processes usually cause minimal movement to large objects on the terrace top.

Oxidation: A chemical process wherein oxygen is added to minerals or other compounds; weathering oxidizes minerals; burning wood and rusting metal are types of oxidation.

Paleoenvironment: Ancient or past environments.

Paleosol: Generally refers to a soil that developed an A horizon and was subsequently buried by younger deposits.

Palimpsest: Archeologically, refers to the inability to distinguish and separate material remains from repeated occupations by a succession of cultural events of different ages due to their deposition and intermixing over time on relatively stable surfaces. Some palimpsest assemblages are buried following a long period of exposure.

Ped: A unit of soil structure such as an aggregate, crumb, prism, block, or granule, formed by natural processes.

Pedogenesis: The dynamic process of soil formation and development, which typically leads to the formation of a darkened, organic-rich A-horizon at or near the surface, and the downward movement of fine clays into, and/or the formation of carbonate nodules within, the underlying B horizons.

Pedoturbation: A general term used to describe soil that has been mixed.

Pee Dee Belmnite: A limestone found in Southern Carolina used as the international standard for various compositional (carbon and oxygen isotopic and elemental) analyses.

Phase: A group of related archeological traits (e.g., artifacts, features) that contain similar cultural material and date to one relatively narrow time period within a limited region.

Pleistocene: The first epoch, which along with the Holocene Epoch constitutes the Quaternary period, spanning the time between roughly 2.0 or 1.65 million years ago and 10,000-years ago. Characterized by repeated continental glaciations, the Pleistocene witnessed the evolution of modern humans.

Polyunsaturated Fatty Acids: Pertaining to long-chain carbon compounds (e.g., C18:2) like fats with multiple double bonds. These fats are very unstable and degrade very rapidly over time. These are detected in archeological samples during lipid residue analysis.

Pressure Flaking: A method used to shape stone tools through the application of force applied by pushing rather than striking. This is generally part of the final stages of finishing a stone tool.

Principal Component Analysis (PCA): This is a pattern recognition technique used for reducing the dimensionality of multivariate data, similar to factor analysis. It uses all the variables measured in a sample and calculates the variation among those variables.

Profile: A cross-sectional exposure of the sequence of horizons that make up a soil or a sequence of sedimentary deposits. It can be the result of either natural erosional down cutting or an artificial excavation.

Provenience: The specific vertical and horizontal location of where an object is found.

Quaternary: The second period, which along with the Tertiary Period, make up the Cenozoic Era, encompassing the Pleistocene and Holocene epochs; roughly the last 2.0 or 1.65 million years.

Radiocarbon Dating: The process of determining the age of a sample based on the amount of radioactive carbon (carbon 14) retained in that object.

Raphides: Needle-shaped crystals in a plant cell, typically of calcium oxalate. These are small (30 to 500 µm) crystals, generally with points on the ends and of similar lengths. They are often found in plants of the Agavaceae family such as sotol, yucca, agave, and lechuguilla. They are not diagnostic of any particular plant. Bohrer (1987) and Kwiatkowski (1992) believe that only agave contain these crystals. In contrast, Dering (2003) believes raphides occur in a variety of Agavaceae including sotol, yucca, agave, and beargrass.

Retouch: A technique of chipped stone artifact manufacture in which pressure flaking is used to detach small flakes to sharpen or otherwise modify the edge of a stone tool.

Saturated Fatty Acids: Each carbon in the chain is connected to its neighboring carbon by a single bond, which makes them relatively stable. The most abundant saturated fatty acids have chain-lengths of either, 14, 16, or 18 carbons. Mammal fats consist primarily of saturated fatty acids and are solid at room temperature. These are detected in archeological samples during lipid residue analysis.

Silt: A particle size that has a range from 0.06 mm to 0.002 mm. These are smaller than sand grains and larger than clay particles.

Siliceous: Pertaining to silica, as in silicon dioxide, the most common chemical constituent on earth, and the dominant component of chert and quartz.

Site Structure: The spatial distribution of features, artifacts, and debris across a single occupation (or within a component) of an archeological site that is used to reconstruct manufacturing, maintenance, processing, production, and disposal activities at specific loci, and the spatial ways prehistoric groups organized their space at a site.

Slackwater: Water that is essentially still/unstressed or with no movement either way.

Soil Horizon: A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons an upper case letter (i.e., A, B, C, R, and O) represents the major horizons with A at the top. Lower case letters that follow the upper case letters represent subdivisions of the major horizons.

Starch: Starch is produced by all green plants for energy storage and is a major food source for humans. Pure starch is a white, tasteless and odorless powder that is insoluble in cold water or alcohol. Starch can be used as a thickening, stiffening or gluing agent when dissolved in warm water, giving, for example, wheat paste. In photosynthesis, plants use light energy to produce glucose from carbon dioxide. The glucose is stored mainly in the form of starch granules. Toward the end of the growing season, starch accumulates in twigs of trees near the buds. Fruit, seeds, rhizomes, and tubers store starch to prepare for the next growing season.

Sterols: These are structural lipids that are present in cell membranes and contain the perhydrocyclopentanophenanthrene ring system. Sterols are a special king of alcohol that serve as precursors to a wide variety of products known as steroids. The cholesterol is the major sterol in animal tissue. Campesterol, stigmasterol and sitosterol are sterols found in plant tissue.

Stigmasterol: This and sitosterol are sterols found in plant tissue and can be detected in lipid analysis.

Stratigraphy: The study of layering in rocks and/or sediments, and how the layers correlate to each other.

Striae: These are tiny, thin, narrow grooves, channels, or lines, often called striations. Here, they were observed during high-powered microscopic use-wear analysis on stone tools and are an indication of the direction of the movement of the tools during their use. They were observed under high magnification in the residues left on the tools.

Terrace: In geologic terms this is an old alluvial plain that is generally flat and borders a river, stream, lake, or sea. Terraces are recognized by different elevations and generally labeled T_0, T_1 and T_2 from lowest to highest.

Triacylglycerol (TAGs): This is a glycerol molecule to which three fatty acids are bounded through ester linkages. These can be detected in lipid analysis.

Turbation: Disturbance to natural matrix deposits generally caused by biological agents (burrowing rodents, insects, worms, and plant roots) and natural (soil creep, desiccation crack displacement, frost heaving, landslides, etc.) processes. These actions tend to move cultural objects in the ground.

Tuber: This is the thick, fleshy underground stem of a plant. This stem serves as the primary storage organ of nutrients that stores food over winter and produces new growth in spring.

Type: This is a group of similar items (ceramic sherds or projectile points) all of which are more or less the same.

Ultraviolet Light: The wave length of light above that is usually detected by the human eye and that fluoresces various kinds of minerals and emits distinctive colors. Here, a multiband light source (UV light 254/366 nm Model UVGI-58) was used to investigate the visual fluorescence of culturally modified stones to help in identifying their source and detect new/recent scars from old flake scars.

Unconformity: Stratigraphic term for a boundary or break created by a depositional hiatus. This boundary separates younger strata from older strata. An unconformity is usually caused by erosion and therefore deposits are missing.

Unsaturated Fatty Acids: These types of fatty acids contain at least one carbon-carbon double bond or point of unsaturation. That point of unsaturation is susceptible to additional reactions. Unsaturated fatty acids are the primary constituents of plant and fish oils and tend to be in liquid-state at room temperature. Their chain-lengths vary with a minimum of 12 carbons but most common ones contain at least 18 carbons.

Use-wear: The high-powered microscopic evidence on a stone tool that was created from sustained use. The wear may appear as striations, tiny nicks, abrasive particles, polish, rounding, soluble inorganic residues, etc The accompanying use-wear study used magnification between 100x and 500x to observe wear and edge-modification on selected artifacts. This detailed analysis contributes to our understanding of the function of tools and potentially substances that tools were used on.

Waxes: These are long-chain fatty acids and long-chain alcohols that form protective coatings on skin, fur, feathers, leaves and fruit, also resist decay. These can be detected in lipid analysis.

Wildrye (*Elymus* sp.): A common grass throughout the Plains of the United States, from Mexico to Canada and is all across Texas. The seeds of this genus are large and it possesses a large distinctive starch grain. This is a cool season C_3 grass (ca. -27.6‰, -27.1‰, Bender 1971) that produces short cell phytoliths. The seeds are available during the summer and fall.

Xeric Condition: A dry or relatively arid condition often in reference to climatic conditions.

Xerophic Plants: These are plants that have adapted to survive in an environment that lacks water, such as a desert. These include cactus, sotol, yucca, agave, and lechuguilla, and others.

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APPENDIX A

RADIOCARBON ASSAY RESULTS

Prepared for:

TRC Environmental Corporation
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Austin, Texas 78752

Prepared by:

Darden Hood
Beta Analytic Inc.
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Miami, Florida 33155

2012

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Darden Hood
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Ronald Hatfield
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Deputy Directors

May 17, 2012

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701

RE: Radiocarbon Dating Results For Samples MI96 15-2c rock#3, MI96 15-5c rock#8, MI96 41-2a rock#2, MI96 49-2c rock#2, MI96 62-5c rock#5, MI96 69-1c rock#1

Dear Dr. Abbott:

Enclosed are the radiocarbon dating results for six samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

Note that three of the samples do not have a Measured Radiocarbon Age and 13C/12C Ratio reported. This is because the sample was too small to do a separate 13C/12C ratio and AMS analysis. The only available 13C/12C ratio available to calculate a Conventional Radiocarbon Age was that determined on a small aliquot of graphite. Although this ratio corrects to the appropriate Conventional Radiocarbon Age, it is not reported since it includes laboratory chemical and detector induced fractionation.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed. Please, forward it to the appropriate officer or send VISA charge authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
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MIAMI, FLORIDA, USA 33155
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REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott — Report Date: 5/17/2012

Texas Department of Transportation — Material Received: 5/2/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321461	1400 +/- 30 BP	-21.7 o/oo	1450 +/- 30 BP

SAMPLE : MI96 15-2c rock#3
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 560 to 650 (Cal BP 1390 to 1300)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321462	NA	NA	1410 +/- 30 BP

SAMPLE : MI96 15-5c rock#8
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 600 to 660 (Cal BP 1350 to 1290)
COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321463	1100 +/- 30 BP	-21.4 o/oo	1160 +/- 30 BP

SAMPLE : MI96 41-2a rock#2
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 780 to 900 (Cal BP 1170 to 1050) AND Cal AD 910 to 970 (Cal BP 1040 to 980)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321464	NA	NA	1210 +/- 30 BP

SAMPLE : MI96 49-2c rock#2
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 710 to 750 (Cal BP 1240 to 1200) AND Cal AD 770 to 890 (Cal BP 1180 to 1060)
COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott

Report Date: 5/17/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321465	930 +/- 30 BP	-22.2 o/oo	980 +/- 30 BP

SAMPLE : MI96 62-5c rock#5
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 1020 to 1050 (Cal BP 940 to 900) AND Cal AD 1080 to 1130 (Cal BP 870 to 820)
Cal AD 1130 to 1150 (Cal BP 820 to 800)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 321466	NA	NA	820 +/- 30 BP

SAMPLE : MI96 69-1c rock#1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 1160 to 1270 (Cal BP 790 to 680)

COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.7:lab. mult=1)

Laboratory number: **Beta-321461**

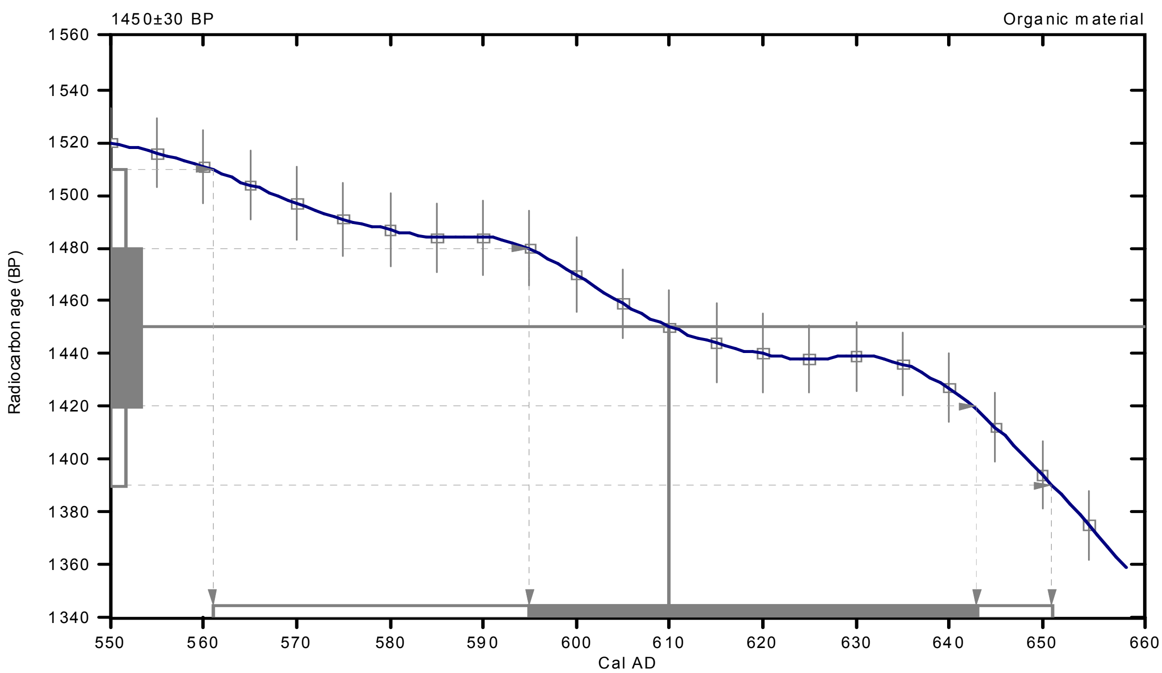
Conventional radiocarbon age: **1450±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 560 to 650 (Cal BP 1390 to 1300)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 610 (Cal BP 1340)

1 Sigma calibrated result: (68% probability) Cal AD 600 to 640 (Cal BP 1360 to 1310)



References:

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Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number: **Beta-321462**

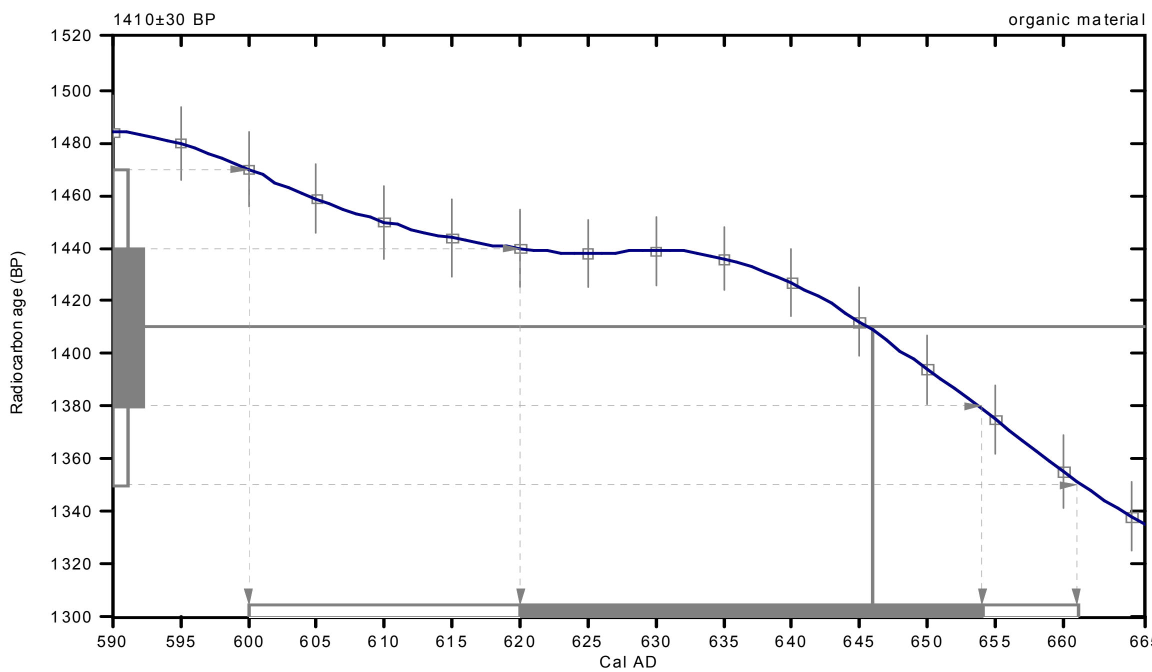
Conventional radiocarbon age: **1410±30 BP**

2 Sigma calibrated result: **Cal AD 600 to 660 (Cal BP 1350 to 1290)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 650 (Cal BP 1300)

1 Sigma calibrated result: Cal AD 620 to 650 (Cal BP 1330 to 1300)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.4:lab. mult=1)

Laboratory number: **Beta-321463**

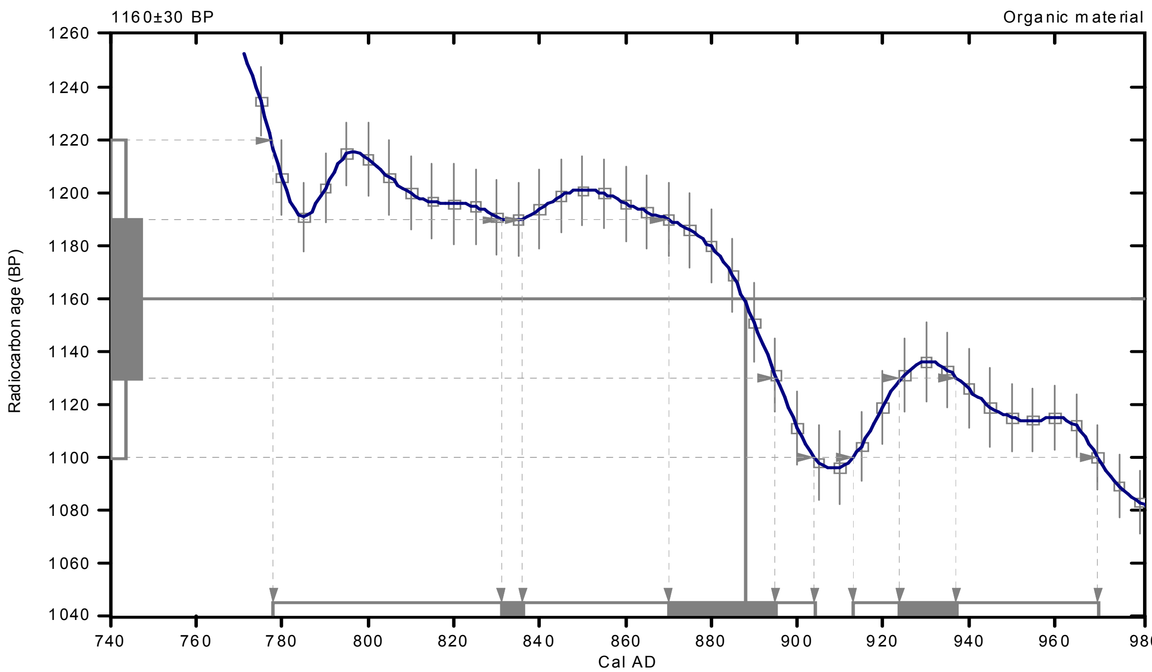
Conventional radiocarbon age: **1160±30 BP**

2 Sigma calibrated results: **Cal AD 780 to 900 (Cal BP 1170 to 1050) and**
(95% probability) **Cal AD 910 to 970 (Cal BP 1040 to 980)**

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 890 (Cal BP 1060)

1 Sigma calibrated results: Cal AD 830 to 840 (Cal BP 1120 to 1110) and
(68% probability) Cal AD 870 to 900 (Cal BP 1080 to 1060) and
Cal AD 920 to 940 (Cal BP 1030 to 1010)



References:
Database used
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References to INTCAL09 database
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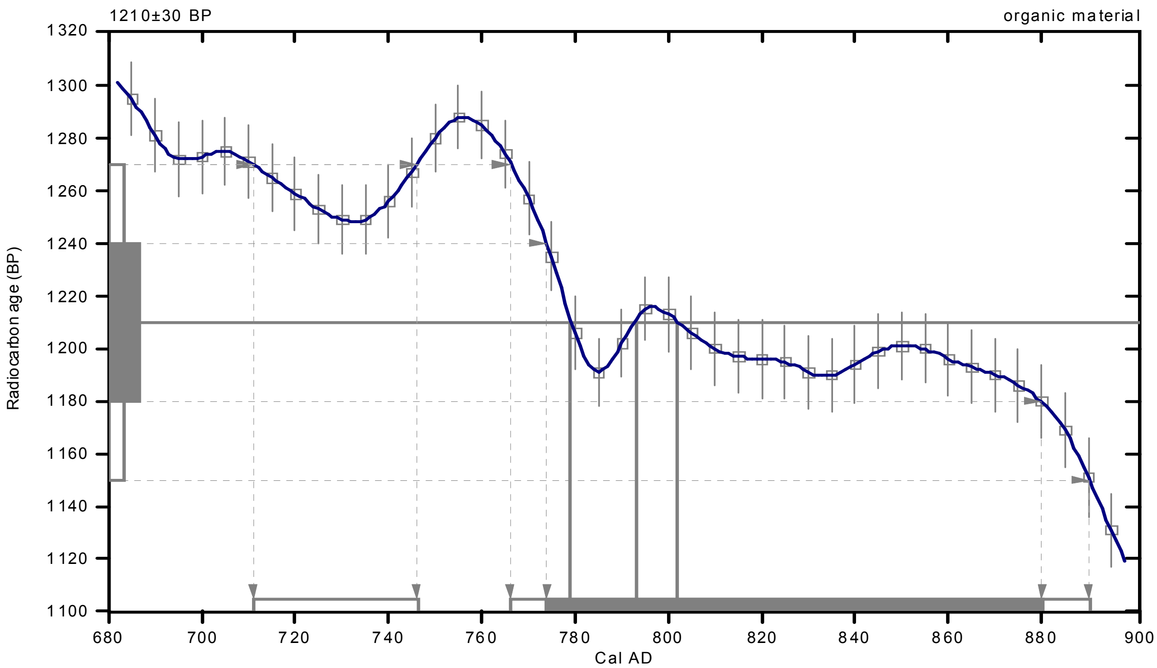
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number:	**Beta-321464**
Conventional radiocarbon age:	**1210±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 710 to 750 (Cal BP 1240 to 1200) and Cal AD 770 to 890 (Cal BP 1180 to 1060)**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 780 (Cal BP 1170) and Cal AD 790 (Cal BP 1160) and Cal AD 800 (Cal BP 1150)
1 Sigma calibrated result: (68% probability)	Cal AD 770 to 880 (Cal BP 1180 to 1070)



References:
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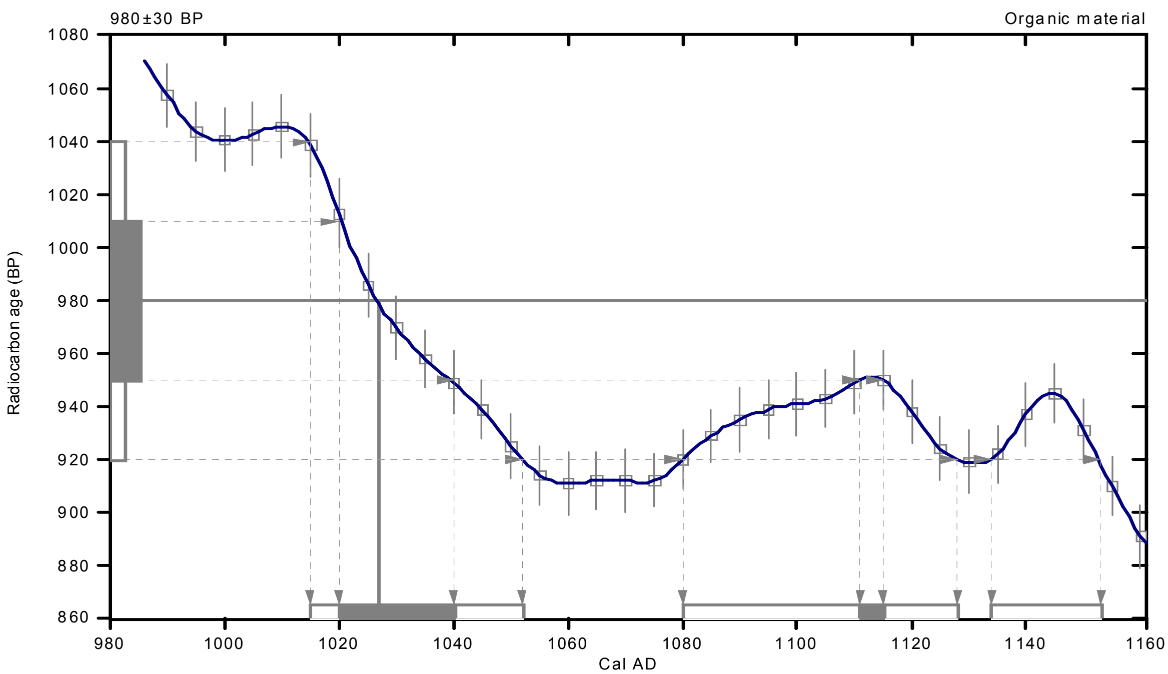
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.2:lab. mult=1)

Laboratory number:	**Beta-321465**
Conventional radiocarbon age:	**980±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 1020 to 1050 (Cal BP 940 to 900) and** **Cal AD 1080 to 1130 (Cal BP 870 to 820) and** **Cal AD 1130 to 1150 (Cal BP 820 to 800)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1030 (Cal BP 920)
1 Sigma calibrated results: (68% probability)	Cal AD 1020 to 1040 (Cal BP 930 to 910) and Cal AD 1110 to 1120 (Cal BP 840 to 840)



References:
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number: **Beta-321466**

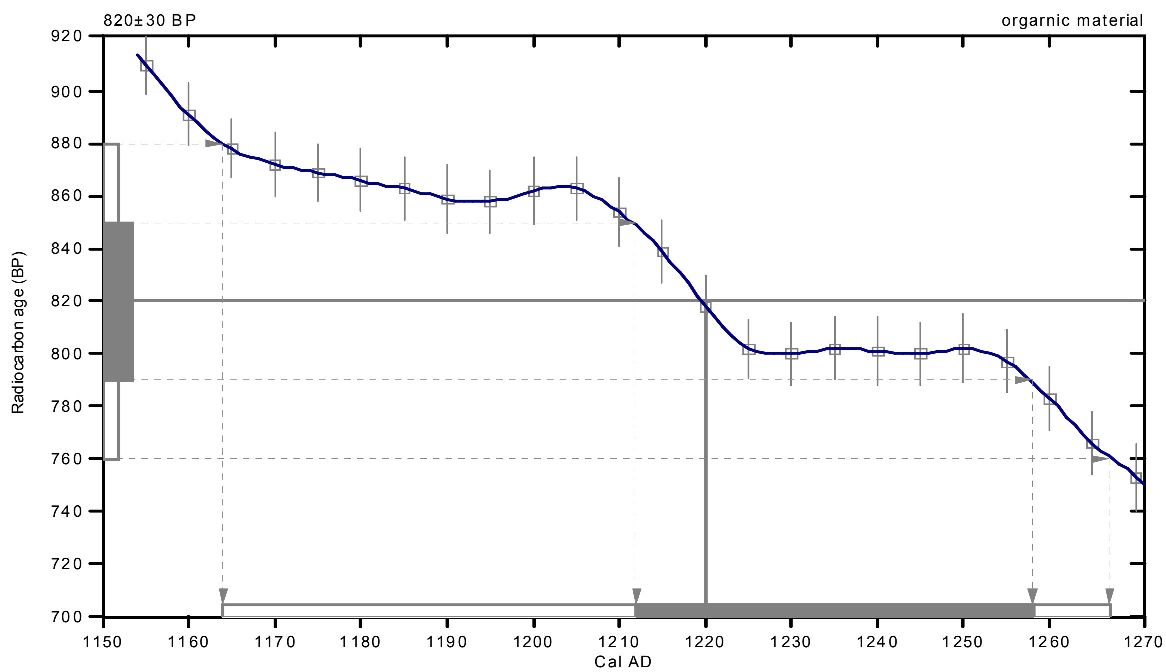
Conventional radiocarbon age: **820±30 BP**

2 Sigma calibrated result: **Cal AD 1160 to 1270 (Cal BP 790 to 680)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1220 (Cal BP 730)

1 Sigma calibrated result: Cal AD 1210 to 1260 (Cal BP 740 to 690)
(68% probability)



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June 15, 2012

Dr. James Abbott
Texas Department of Transportation
Cultural Resource Management
Environmental Affairs Division
125 East 11th Street
Austin, TX 78701
USA

RE: Radiocarbon Dating Results For Samples MI96 41-1c rock#1, MI96 49-5c rock#5, MI96 61-2c rock#2

Dear Dr. Abbott:

Enclosed are the radiocarbon dating results for three samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

Note that two of the samples do not have a Measured Radiocarbon Age and 13C/12C Ratio reported. This is because the sample was too small to do a separate 13C/12C ratio and AMS analysis. The only available 13C/12C ratio available to calculate a Conventional Radiocarbon Age was that determined on a small aliquot of graphite. Although this ratio corrects to the appropriate Conventional Radiocarbon Age, it is not reported since it includes laboratory chemical and detector induced fractionation.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice is enclosed with the mailed report copy. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD

4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. James Abbott — Report Date: 6/15/2012

Texas Department of Transportation — Material Received: 6/1/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 323139	1060 +/- 30 BP	-21.4 o/oo	1120 +/- 30 BP

SAMPLE : MI96 41-1c rock#1
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 880 to 990 (Cal BP 1070 to 960)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 323140	NA	NA	1330 +/- 40 BP

SAMPLE : MI96 49-5c rock#5
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 650 to 730 (Cal BP 1300 to 1220) AND Cal AD 740 to 770 (Cal BP 1210 to 1180)
COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 323141	NA	NA	910 +/- 30 BP

SAMPLE : MI96 61-2c rock#2
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic material): acid washes
2 SIGMA CALIBRATION : Cal AD 1030 to 1210 (Cal BP 920 to 740)
COMMENT: The original sample was too small to provide a 13C/12C ratio on the original material. However, a ratio including both natural and laboratory effects was measured during the 14C detection to calculate the true Conventional Radiocarbon Age.

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.4:lab. mult=1)

Laboratory number: **Beta-323139**

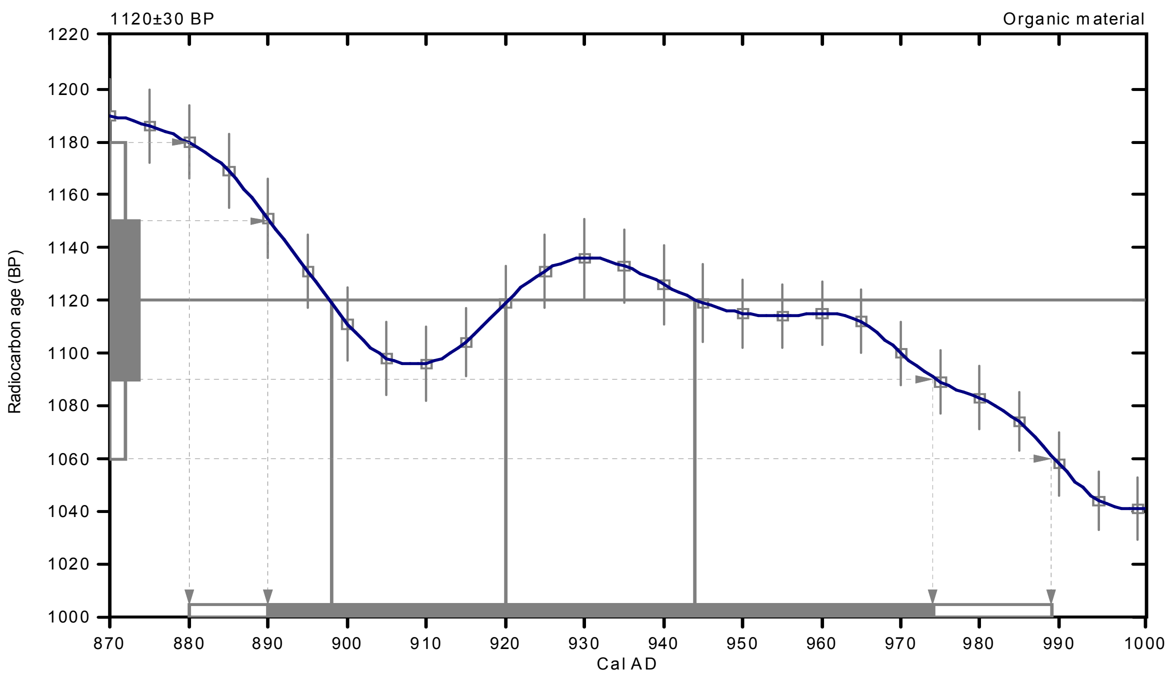
Conventional radiocarbon age: **1120±30 BP**

2 Sigma calibrated result: **Cal AD 880 to 990 (Cal BP 1070 to 960)**
(95% probability)

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal AD 900 (Cal BP 1050) and
Cal AD 920 (Cal BP 1030) and
Cal AD 940 (Cal BP 1010)

1 Sigma calibrated result: Cal AD 890 to 970 (Cal BP 1060 to 980)
(68% probability)



References:

Database used
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number: **Beta-323140**

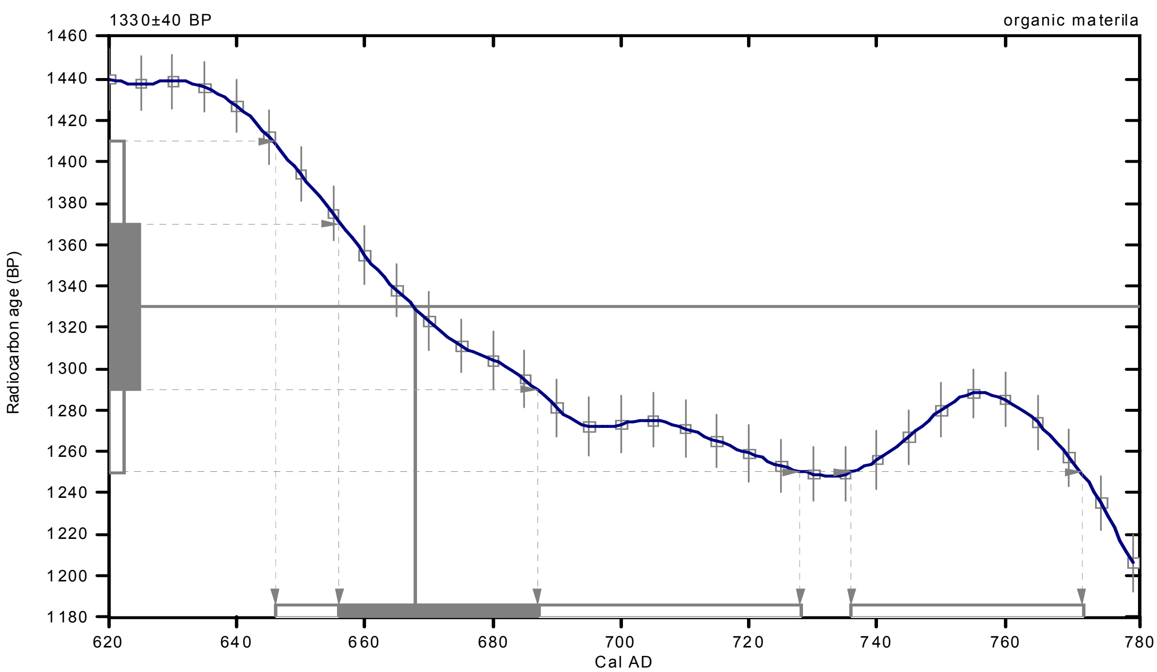
Conventional radiocarbon age: **1330±40 BP**

2 Sigma calibrated results: **Cal AD 650 to 730 (Cal BP 1300 to 1220) and**
(95% probability) **Cal AD 740 to 770 (Cal BP 1210 to 1180)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 670 (Cal BP 1280)

1 Sigma calibrated result: Cal AD 660 to 690 (Cal BP 1290 to 1260)
(68% probability)



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Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=N/A:lab. mult=1)

Laboratory number: **Beta-323141**

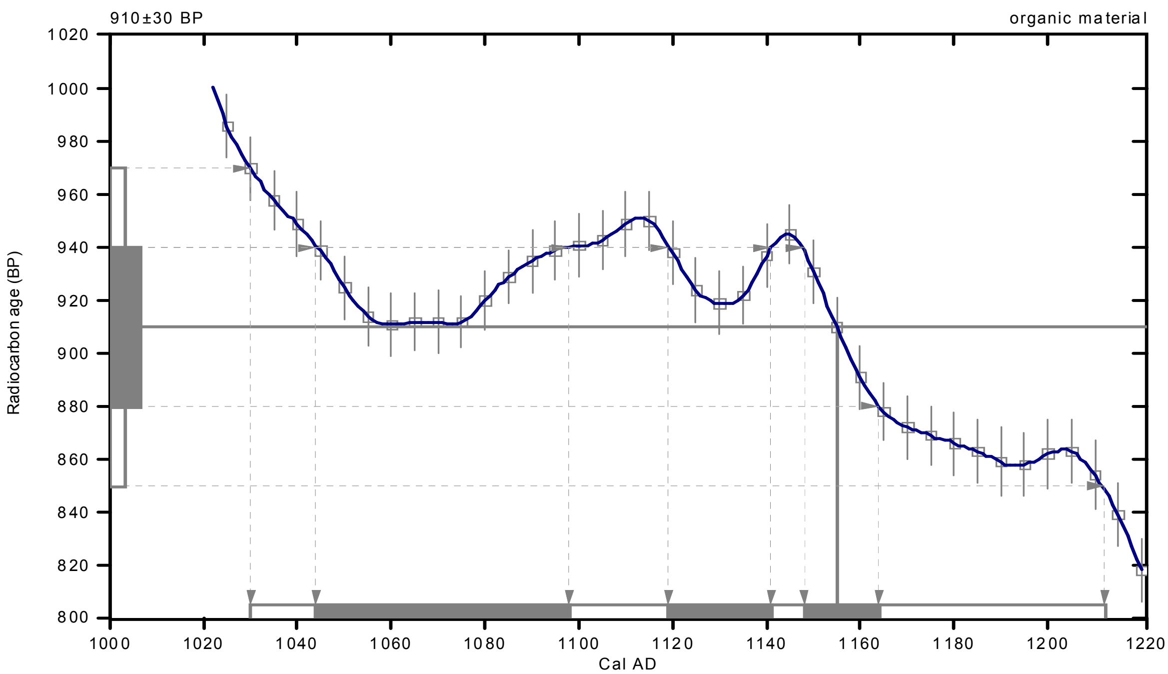
Conventional radiocarbon age: **910±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1030 to 1210 (Cal BP 920 to 740)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1160 (Cal BP 800)

1 Sigma calibrated results: (68% probability) Cal AD 1040 to 1100 (Cal BP 910 to 850) and
Cal AD 1120 to 1140 (Cal BP 830 to 810) and
Cal AD 1150 to 1160 (Cal BP 800 to 790)



References:
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APPENDIX B

MICROSCOPIC USE-WEAR AND RESIDUE ANALYSES OF STONE TOOLS FROM 41MI96, MILLS COUNTY, TEXAS

Prepared for:

TRC Environmental Corporation
505 East Huntland Drive, Suite 250
Austin, Texas 78752

Prepared by:

Bruce L. Hardy, Ph.D.
Department of Anthropology
Kenyon College
Gambier, OH 43022

June 2012

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B.1 INTRODUCTION

A sample of 15 stone tools was selected from the 41MI96. Typologically, the sample included edge-modified flakes, bifaces, a wedge, and choppers. None of the artifacts had been washed prior to analysis, although they had all been spot cleaned and labeled with ink and fingernail polish.

B.2 METHODS

The methods used for this analysis include a combination of microscopic use-wear and residue analysis that provides the potential for both specific identification of use-material (residue analysis) and contextual information and corroboration of function (use-wear analysis). The methods for this report follow those of Hardy et al. (2008):

> *All artifacts were examined with an Olympus BH microscopeunder bright-field incident light at magnifications rangingfrom 100 to 500 diameters. All wear patterns and residues were photographed using a Nikon Coolpix 995 digitalcamera, and their location on the surface was recorded ona line drawing of the artifact. Identifications of residues were made by comparison with published materials and a comparative collection of experimental stone-tool replicas (Brunner and Coman 1974; Catling and Grayson 1982; Beyries1988; Anderson-Gerfaud 1990; Hoadley 1990; Fullagar1991; Teerink 1991; Hather 1993; Hardy 1994; Brom1986; Kardulias and Yerkes 1996; Williamson 1996; Hardyand Garufi 1998; Pearsall 2000; Haslam 2004; Dove et al.2005; Fullagar et al. 2006). Residue recognition was the primary goal of the analysis; therefore, no special procedures were conducted to clean the tools for the sake of rendering use-wear patterns more visible. While this procedure may limit the use-wear information obtained, it serves to maximize the residues observed (Hardy and Garufi 1998; Hardy et al. 2001; Hardy 2004, 2010). Potentially identifiable residues include plant (plant tissue, plant fibers, starchy residue, epidermal cell tissue, wood, rawhides, phytoliths, resin) and animal tissues (muscle tissue, collagen, fat, bone/antler, blood, hair, and feathers) (Hardy et al. 2001; Lombard 2004; Wadley et al. 2004). Distribution of residues and use-wear on the artifact surface were used to help demonstrate use-relatedness and to identify use-action (Hardy and Garufi 1998; Hardy et al. 2001; Lombard 2004).*
>
> *Use-wear patterns recorded included edge damage (microflake scars, edge rounding), striations, and polishes. These were used to help identify use-action (Odell and Odell-Vereecken 1980; Mansur-Franchomme 1986). Due to the potential overlap of polishes produced by different materials, use-wear polishes were categorized as either "soft" or "hard/high silica" (e.g., Newcomer et al. 1986, 1988; Moss1987; Bamforth 1988; Hurcombe 1988; Bamforth et al.1990; Grace 1990; Fullagar 1991; Shea 1992). Soft polish often results from processing animal tissue such as skin and-meat. Hard/high-silica polish is produced when processing soft plants with high silica content, such as reeds and grasses, and wood, bone/antler, and tilling soil. The amount of time a tool was used, silica content of the processed material, and presence of water are all factors that can influence polish formation (Fullagar 1991; Hardy 2004). A combination of residue and use-wear analysis can provide complementary and corroborative information, potentially producing more accurate results than either technique used alone (Hardy 1998; Hardy and Kay 1998; Hardy et al. 2001; Rots and Williamson2004; Hardy et al. 2008:651-2).*

One modification of this protocol involves the use of a Dino-Lite USB digital eyepiece camera and Dinocapture 2.0 software to record images.

B.3 RESULTS AND DISCUSSION

This sample of artifacts exhibited evidence of the processing of wood, plants, bone, and hide as well as unspecified soft and hard material. Two artifacts, one broken hafted biface and one chopper showed no evidence of use. The lack of functional evidence on the broken hafted biface suggests that it may have broken during manufacture. There are wood fragments trapped in a flake scar on this artifact, but their location does not suggest that they are use-related. The other unused artifact, a chopper, has some isolated plant fragments on its surface, but they do not show any patterning indicating that they are use-related. One edge-modified flake has soft polish but lacks any residues to allow for more specific identification of its use. See Figures B-1 and B-2 for a visual summary of functional evidence of tool use.

B.3.1 Plant and Woodworking

Four artifacts preserve evidence of wood working in the form of wood fragments and associated use-wear. Three of these are edge-modified flakes while the final one is a chopper. One end of the chopper is characterized by steep step fractures suggesting that this area came into contact with wood under high dynamic loading through chopping or heavy scraping. An additional four artifacts (all edge-modified flakes) were used to cut hard/high silica (HHS) material. It is possible that these artifacts were also used on wood, although no residues were observed. One other edge-modified flake has undiagnostic plant fibers and HHS polish and was likely used to process wood. Two artifacts show evidence of cutting softer plants but lack diagnostic anatomy to allow for a more specific identification.

One edge-modified flake (#60-10) pictured in Figure B-3 shows wood fibers with diagnostic anatomy. Figure B-3B shows a tracheid fiber with spiral checking that is found intracheids of gymnosperms and may be characteristic of reaction wood (Hoadley 1990:18).

B.3.2 Hide and Bone Working

Three artifacts have use-wear and hair fragments consistent with use in hide working. Figure B-4 shows an edge-modified flake (#54-10) with hair fragments and striations parallel to the tool edge. This pattern suggests either use in hide working or butchery activities. Figure B-5 illustrates a large bifacially worked wedge (#45-10). One end shows heavy wear with numerous steep step fractures. This end preserves bone fragments and edge damage (Figure B-5A and B) as well as hair fragments (Figure B-5C). The morphology of the artifact along with the residue and wear patterns are consistent with general butchery activities but may also indicate heavier impact on bone. If this is the case, it could be the result of cracking bones for marrow or in the modification of bone to produce bone tools. One final artifact associated with butchery, an edge-modified flake (#65-10), shows one edge with soft polish and hair fragments while another edge has hard/high silica polish. While both edges could be related to butchery, it is possible that the artifact was also used on another hard material.

B.4 CONCLUSIONS

This small sample of artifacts shows evidence of use in woodworking, plant processing and butchering.

B.5 REFERENCES CITED

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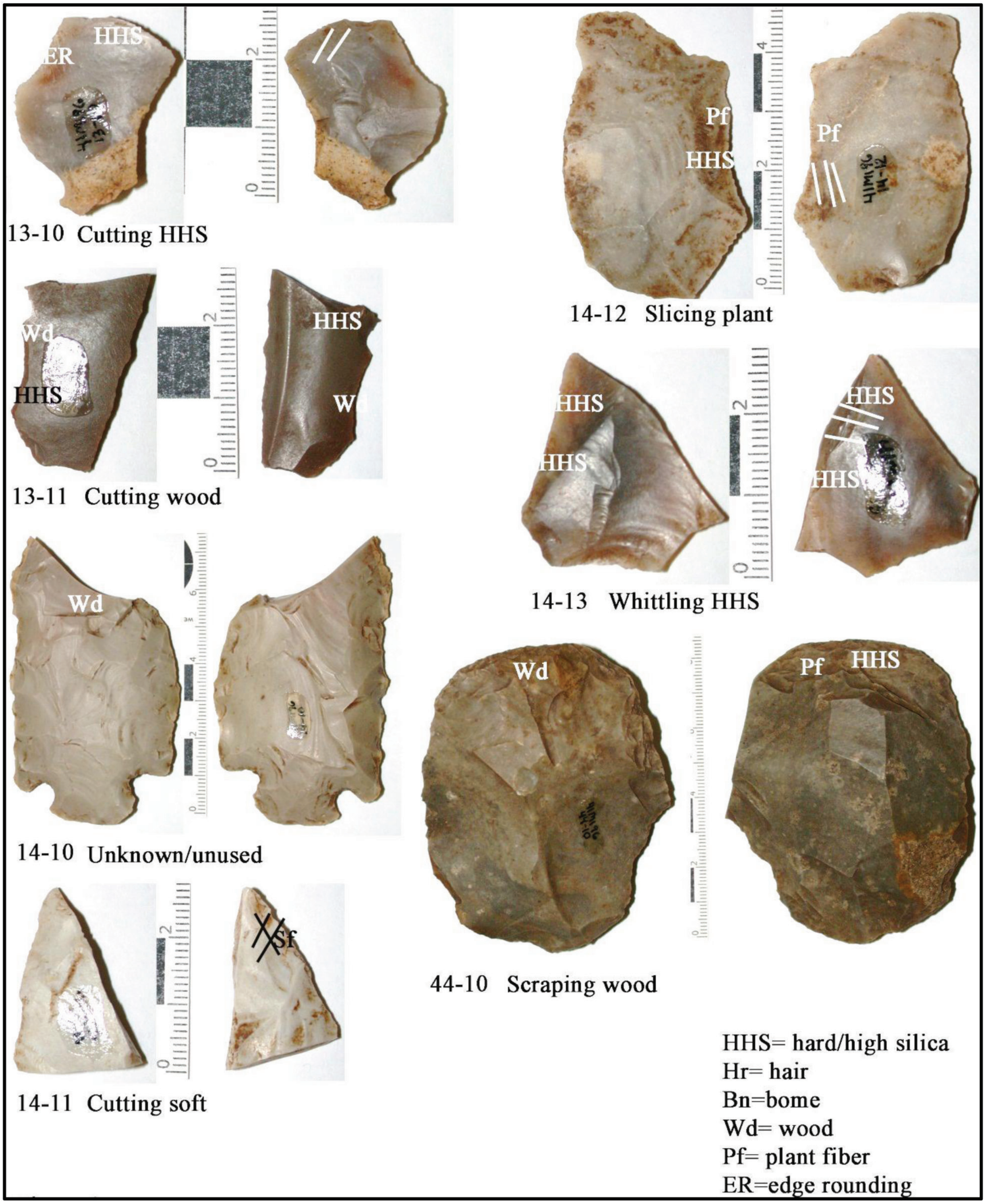

Figure B-1. Visual summary of functional evidence on seven tools.

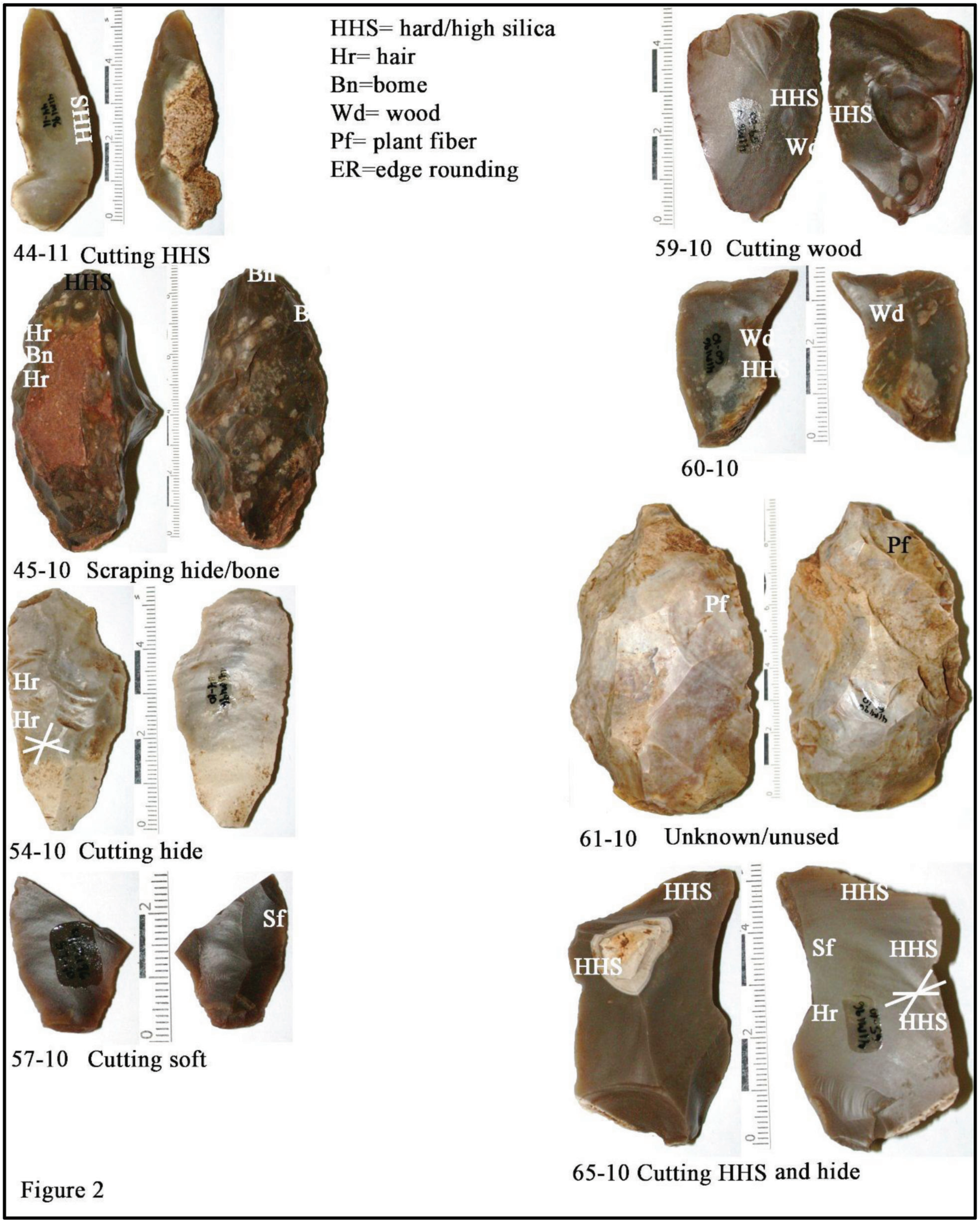

Figure B-2. Visual summary of functional evidence on eight tools.

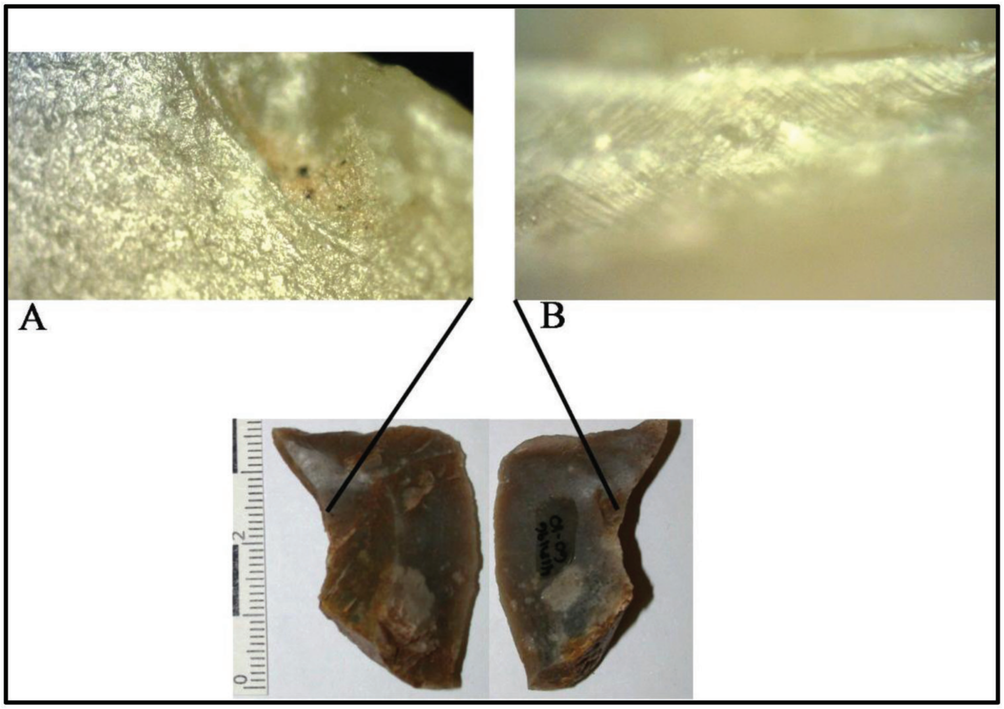

Figure B-3. Edge-modified flake (#60-10) detail; A shows hard/high silica polish and edge damage; B shows vessel tracheid with spiral checking.

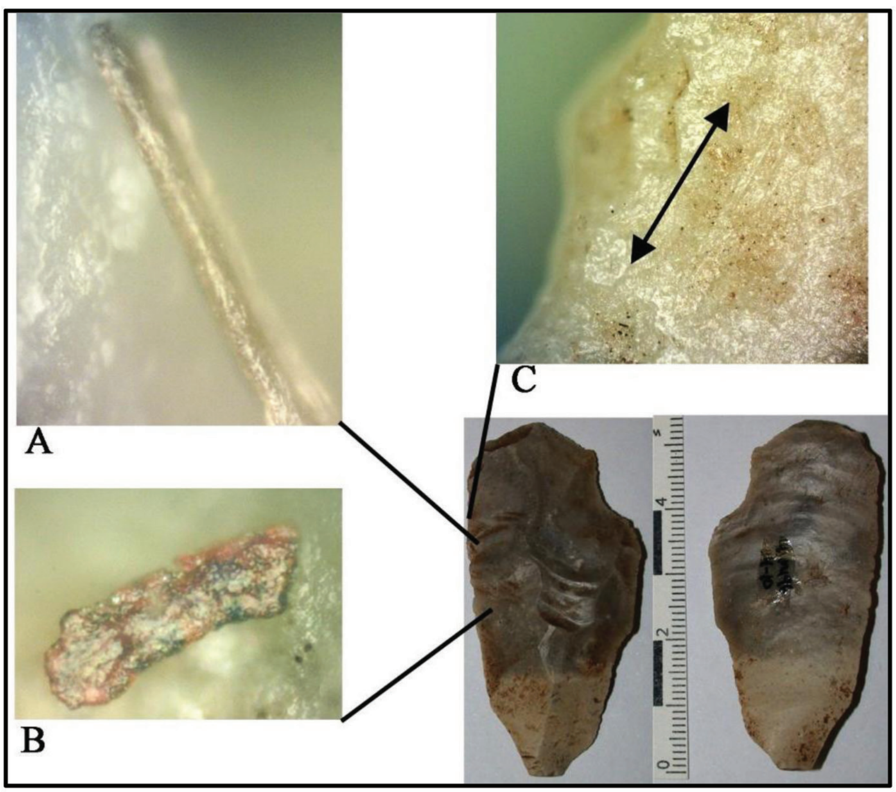

Figure B-4. Edge-modified flake (#54-10) detail; A and B depict hair fragments; C shows soft polish with striations parallel to edge.

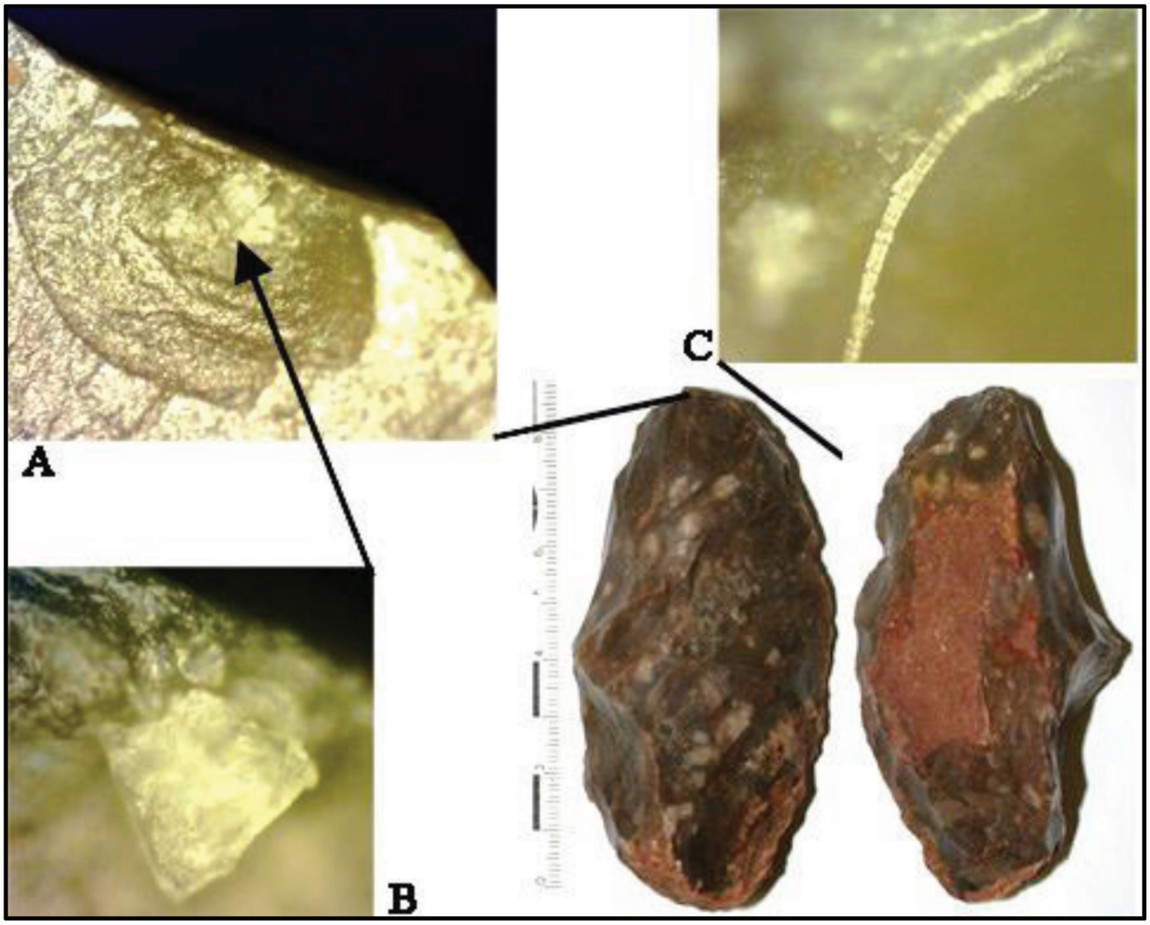

Figure B-5. Wedge (#45-10) details; A shows microflake scar with bone fragment; B shows bone fragment at 500x magnification; C shows hair fragment.

Table B-1. Summary of Tool Function

Cat. No.	Unit	Artifact Type	Residues	Use-wear	Function
13-10	1	Edge-modified	-----	Striae, edge rounding	Cutting HHS material
13-11	1	Edge-modified	Wood, plant fibers	HHS polish	Cutting wood
14-10	1	Biface, hafted	Wood	-----	Unknown/unused
14-11	1	Biface, lateral edge	-----	Soft polish, striae	Cutting plant
14-12	1	Edge-modified	Plant fibers	HHS polish, striae	Cutting plant
14-13	1	Edge-modified	-----	Striae, HHS polish	Whittling HHS material
44-10	9	Chopper	Wood	HHS polish	Scraping wood
44-11	9	Edge-modified	-----	HHS polish	Cutting HHS material
45-10	9	Wedge	Bone, hair	HHS polish, edge damage	Scraping bone/hide
54-10	12	Edge-modified	Hair	Striae	Cutting hide
57-10	13	Edge-modified	-----	Soft polish	Cutting soft material
59-10	14	Edge-modified	Wood, plant fibers	HHS polish, striae	Whittling wood
60-10	14	Edge-modified	Wood	HHS polish	Cutting wood (gymnosperm)
81-10	14	Chopper	Plant fibers	-----	Unknown/unused
65-10	16	Edge-modified	Hair fragment	Soft polish, HHS polish, striae	Cutting hide and HHS material

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APPENDIX C

STARCH ANALYSIS OF ARTIFACTS FROM 41MI96

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C.1 INTRODUCTION TO STARCH GRAIN ANALYSES

Archeobotanical investigators are constantly seeking new methods by which previously unobtainable data can be recovered. Among archeologists who work in regions characterized by the poor preservation of organic remains, the analyses of starch granules have proven particularly useful in accessing the residues of starchy root and tuber crops that have previously been invisible in the archeological record (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarté et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007; Perry and Quigg 2011a, 2011b; Perry et al. 2006, 2007, 2010; Piperno and Holst 1998; Piperno et al. 2000). These residues have proven to be tenacious survivors in harsh climates, and their preservation on the surfaces of lithic tools that were used in the processing of starch-bearing plants occurs consistently in archeobotanical investigations (Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007, 2010; Perry and Quigg 2011a; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000).

Investigations of the starchy remains of plant foods on the surfaces of archeological lithic tools began with simple analyses using chemical reagents that identified the residues in question as plant-derived storage starch (Bruier 1976) rather than animal tissue. Within the last fifteen years, however, archeologists have been successfully employing morphological criteria to identify plant taxa. The methods are almost identical to those used in the analysis of phytolith microfossils.

Just as different plants produce characteristically shaped leaves, flowers, and seeds, different genera and species make starch grains that are distinctive to and diagnostic for each taxon. The anatomical features that distinguish the starch of one species of plant from another have been noted by botanists (e.g., Denniston 1904; MacMasters 1964; Reichert 1913), and their methods have been expanded by archeobotanists who are now able even to distinguish wild from domesticated species in some plant families (Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002, 2004; Piperno et al. 2000). Basic physical features that are comparable between modern reference specimens and archeological samples can be viewed using a light microscope and include gross morphological features such as shape and faceting, the location of and appearance of the hilum, and presence and patterning of lamellae (Iriarté et al. 2004; Loy 1994; Pearsall 2004; Perry 2004; Piperno and Holst 1998; Piperno et al. 2000). Fissuring and other internal patterning have also proven to be useful criteria for identification. The successful identification of starch granules relies upon the viewing of each granule in three dimensions to gain an accurate assessment of its morphological features.

Because starch granules differ morphologically between plants, their distinctive characteristics can often allow identification to the level of genus or species in archeological samples (e.g., Iriarté et al. 2004; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005, 2007; Perry et al. 2006, 2007; Piperno and Holst 1998; Piperno et al. 2000). The method has proven particularly useful in identifying the remains of plant tissues that would not usually be preserved as macroremains, such as the remnants of root and tuber crops (Bryant 2003; Coil et al. 2003; Fullagar et al. 1998; Hall et al. 1989; Iriarté et al. 2004; Loy et al. 1992; Pearsall et al. 2004; Perry 2001, 2002, 2004, 2005; Piperno and Holst 1998; Piperno et al. 2000). This role of starch analysis as a tool for revealing the significance of plant foods in the archeobotanical record also adds to our understanding of the pre-contact significance of starchy seed crops like maize (*Zea mays*).

In a citation of preliminary results from an ongoing study, the archeological remains of maize starch have been extracted from 2000 year-old obsidian artifacts from the Honduran site of Copán (Haslam 2003, 2004). The starchy residues of maize were also successfully recovered and identified from a migmatite milling stone from Cueva de los Corrales 1 in Argentina (Babot and Apella 2003). In this case, the grinding stone was found to have multiple purposes, including the grinding of burnt bone, presumable for a non-food purpose. Starch analyses of ground stone artifacts from Real Alto have supported previously published phytolith studies that indicate the great antiquity of maize in Ecuador, and its role in subsistence during the Formative period (Pearsall et al. 2004). Seventeen examined artifacts from Real Alto yielded concentrations of maize starch granules ranging from one to more than ten granules per sampled tool. Other Neotropical studies have resulted in the recovery of more complex assemblages of starches.

Archeologists have recovered starch granules from maize, beans (*Phaseolus* sp.), and Canna from the Los Ajos mound complex in Uruguay (Iriarté et al. 2004). Maize starch granules were reported from three ground stone tools including one mano and two milling stone bases. Concentrations of maize starches ranged from two to eleven granules on tools from contexts dating from 3600 years before present to about 500 years before present (Iriarté et al. 2004: supplementary information). The starch data were combined with phytolith evidence and, together, these results introduce compelling evidence for the early development of a mixed subsistence economy in this region of South America. In other regions of the Neotropics, starch analysis has been an essential tool in defining similar subsistence patterns that included the exploitation of root and tuberous food plants.

Starch granules of maize, manioc (*Manihot esculenta*), both wild type and domesticated yams (*Dioscorea* spp.), and arrowroot (*Maranta arundinacea*) have been recovered from edge ground cobbles and grinding stone bases collected from the Aguadulce rock shelter as well as the sites of Monagrillo, La Mula, and Cerro Juan Diaz in Panama (Piperno and Holst 1998; Piperno et al. 2000). Edge ground cobbles are characterized by faceting that is hypothesized to have resulted from the processing of root crops against larger grinding stone bases (Ranere 1975), and the analyses of the residual remains of plant tissues supports this hypothesis. However, the use of the milling stones does appear to have been more complex than previously believed. Maize remains were recovered from all twelve artifacts that bore starch (Piperno et al. 2000). The numbers of starch granules of maize per artifact ranged from one to twenty-five per artifact. Two starch granules of arrowroot occurred on a single artifact, manioc starch granules were recovered from three artifacts (one, five, and eight granules), and yam starch granules were found on the surfaces of three of the artifacts (two, three, and sixteen granules) (Piperno et al. 2000). These investigations resulted in the recovery of the oldest evidence for root and tuber crop cultivation in the Neotropics, with radiocarbon dates spanning from 5,000 to 7,000 years before present.

Starch granules of maize, yams, and arrowroot have also been recovered from twelve flake and three ground stone tools collected from Pozo Azul Norte 1 and Los Mangos del Parguaza in Venezuela (Perry 2001, 2002, 2004, 2005). These sites date from the middle first century AD to contact. As in the above-cited set of studies, maize remains were recovered from every examined artifact and ranged in number from two to fifty-one per artifact. Additionally, four granules of yam starch were recovered from two flake tools, four flake tools yielded four granules of guapo (*Myrosma* sp.) starch, and seven starch granules from arrowroot were collected from five tools, one of which was a ground stone artifact. These findings were significant in that five of the examined artifacts were chosen for study due to their hypothetical function as microlithic grater flakes from a manioc specific grater board. The evidence indicated a more complex function of these tools that did not include the processing of manioc.

More recent investigations have led to the recovery of direct evidence for contact between the highland Peruvian Andes and the lowland tropical forest to the east (Perry et al. 2006). This contact and interaction had been a significant component of Andean theory for decades, but direct evidence had been elusive until starch microfossils of arrowroot were collected from both sediment samples and lithic tools at the mid-elevation site of Waynuna (Perry et al. 2006). Further, the discovery and cataloging of a microfossil will allow for the recovery and understanding of the origins and subsequent dispersals of chili peppers (Perry et al. 2007), plants whose histories are poorly understood due to the lack of preservation of macroremains in the archeobotanical record. Remains of these plants have been successfully recovered throughout the Americas from ceramic sherds, lithic tools, and sediment samples dating from 6250 B.P. to European contact.

C.2 UNDERSTANDING THE RELATIONSHIP BETWEEN RESIDUES AND ARTIFACTS

'Early work on starch remains from Panamanian sites used stepwise analysis to support the direct association between starchy residues on tools and the tools' use (Piperno et al. 2000). These studies demonstrated that starch grains were not present in sediments adhering to stone tools or on unused parts of the lithics, but they did occur in the cracks and crevices of the tools on used surfaces, thus indicating that the residues were the result of the tools' use and not environmental contamination. Similar experiments have been undertaken independently by other researchers, and the results were equivalent.

In a study of obsidian artifacts recovered from an open air site in Papua New Guinea, the frequency of starch granules recovered from stone artifacts was compared to that present in the soil matrix immediate to the tool (Barton et al. 1998). The frequency of starch granules was found to be much higher on used artifacts than in the surrounding soil. Thus, the conclusion was drawn that the tools were not contaminated by environmental starch sources. Further, use-wear analyses were used in combination with the soil and starch analyses to assess the degree of association of starchy residues with the used surfaces of tools (Barton et al. 1998). The researchers found that, indeed, the occurrence of starch granules was highly correlated with obsidian tools that bore use-wear and was not correlated with unused tools.

In a study of starch residues occurring on stone pounding tools from the Jimmium site in north central Australia, the starch forms in soil samples were compared to those extracted from the artifacts (Atchison and Fullagar 1998). It was found that, although starch granules did occur in the soil matrices surrounding the tools, they were of different size and shape than those present on the pounding stones, and, therefore, are probably not from the same plant source. This result was interpreted as evidence that the tools had not been contaminated by soil-borne starches.

Another method for assessing whether or not starch residues are culturally deposited involves the analysis of control samples from non-cultural contexts surrounding a site. If different types of starches, or different concentrations of starches, or no plant residue whatsoever are recovered from the control samples than are recovered from the artifacts undergoing testing, then one can be more secure that the residues are the remains of prehistoric food processing (Brieur 1976).

In addition to the study of association of microfossils with tool use, experimentation with processing methods has also been undertaken. In Argentina, a researcher replicated ancient Andean methods of food processing and found that each different process resulted in diagnostic damage to starch granules in plant tissues including potato tubers (*Solanum tuberosum*) and quinoa seeds (*Chenopodium* spp.) (Babot 2003). Modern plant materials were subjected to freeze-drying, dehydration, roasting, charring, desaponification (a process particular to the preparation of quinoa), and grinding. It was found that fragments of starches that would probably otherwise be identified as unknowns or non-starches are actually damaged starches. Further, with careful analysis, researchers can link damage patterns with processing techniques (Babot 2003). Experimentation with various cooking techniques has resulted in similar conclusions: cooked starches are identifiable as such, and different cooking techniques yield different patterns of damage (Henry et al. 2009).

Recent work at the Pipeline, Pavilion, and Corral sites in Texas have demonstrated the utility of starch grain analysis in understanding the function of burned rocks in archeological contexts (Perry 2010; Perry and Quigg 2011a). Here, the analysis of burned rocks yielded starch grains that bore clear damage from boiling and secured the function of many burned rocks as boiling stones used for the cooking of wildrye (*Elymus* spp.). The analysis of other artifacts from the sites yielded wildrye starches bearing damage from grinding, thus indicating that the grain was probably milled into flour prior to cooking (Perry 2010; Perry and Quigg 2011a).

Archeobotanists have focused their energies upon honing their methods toward the effective recovery of and identification of residual starch granules to understand plant use and processing. Studies have resulted in an impressive assemblage of various suites of starchy food plants, both wild and domesticated, raw and cooked. At this juncture in time, more studies are being undertaken and starch remains are being successfully recovered. What we now lack are baseline data as to how and why different plant materials may or may not adhere to stone tools. Thus, we are not yet able to understand issues such as intensity of use based upon numbers of recovered grains, or the history of a tool based upon the numbers of species of plants recovered from its surface. Linda Perry has obtained funding and will be performing experiments over the next year in the hopes of gaining an understanding of these issues.

C.3 METHODS

Forty samples, 20 flaked tools and 20 burned rocks, were selected for analysis. All artifacts were collected and bagged separately without washing. Washing is a traditional step in the collection and curation of artifacts, but it will remove some of the residues that are of interest to archeologists.

All artifacts were placed in clean, metal beakers and were covered with filtered water. The beakers were then set aside for ten minutes to soak in the hope that this step would loosen the microfossils and allow for a better extraction. At this point, the beakers were placed in a sonic bath for ten minutes to shake the microfossils loose from the artifacts. The artifacts were removed from the beakers and the surfaces were rinsed with filtered water that was collected in the same effluent vessel.

The effluent from the cleaning was allowed to settle overnight, then the settled material was centrifuged for ten minutes at 1000 RPM to pellet out the solids. The solid materials were then subject to a heavy liquid flotation using cesium chloride (CsCl) at a density of 1.8 g/cm^3 to separate the starch grains from the sediment matrix.

The material collected from the flotation was rinsed and centrifuged three times with filtered water to ensure that the CsCl was completely removed from the solution. At this point, the pellet from the final centrifugation was placed on a clean glass slide with a small amount of water/glycerin solution.

Slides were scanned with a Zeiss Universal compound microscope with polarized light at 200x, and identifications were made at 400x using standard methods. Digital images were captured at 800x magnification using a Micropublisher 3.3 camera and software.

C.4 RESULTS

A total of 32 starch grains were recovered from 20 of the 40 analyzed tools, 23 of which were identifiable to a taxonomic group (Table C-1). Ten of the 20 flaked tools yielded starchy remains, and 10 of the 20 burned rocks yielded starchy remains. The remains were recovered in small numbers, and it should be noted that preservation was not ideal for organic remains in this site.

Lenticular starch grains are derived from grass seeds from either wildrye (*Elymus* spp.) or little barley (*Hordeum pusillum*) (Figure C-1a). Maize starch grains are solidly identified due to the presence of a diagnostic elongate hemisphere with a single, basal facet, or "vase" form recovered from a burned rock found in Feature 2 (#61-3a, Figure C-1b, c). Grass starches are derived from grasses other than those in the Triticeae, wildrye or little barley, but are not clearly identifiable as maize or other prairie grasses that produce large starch grains. Unidentified starch grains may be derived from the clearly identifiable groups, but their lack of diagnostic features or lack of good preservation prevented a solid identification. None of the unidentified starches are of unique morphology or well-preserved to expect identification in the future.

Additionally, damage was noted in some of the samples. Starch grains that were subjected to heating, grinding, and heating in the presence of water (gelatinization) were recorded throughout the samples (Table C-1).

C.4.1 Results by Unit and Feature

Samples from eight test units and five features were analyzed. Starch grains were found in seven test

Table C-1. Starch Remains Recovered from site 41MI96.
Damage codes are as follows: X = unidentified source of damage, H = heating, GD = grinding, GL = gelatinization.

Site #	Provenience	PNUM	Feature	Artifact type	Lenticular	Maize	Grass	Unidentified	Damage	Total
41MI96	Unit 1	14-11	4	Biface		1				**1**
41MI96	Unit 1	14-12	4	Edge Mod						**0**
41MI96	Unit 1	14-13	4	Edge Mod	1					**1**
41MI96	Unit 1	44-10	4	Chopper						**0**
41MI96	Unit 1	15-1a	4	Burned Rock						**0**
41MI96	Unit 1	15-2a	4	Burned Rock	1				H	**1**
41MI96	Unit 1	15-4a	4	Burned Rock			1	1		**2**
41MI96	Unit 1	15-5a	4	Burned Rock			1		GL	**1**
41MI96	Unit 1	14-14		Edge Mod						**0**
41MI96	Unit 1	14-15		Edge Mod						**0**
41MI96	Unit 1	13-10		Edge Mod	4	1			H	**5**
41MI96	Unit 1	13-11		Edge Mod						**0**
41MI96	Unit 7	38-10		Edge Mod						**0**
41MI96	Unit 7	39-10		Edge Mod						**0**
41MI96	Unit 7	39-11		Edge Mod				2		**2**
41MI96	Unit 7	40-10		Edge Mod						**0**
41MI96	Unit 7	41-1a	5	Burned Rock						**0**
41MI96	Unit 7	41-3a	5	Burned Rock						**0**
41MI96	Unit 7	41-4	5	Burned Rock						**0**
41MI96	Unit 7	41-6a	5	Burned Rock						**0**
41MI96	Unit 9	44-11	7	Edge Mod						**0**
41MI96	Unit 9	49-1a	7	Burned Rock	4			1	GD	**5**
41MI96	Unit 9	49-2	7	Burned Rock						**0**
41MI96	Unit 9	49-3	7	Burned Rock						**0**
41MI96	Unit 9	49-4a	7	Burned Rock						**0**
41MI96	Unit 9	45-10		Edge Mod						**0**
41MI96	Unit 10	47-10		Chopper						**0**
41MI96	Unit 13	61-2a	2	Burned Rock	1				GL GD	**1**
41MI96	Unit 13	61-3a	2	Burned Rock		1	1			**2**
41MI96	Unit 13	61-4	2	Burned Rock		1				**1**
41MI96	Unit 13	61-1	2	Burned Rock						**0**
41MI96	Unit 13	62-5	3	Burned Rock		1			GL	**1**
41MI96	Unit 13	57-10		Edge Mod				1		**1**
41MI96	Unit 14	59-10		Edge Mod				1		**1**
41MI96	Unit 14	60-10		Edge Mod	1		1		H	**2**

Table C-1. Starch Remains Recovered from site 41MI96.
Damage codes are as follows: X = unidentified source of damage, H = heating, GD = grinding, GL = gelatinization.

Site #	Provenience	PNUM	Feature	Artifact type	Lenticular	Maize	Grass	Unidentified	Damage	Total
41MI96	Unit 14	81-10		Edge Mod	1				X	**1**
41MI96	Unit 15	69-1a	3	Burned Rock						**0**
41MI96	Unit 15	69-2a	3	Burned Rock		1		1		**2**
41MI96	Unit 15	69-3a	3	Burned Rock				1		**1**
41MI96	Unit 16	65-10		Edge Mod				1		**1**
Total					**13**	**6**	**4**	**9**	**X H GD GL**	**32**

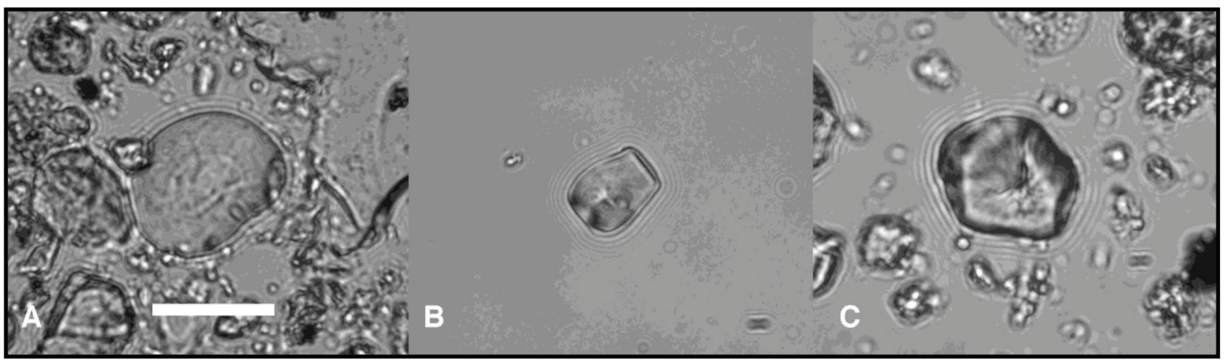

Figure C-1. Starch remains from site 41MI96.
A. Lenticular starch grain from burned rock 49-1a, Feature 7. B. Maize "vase" form from burned rock 61-3a, Feature 2. C. Maize starch from burned rock 61-4, Feature 2.

units and four features. No starchy plant remains were recovered from Feature 5 or Unit 10.

Unit 1 and Feature 4:
Twelve samples from Unit 1 were tested, four burned rocks and eight flaked tools. Of these, five samples, three burned rocks and two flaked tools, yielded starch grains. Lenticular starches were recovered from one burned rock (#15-2a) and two flaked tools (#14-13 and #13-10), maize starches were recovered from two flaked tools (#14-11 and #13-10), grass starches were recovered from two burned rocks (#15-4a and #15-5a), and a single unidentified starch grain was recovered from a burned rock (#15-4a). Damage due to heating was noted in samples from a burned rock (#15-2a) and a flaked tool (#13-10), and gelatinization due to heating in the presence of water was noted on one burned rock (#15-5a).

Feature 4 from Unit 1 included all the starch-bearing samples except for a single flaked tool (#13-10). All categories of remains were recovered from Feature 4.

Unit 7 and Feature 5:
Eight samples from Unit 7 were studied, four flaked tools, and four burned rocks from Feature 5. A single flaked artifact (#39-10) yielded two unidentified starch grains.

Unit 9 and Feature 7:
Six samples were analyzed from Unit 9, two flaked tools and four burned rocks. A single burned rock from Feature 7 (#49-1a) yielded four lenticular starch grains and one unidentified starch grain. Grinding damage was also noted in this sample.

Unit 13, Features 2 and 3:
Six artifacts from Unit 13, five burned rocks and one flaked tool, were analyzed. Three burned rocks from Feature 2 yielded residues including a single lenticular grain along with evidence of cooking in the presence of water and grinding (#61-2a), one maize grain and an unidentified grass starch (#61-3a), and one maize grain (#61-4). The burned rock from Feature 3 (#62-5) also yielded one maize grain along with evidence of cooking in the presence of water. A single, unidentifiable starch grain was recovered from the flaked tool (#57-10).

Notably, burned rock #61-3a yielded a vase-shaped starch grain. This type of starch has been documented only in maize, and is a solid indicator of its presence at a site.

Unit 14:
Three flaked artifacts from Unit 14 were tested, and all yielded starch remains. A single, unidentified grain was recovered from flaked tool #59-10, a lenticular and grass grain were recovered from tool #60-10 along with evidence for damage from heating, and a single lenticular grain was recovered from artifact #81-10 along with unidentified damage.

Unit 15 and Feature 3:
Four burned rocks from Feature 3 in Unit 15 were studied, and three yielded starchy remains. Burned rock #69-2a contained a single grain of maize and an unidentified grain, and burned rock #69-3a yielded a single, unidentifiable grain.

Unit 16:
The flaked tool from Unit 16 (65-10) yielded a single, unidentifiable starch grain.

C.5 DISCUSSION

Burned rock Features 2, 3, 4, and 7 are associated with the processing of plant food resources. The use of grass seeds from wildrye or little barley are documented in Features 2, 4, and 7. The use of maize is documented in Features 2, 3, and 4, with the evidence from Feature 2 being the most solid with a diagnostic vase form. Other grasses and unidentified starches that may be part of these other assemblages were processed in Features 2, 3, 4, and 7. Although the interpretation of negative evidence can be difficult, Feature 5 may not be associated with plant processing.

Notably, authors believe that the characteristics of Feature 5 represented a small dump rather than an *in situ* heating element. In contrast, Features 2, 3, and 4 were intact heating elements. Feature 7 was less easily defined, but also appeared to be some sort of deposit of discarded artifacts that were used in previous cooking events. Rocks from Features 2, 3, and 4 were more reliable sources of starch remains than samples from Feature 7, and samples from Feature 5 did not yield any starchy plant remains at all. Thus, the concentrations of starch remains were recovered from the intact, *in situ* heating elements, further supporting the interpretations of the authors that these features were used in the preparation of plant foods.

The analyses also indicate that the grass seeds were being ground into flour prior to use, and that they were being heated for cooking, sometimes in the presence of water. The presence of gelatinized starches on burned rocks is a good indicator that stone boiling was in use at the site. Thus, the processing and cooking of both wildrye and/or little barley and maize seeds are documented at the site.

In summary, the analysis of these forty samples was undertaken to investigate the viability of starch analysis in a context in which macroremains and other sources of organic evidence had not preserved, and, thus, the understanding of plant food subsistence was not available through traditional methods. The results show that, though preservation of organic remains at the site was not good, the use of plant food resources could be documented via starch analysis.

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APPENDIX D

ANALYSIS OF THE LIPID COMPOSITIONS OF ARCHEOLOGICAL BURNED ROCK RESIDUES FROM SITE 41MI96

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D.1 INTRODUCTION

Twenty fragments of burned rock from site 41MI96 were submitted for analysis. Exterior surfaces were ground off to remove any contaminants; samples were crushed and absorbed lipid residues were extracted with organic solvents. The lipid extract was analyzed using gas chromatography (GC), high temperature GC (HT-GC) and high temperature gas chromatography with mass spectrometry (HT-GC/MS). Residue identifications were based on fatty acid decomposition patterns of experimental residues, lipid distribution patterns and the presence of biomarkers. Procedures for the identification of archeological residues are outlined below; following this, analytical procedures and results are presented.

D.2 THE IDENTIFICATION OF ARCHEOLOGICAL RESIDUES

D.2.1 Identification of Fatty Acids

Fatty acids are the major constituents of fats and oils (lipids) and occur in nature as triglycerides, consisting of three fatty acids attached to a glycerol molecule by ester-linkages. The shorthand convention for designating fatty acids, Cx:yωz, contains three components. The "Cx" refers to a fatty acid with a carbon chain length of x number of atoms. The "y" represents the number of double bonds or points of unsaturation, and the "ωz" indicates the location of the most distal double bond on the carbon chain, i.e. closest to the methyl end. Thus, the fatty acid expressed as C18:1ω9, refers to a mono-unsaturated isomer with a chain length of 18 carbon atoms with a single double bond located nine carbons from the methyl end of the chain. Similarly, the shorthand designation, C16:0, refers to a saturated fatty acid with a chain length of 16 carbons.

Their insolubility in water and relative abundance compared to other classes of lipids, such as sterols and waxes, make fatty acids suitable for residue analysis. Since employed by Condamin et al. (1976), gas chromatography has been used extensively to analyze the fatty acid component of absorbed archeological residues. The composition of uncooked plants and animals provides important baseline information, but it is not possible to directly compare modern uncooked plants and animals with highly degraded archeological residues. Unsaturated fatty acids, which are found widely in fish and plants, decompose more readily than saturated fatty acids, sterols or waxes. In the course of decomposition, simple addition reactions might occur at points of unsaturation (Solomons 1980) or peroxidation might lead to the formation of a variety of volatile and non-volatile products which continue to degrade (Frankel 1991). Peroxidation occurs most readily in fatty acids with more than one point of unsaturation.

Attempts have been made to identify archeological residues using criteria that discriminate uncooked foods (Marchbanks 1989; Skibo 1992; Loy 1994). The major drawback of the distinguishing ratios proposed by Marchbanks (1989), Skibo (1992) and Loy (1994) is they have never been empirically tested. The proposed ratios are based on criteria that discriminate food classes on the basis of their original fatty acid composition. The resistance of these criteria to the effects of decompositional changes has not been demonstrated. Rather, Skibo (1992) found his fatty acid ratio criteria could not be used to identify highly decomposed archeological samples.

In order to identify a fatty acid ratio unaffected by degradation processes, Patrick et al. (1985) simulated the long-term decomposition of one sample and monitored the resulting changes. An experimental cooking residue of seal was prepared and degraded in order to identify a stable fatty acid ratio. Patrick et al. (1985) found that the ratio of two C18:1 isomers, oleic and vaccenic, did not change with decomposition; this fatty acid ratio was then used to identify an archeological vessel residue as seal. While the fatty acid composition of uncooked foods must be known, Patrick et al. (1985) showed that the effects of cooking and decomposition over long periods of time on the fatty acids must also be understood.

D.2.2 Development of the Identification Criteria

As the first stage in developing the identification criteria used herein, the fatty acid compositions of more than 130 uncooked Native food plants and animals from Western Canada were determined using gas chromatography (Malainey 1997; Malainey et al. 1999a). When the fatty acid compositions of modern food plants and animals were subject to cluster and principal component analyses, the resultant groupings generally corresponded to divisions that exist in nature (Table D-1). Clear differences in the fatty acid composition of large mammal fat, large herbivore meat, fish, plant roots, greens and berries/seeds/nuts were detected, but the fatty acid composition of meat from medium-sized mammals resembles berries/seeds/nuts.

Samples in cluster A, the large mammal and fish cluster had elevated levels of C16:0 and C18:1 (Table D-1). Divisions within this cluster stemmed from the very high level of C18:1 isomers in fat, high levels of C18:0 in bison and deer meat and high levels of very long chain unsaturated fatty acids (VLCU) in fish. Differences in the fatty acid composition of plant roots, greens and berries/seeds/nuts reflect the amounts of C18:2 and C18:3ω3 present. The berry, seed, nut and small mammal meat samples appearing in cluster B have very high levels of C18:2, ranging from 35% to 64% (Table D-1). Samples in subclusters V, VI and VII have levels of C18:1 isomers from 29% to 51%, as well. Plant roots, plant greens and some berries appear in cluster C. All cluster C samples have moderately high levels of C18:2; except for the berries in subcluster XII, levels of C16:0 are also elevated. Higher levels of C18:3ω3 and/or very long chain saturated fatty acids (VLCS) are also common except in the roots which form subcluster XV.

Secondly, the effects of cooking and degradation over time on fatty acid compositions were examined. Originally, 19 modern residues of plants and animals from the plains, parkland and forests of Western Canada were prepared by cooking samples of meats, fish and plants, alone or combined, in replica vessels over an open fire (Malainey 1997; Malainey et al. 1999b). After four days at room temperature, the vessels were broken and a set of sherds analysed to determine changes after a short term of decomposition. A second set of sherds remained at room temperature for 80 days, then placed in an oven at 75°C for a period of 30 days in order to simulate the processes of long term decomposition. The relative percentages were calculated on the basis of the ten fatty acids (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11, C18:2) that regularly appeared in Precontact Period vessel residues from Western Canada. Observed changes in fatty acid composition of the experimental cooking residues enabled the development of a method for identifying the archeological residues (Table D-2).

It was determined that levels of medium chain fatty acids (C12:0, C14:0 and C15:0), C18:0 and C18:1 isomers in the sample could be used to distinguish degraded experimental cooking residues (Malainey 1997; Malainey et al. 1999b). Higher levels of medium chain fatty acids, combined with low levels of C18:0 and C18:1 isomers, were detected in the decomposed experimental residues of plants, such as roots, greens and most berries. High levels of C18:0 indicated the presence of large herbivores. Moderate levels of C18:1 isomers, with low levels of C18:0, indicated the presence of either fish or foods similar in composition to corn. High levels of C18:1 isomers with low levels of C18:0, were found in residues of beaver or foods of similar fatty acid composition. The criteria for identifying six types of residues were established experimentally; the seventh type, plant with large herbivore, was inferred (Table D-2). These criteria were applied to residues extracted from more than 200 pottery cooking vessels from 18 Western Canadian sites (Malainey 1997; Malainey et al. 1999c; 2001b). The identifications were found to be consistent with the evidence from faunal and tool assemblages for each site.

Work has continued to understand the decomposition patterns of various foods and food combinations (Malainey et al. 2000a, 2000b, 2000c, 2001a; Quigg et al. 2001). The collection of modern foods has expanded to include plants from the Southern Plains. The fatty acid compositions of mesquite beans (*Prosopis glandulosa*), Texas ebony seeds (*Pithecellobium ebano Berlandier*), tasajillo berry (*Opuntia leptocaulis*), prickly pear fruit and pads (*Opuntia engelmannii*), Spanish dagger pods (*Yucca treculeana*), cooked sotol (*Dasylirion wheeler*), agave (*Agave lechuguilla*), cholla (*Opuntia imbricata*), piñon (*Pinus edulis*) and Texas mountain laurel (or mescal) seed (*Sophora secundiflora*) have been determined. Experimental residues of many of these plants, alone or in combination with deer meat,

Table D-1. Summary of Average fatty Acid Compositions of Modern Food Groups Generated by Hierarchical Cluster Analysis.

Cluster	A				B						C				
Subcluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Type	Mammal Fat and Marrow	Large Herbivore Meat	Fish	Fish	Berries and Nuts	Mixed	Seeds and Berries	Roots	Seeds	Mixed	Greens	Berries	Roots	Greens	Roots
C16:0	19.9	19.39	16.07	14.1	3.75	12.06	7.48	19.98	7.52	10.33	18.71	3.47	22.68	24.19	18.71
C18:0	7.06	20.35	3.87	2.78	1.47	2.36	2.58	2.59	3.55	2.43	2.48	1.34	3.15	3.66	5.94
C18:1	56.77	35.79	18.28	31.96	51.14	35.29	29.12	6.55	10.02	15.62	5.03	14.95	12.12	4.05	3.34
C18:2	7.01	8.93	2.91	4.04	41.44	35.83	54.69	48.74	64.14	39.24	18.82	29.08	26.24	16.15	15.61
C18:3	0.68	2.61	4.39	3.83	1.05	3.66	1.51	7.24	5.49	19.77	35.08	39.75	9.64	17.88	3.42
VLCS	0.16	0.32	0.23	0.15	0.76	4.46	2.98	8.5	5.19	3.73	6.77	9.1	15.32	18.68	43.36
VLCU	0.77	4.29	39.92	24.11	0.25	2.7	1	2.23	0.99	2.65	1.13	0.95	2.06	0.72	1.1
VLCS- Very Long Chain (C20, C22 and C24) Saturated Fatty Acids															
VLCU - Very Long Chain (C20, C22 and C24) Unsaturated Fatty Acids															

Table D-2. Criteria for the Identification of Archaeological Residues Based on the Decomposition Patterns of Experimental Cooking Residues Prepared in Pottery Vessels.

Identification	Medium Chain	C18:0	C18:1 isomers
Large herbivore	≤ 15%	≥ 27.5%	≤ 15%
Large herbivore with plant OR Bone marrow	low	≥ 25%	15% ≤ X ≤ 25%
Plant with large herbivore	≥15%	≥ 25%	no data
Beaver	low	low	≥ 25%
Fish or Corn	low	≤ 25%	15% ≤ X ≤ 27.5%
Fish or Corn with Plant	≥ 15%	≤ 25%	15% ≤ X ≤ 27.5%
Plant (except corn)	≥ 10%	≤ 27.5%	≤ 15%

have been prepared by boiling foods in clay cylinders or using sandstone for either stone boiling (Quigg et al. 2000) or as a griddle. In order to accelerate the processes of oxidative degradation that naturally occur at a slow rate with the passage of time, the rock or clay tile containing the experimental residue was placed in an oven at 75°C. After either 30 or 68 days, residues were extracted and analysed using gas chromatography. The results of these decomposition studies enabled refinement of the identification criteria (Malainey 2007).

D.3 USING LIPID DISTRIBUTION AND BIOMARKERS TO IDENTIFY ARCHEOLOGICAL RESIDUES

Archeological scientists working in the United Kingdom have had tremendous success using high temperature-gas chromatography (HT-GC) and gas chromatography with mass spectrometry (HT-GC/MS) to identify biomarkers. High temperature gas chromatography is used to separate and assess a wide range of lipid components, including fatty acids, long chain alcohols and hydrocarbons, sterols, waxes, terpenoids and triacylglycerols (Evershed et al. 2001). The molecular structure of separated components is elucidated by mass spectrometry (Evershed 2000).

Triacylglycerols, diacylglycerols and sterols can be used to distinguish animal-derived residues, which contain cholesterol and significant levels of both triacylglycerols, from plant-derived residues, indicated by plant sterols, such as β-sitosterol, stigmasterol and campesterol, and only traces of triacylglycerols (Evershed 1993; Evershed et al. 1997a; Dudd and Evershed 1998). Barnard et al. (2007), however, have recently suggested that microorganisms living off residues can introduce β-sitosterol into residues resulting from the preparation of animal products. Waxes, which are long-chain fatty acids and long-chain alcohols that form protective coatings on skin, fur, feathers, leaves and fruit, also resist decay. Evershed et al. (1991) found epicuticular leaf waxes from plants of the genus Brassica in vessel residues from a Late Saxon/Medieval settlement. Cooking experiments later confirmed the utility of nonacosane, nonacosan-15-one and nonacosan-15-ol to indicate the preparation of leafy vegetables, such as turnip or cabbage (Charters et al. 1997). Reber et al. (2004) recently suggested n-dotriacontanol could serve as an effective biomarker for maize in vessel residues from sites located in Midwestern and Eastern North America. Beeswax can be identified by the presence and distribution of n-alkanes with carbon chains 23 to 33 atoms in length and palmitic acid wax esters with chains between 40 and 52 carbons in length (Heron et al. 1994; Evershed et al. 1997b).

Terpenoid compounds, or terpenes, are long chain alkenes that occur in the tars and pitches of higher plants. The use of GC and GC/MS to detect the diterpenoid, dehydroabietic acid, from conifer products in archeological residues extends over a span of 25 years (Shackley 1982; Heron and Pollard 1988). Lupeol, α- and β-amyrin and their derivatives indicate the presence of plant materials (Regert 2007). Eerkens (2002) used the predominance of the diterpenoid, Δ–8(9)-isopimaric acid, in a vessel residue from the western Great Basin to argue it contained piñyon resins. Other analytical techniques have also been used to identify terpenoid compounds. Sauter et al. (1987) detected the triterpenoid, betulin, in Iron Age tar using both 1H and 13C nuclear magnetic resonance spectroscopy (NMR), confirming the tar was produced from birch.

D.4 METHODOLOGY

Possible contaminants were removed by grinding off exterior surfaces of each sample with a Dremel® tool fitted with a silicon carbide bit. Immediately thereafter, it was crushed with a hammer mortar and pestle and the powder transferred to an Erlenmeyer flask. Lipids were extracted using a variation of the method developed by Folch et al. (1957). The powdered sample was mixed with a 2:1 mixture, by volume, of chloroform and methanol (2 × 25 mL) using ultrasonication (2 × 10 min). Solids were removed by filtering the solvent mixture into a separatory funnel. The lipid/solvent filtrate was washed with 13.3 mL of ultrapure water. Once separation into two phases was complete, the lower chloroform-lipid phase was transferred to a round-bottomed flask and the chloroform removed by rotary evaporation. Any remaining water was removed by evaporation with 2-propanol (1.5 mL); 1.5 mL of chloroform-methanol (2:1, v/v) was used to transfer the dry total lipid extract to a screw-top glass vial with a Teflon®-lined cap. The resulting total lipid extract was flushed with nitrogen and stored in a -20°C freezer.

D.4.1 Preparation of FAMES

A 400 µL aliquot of the total lipid extract solution was placed in a screw-top test tube and dried in a heating block under nitrogen. Fatty acid methyl esters (FAMES) were prepared by treating the dry lipid with 3 mL of 0.5 N anhydrous hydrochloric acid in methanol (68ºC; 60 min). Fatty acids that occur in the sample as di- or triglycerides are detached from the glycerol molecule and converted to methyl esters. After cooling to room temperature, 2.0 mL of ultrapure water was added. FAMES were recovered with petroleum ether (2 × 1.5 mL) and transferred to a vial. The solvent was removed by heat under a gentle stream of nitrogen; the FAMES were dissolved in 75 µL of iso-octane then transferred to a GC vial with a conical glass insert.

D.4.2 Preparation of TMS Derivatives

A 200 µL aliquot of the total lipid extract solution was placed in a screw-top vial and dried under nitrogen. Trimethylsilyl (TMS) derivatives were prepared by treating the lipid with 70 µL of N,O-bis (trimethylsilyl) trifluoroacetamide (BSTFA) containing 1percent trimethylchlorosilane, by volume (70ºC; 30 min). The sample was then dried under nitrogen and the TMS derivatives were redissolved in 100 µL of hexane.

Solvents and chemicals were checked for purity by running a sample blank. Traces of fatty acid contamination were subtracted from sample chromatograms. The relative percentage composition was calculated by dividing the integrated peak area of each fatty acid by the total area of fatty acids present in the sample.

In order to identify the residue on the basis of fatty acid composition, the relative percentage composition was determined first with respect to all fatty acids present in the sample (including very long chain fatty acids) and second with respect to the ten fatty acids utilized in the development of the identification criteria (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1w9, C18:1w11 and C18:2) (not shown). The second step is necessary for the application of the identification criteria presented in Table D-2. It must be understood that the identifications given do not necessarily mean that those particular foods were actually prepared because different foods of similar fatty acid composition and lipid content would produce similar residues (see Table D-3). It is possible only to say that the material of origin for the residue was similar in composition to the food(s) indicated. High temperature gas chromatography and high temperature gas chromatography with mass spectrometry is used to further clarify the identifications.

Table D-3. Known Food Sources for Different Types of Decomposed Residues.

Decomposed Residue Identification	Plant Foods Known to Produce Similar Residues	Animal Foods Known To Produce Similar Residues
Large herbivore	Tropical seed oils, including sotol seeds	Bison, deer, moose, fall-early winter fatty elk meat, Javelina meat
Large herbivore with plant OR Bone marrow		
Low Fat Content Plant (Plant greens, roots, berries)	Jicama tuber, buffalo gourd, yopan leaves, biscuit root, millet	Cooked Camel's milk
Medium-Low Fat Content Plant	Prickly pear, Spanish dagger	None
Medium Fat Content (Fish or Corn)	Corn, mesquite beans, cholla	Freshwater fish, Rabdotus snail, terrapin, late winter fat-depleted elk
Moderate-High Fat Content (Beaver)	Texas ebony	Beaver and probably raccoon or any other fat medium-sized mammals
High Fat Content	High fat nuts and seeds, including acorn and pecan	Rendered animal fat (other than large herbivore), including bear fat
Very High Fat Content	Very high fat nuts and seeds, including pine nuts	Freshly rendered animal fat (other than large herbivore)

D.4.3 Gas Chromatography Analysis Parameters

The GC analysis was performed on a Varian 3800 gas chromatograph fitted with a flame ionization detector connected to a personal computer. Samples were separated using a VF-23 fused silica capillary column (30 m × 0.25 mm I.D.; Varian; Palo Alto, CA). An autosampler injected a 3 µL sample using a split/splitless injection system. Hydrogen was used as the carrier gas with a column flow of 1.0 mL/min. Column temperature was increased from 80°C to 140°C at a rate of 20°C per minute then increased to 185°C at a rate of 4°C per minute. After a 4.0 minute hold, the temperature was further increased to 250°C at 10°C per minute and held for 2 minutes. Chromatogram peaks were integrated using Varian MS Workstation® software and identified through comparisons with external qualitative standards (NuCheck Prep; Elysian, MN).

D.4.4 High Temperature Gas Chromatography and Gas Chromatography with Mass Spectrometry

Both HT-GC and HT GC-MS analyses were performed on a Varian 3800 gas chromatograph fitted with a flame ionization detector and a Varian 4000 mass spectrometer connected to a personal computer. For HT-GC analysis, the sample was injected onto a DB-1HT fused silica capillary column (15 m × 0.32 mm I.D.; Agilent J&W; Santa Clara, CA) connected to the flame ionization detector, using hydrogen as the carrier gas. The column temperature was held at 50°C for 1 minute then increased to 350°C at a rate of 15°C per minute and held for 26 minutes. For HT-GC/MS analysis, samples were injected onto a DB-5HT fused silica capillary column (30 m × 0.25 mm I.D.; Agilent J&W; Santa Clara, CA) connected to the ion trap mass spectrometer in an external ionization configuration using helium as the carrier gas. After a 1 minute hold at 50°C, the column temperature was increased to 180°C at a rate of 40°C per minute then ramped up to 230°C at a rate of 5°C per minute and finally increased to 350°C at a rate of 15°C per minute and held for 27.75 minutes. The Varian 4000 mass spectrometer was operated in electron-impact ionization mode scanning from m/z 50-700. Chromatogram peaks and MS spectra were processed using Varian MS Workstation® software and identified through comparisons with external qualitative standards (Sigma Aldrich; St. Louis, MO and NuCheck Prep; Elysian, MN), reference samples and the National Institute of Standards and Technology (NIST) database.

D.5 RESULTS OF ARCHEOLOGICAL DATA ANALYSIS

Descriptions of the samples from which lipids were extracted are presented in Table D-4. The fatty acid compositions of residues extracted from 11 samples are presented in Table D-5. The term, Area, represents the area under the chromatographic peak of a given fatty acid, as calculated by the Varian MS Workstation® software minus the solvent blank. The term, Rel%, represents the relative percentage of the fatty acid with respect to the total fatty acids in the sample. Hydroxide or peroxide degradation products can interfere with the integration of the C22:0 and C22:1 peaks; these fatty acids were excluded from the analysis. Nine of the twenty samples contained insufficient fatty acids to enable identification but lipid biomarkers and/or triacylglycerols were detected (Table D-6).

The presence of lipid biomarkers and distributions of triacylglycerols (TAGs) were determined using HT-GC and HT-GC/MS. The data obtained is useful for distinguishing plant residues, animal residues and plant/animal combinations. The sterol cholesterol is associated with animal products; β-sitosterol and stigmasterol are associated with plant products. The presence and abundance of TAGs varies with the material of origin. If present, amounts of TAGs in plant residues tend to decrease with increasing numbers of carbon atoms (Malainey et al. 2010).

The peak arising from the C48 TAG is largest and peak size (and area) progressively decreases with the C54 TAG being the smallest. A line drawn to connect the tops of the C48, C50, C52 and C54 TAG peaks slopes down to the right. In animal residues, amounts of TAGs tend to increase with carbon numbers, with the C52 or C54 TAG being the largest (Malainey et al. 2010). A line drawn to connect the tops of the C48, C50, C52 and C54 TAG peaks appears as a hill or the line slopes up to the right. A parabola-like pattern, such as the shape of a "normal distribution," can also occur in the residues of oil seeds that contain high levels of C18:1 isomers.

D.5.1 Borderline Moderate-high and High Fat Content Residues

The level of C18:1 isomers in residue 15-4b (12MQ 3) is 38.08%, which falls on the border between moderate-high and high fat content. Foods known to produce moderate-high fat residues include Texas ebony seeds and the fatty meat of medium-sized mammals, such as beaver. The decomposed residues of foods of high fat content seeds or nuts, such as piñon, and the rendered fats of certain mammals (other than large herbivores) are high fat content. Residue 15-4b (12MQ 3) has an elevated level of C18:2, suggesting the occurrence of plants but there is evidence of both plant and animal products. The animal sterol cholesterol and the plant sterol β-sitosterol were detected and both the C50 TAG peak and the C48 TAG peak are very large. The ratio of C48, C50, C52 and C54 TAG peaks is 5.9: 6.9: 4.0: 1.0. Dehydroabietic acid was also detected; this biomarker indicates the presence of conifer products, which may have been introduced from firewood, resins or other conifer products.

D.5.2 Medium Fat Content Residues

Two residues, 61-2b (12MQ 6) and 41-1b (12MQ 13), appear to result from the preparation of medium fat content plant and/or animal foods. Examples of medium fat content plant foods include mesquite, corn and cholla. Freshwater fish, terrapin, Rabdotus snail and late winter, fat-depleted elk are examples of medium fat content animal foods. The plant sterol β-sitosterol and the animal sterol cholesterol occurs in both residues; the plant sterol stigmasterol may be present in residue 61-2b (12MQ 6). The conifer biomarker dehydroabietic acid was found in residue 41-1b (12MQ 13). The distributions of TAG peaks indicates these residues were primarily derived from plant products because they both feature a large C48 TAG peak and progressively smaller C50 and C52 TAG peaks; the C54 TAG peak could not be detected.

Table D-4. List of Burned Rock Samples from Site 41MI96.

Lab No.	TU No.	Level No.	Feature No.	Burned Rock No.	PNUM	Mass (g)
12MQ 1	1	4	4	2	15-1b	27.594
12MQ 2	1	4	4	3	15-2b	33.814
12MQ 3	1	4	4	6	15-4b	29.974
12MQ 4	1	4	4	8	15-5b	31.072
12MQ 5	13	2	2	1	61-1b	33.203
12MQ 6	13	2	2	2	61-2b	33.756
12MQ 7	13	2	2	3	61-3b	14.785
12MQ 8	13	2	2	4	61-4b	33.54
12MQ 9	13	2	3	5	62-5b	30.143
12MQ 10	15	2	3	1	69-1b	34.801
12MQ 11	15	2	3	2	69-2b	32.85
12MQ 12	15	2	3	3	69-3b	24.324
12MQ 13	7	2	5	1	41-1b	28.163
12MQ 14	7	2	5	3	41-3b	29.356
12MQ 15	7	2	5	4	41-4b	33.995
12MQ 16	7	2	5	6	41-6b	29.625
12MQ 17	9	3	7	1	49-1b	31.486
12MQ 18	9	3	7	2	49-2b	34.849
12MQ 19	9	3	7	3	49-3b	34.454
12MQ 20	9	3	7	5	49-4b	31.652

Table D-5. Lipid Composition of Burned Rock Residues.

Fatty acid	12MQ 3		12MQ 5		12MQ 6		12MQ 7	
	Area	Rel%	Area	Rel%	Area	Rel%	Area	Rel%
C12:0	3924	1.33	5030	1.67	2109	0.74	10924	2.27
C14:0	9843	3.34	10379	3.45	9884	3.47	20001	4.15
C14:1	0	0.00	0	0.00	0	0.00	0	0.00
C15:0	3155	1.07	9798	3.26	4592	1.61	9832	2.04
C16:0	110371	37.43	190817	63.48	171934	60.39	242289	50.24
C16:1	14884	5.05	2248	0.75	4690	1.65	5958	1.24
C17:0	3127	1.06	6308	2.10	7422	2.61	10438	2.16
C17:1	8719	2.96	0	0.00	0	0.00	0	0.00
C18:0	11797	4.00	22894	7.62	27666	9.72	52577	10.90
C18:1s	112278	38.08	41347	13.76	43601	15.32	59034	12.24
C18:2	15522	5.26	4628	1.54	5890	2.07	6877	1.43
C18:3ω3	0	0.00	4242	1.41	0	0.00	10820	2.24
C20:0	1255	0.43	2899	0.96	4261	1.50	4303	0.89
C20:1	0	0.00	0	0.00	2646	0.93	46887	9.72
C24:0	0	0.00	0	0.00	0	0.00	2276	0.47
Total	294876	100.00	300591	100.00	284696	100.00	482217	100.00
Biomarkers	Cholesterol; β-sitosterol; Dehydroabietic acid		β-sitosterol; Cholesterol; possibly Stigmasterol; Dehydroabietic acid		β-sitosterol; Cholesterol; possibly Stigmasterol		β-sitosterol; Cholesterol; possibly Stigmasterol	
TAG Distribution	5.9: 6.9: 4.0: 1.0 Animal and Plant Combination		136: 25: 4.3: 1.0 Plant distribution		C48 TAG peak largest; C54 TAG absent Plant distribution		355: 64: 8.2: 1.0 Plant Distribution	
Identification	Borderline Moderate-High and High fat content; Animal and Plant combination Conifer products present		Medium Low fat content; Plant with traces of animal products; Conifer products present		Medium fat content; Plant with traces of animal products		Medium low fat content; Plant with traces of animal products	
PNUM	15-4b		61-1b		61-2b		61-3b	

Table D-5. Lipid Composition of Burned Rock Residues. (cont.)

Fatty acid	12MQ 9		12MQ 10		12MQ 13		12MQ 15	
	Area	Rel%	Area	Rel%	Area	Rel%	Area	Rel%
C12:0	8919	3.61	6569	1.67	10899	2.41	12398	5.84
C14:0	30479	12.34	9366	2.38	22356	4.95	19759	9.31
C14:1	0	0.00	0	0.00	0	0.00	0	0.00
C15:0	4078	1.65	5362	1.36	3641	0.81	3493	1.65
C16:0	147310	59.65	126751	32.21	239452	52.99	108270	51.01
C16:1	0	0.00	0	0.00	2153	0.48	0	0.00
C17:0	6093	2.47	5988	1.52	3583	0.79	3393	1.60
C17:1	0	0.00	0	0.00	0	0.00	0	0.00
C18:0	31212	12.64	190447	48.40	76746	16.98	50537	23.81
C18:1s	9843	3.99	38544	9.80	73469	16.26	8675	4.09
C18:2	0	0.00	2693	0.68	6378	1.41	0	0.00
C18:3ω3	4481	1.81	2875	0.73	4550	1.01	3018	1.42
C20:0	4535	1.84	4874	1.24	2454	0.54	2698	1.27
C20:1	0	0.00	0	0.00	6216	1.38	0	0.00
C24:0	0	0.00	0	0.00	0	0.00	0	0.00
Total	246951	100.0 0	393470	100.00	451898	100.00	212242	100.00
Biomarkers	β-sitosterol; Cholesterol		β-sitosterol; Cholesterol		β-sitosterol; Cholesterol; Dehydroabietic acid		β-sitosterol; Cholesterol; Azelaic acid; possibly Dehydroabietic acid	
TAGs	C48 TAG peak much larger than C50 TAG Distribution more similar to a plant pattern		C48 TAGs present Distribution more similar to a plant pattern		C48 TAG peak largest; C54 TAG absent Plant distribution		C48 TAGs present Distribution more similar to a plant pattern	
Identification	Low Fat Content Plant with traces of animal products		High 18:0 level; Large herbivore, Javelina or Tropical plant seed; Plant and animal products present; Plant products may dominate		Medium fat content; Plant and Animal products present; Plant products may dominate; Conifer products present		Low fat content plant and elevated C18:0 level; Plant and Animal products present; Plant products may dominate; Conifer products may be present	
PNUM	62-5b		69-1b		41-1b		41-4b	

Table D-5. Lipid Composition of Burned Rock Residues. (cont.)

Fatty acid	12MQ 17			12MQ 19			12MQ 20	
	Area	Rel%	Recalc Rel %	Area	Rel%	Recalc Rel%	Area	Rel%
C12:0	0	0.00	0.00	2477	1.29	1.40	10226	1.90
C14:0	3774	1.46	1.54	8014	4.18	4.54	24734	4.59
C14:1	0	0.00	0.00	0	0.00	0.00	0	0.00
C15:0	0	0.00	0.00	3797	1.98	2.15	5628	1.04
C16:0	134305	52.09	54.76	116210	60.63	65.77	302718	56.18
C16:1	4787	1.86	1.95	2538	1.32	1.44	0	0.00
C17:0	2581	1.00	1.05	4460	2.33	2.52	5754	1.07
C17:1	0	0.00	0.00	0	0.00	0.00	0	0.00
C18:0	15519	6.02	6.33	20534	10.71	11.62	79040	14.67
C18:1s	71776	27.84	29.27	13974	7.29	7.91	77635	14.41
C18:2	11321	4.39	4.62	2794	1.46	1.58	8090	1.50
C18:3ω3	12597	4.89	0.00	14965	7.81	0.00	13014	2.42
C20:0	1195	0.46	0.49	1904	0.99	1.08	3883	0.72
C20:1	0	0.00	0.00	0	0.00	0.00	5748	1.07
C24:0	0	0.00	0.00	0	0.00	0.00	2391	0.44
Total	257856	100.00	100.00	191668	100.00	100.00	538862	100.00
Biomarkers	β-sitosterol; Cholesterol; possibly Stigmasterol; Azelaic acid			β-sitosterol; Cholesterol; Azelaic acid; possibly Dehydroabietic acid			β-sitosterol; Cholesterol	
TAGs	21: 12: 5.1: 1.0 Plant distribution			C48 TAG peak largest; C54 TAG absent Plant distribution			C48 TAG peak largest; C54 TAG absent Plant distribution	
Identification	Borderline Medium and Moderate High fat content; Plant seed with traces of animal products			Possible decomposed plant seed residue with traces of animal products; Conifer products may be present			Medium Low fat content; Plant and animal products present; Plant products may dominate	
PNUM	49-1b			49-3b			49-4b	

D.5.3 Medium-Low Fat Content Residues

Residues 61-1b (12MQ 5), 61-3b (12MQ 7) and 49-4b (12MQ 20) have C18:1 isomer levels below 15% but they are still somewhat elevated. Foods known to produce these medium-low fat content residues include prickly pear and Spanish dagger. The plant sterol β-sitosterol, the animal sterol cholesterol and possibly the plant sterol stigmasterol occur in residues 61-1b (12MQ 5) and 61-3b (12MQ 7). Only β-sitosterol and cholesterol were detected in residue 49-4b (12MQ 20). The distributions of TAGs in all three residues indicate they are dominated by plant products. The ratios of C48, C50, C52 and C54 TAG peaks in residues 61-1b (12MQ 5) and 61-3b (12MQ 7) are 136: 25: 4.3: 1.0 and 355: 64: 8.2: 1.0, respectively. Residue 49-4b (12MQ 20) has a large C48 TAG peak and progressively smaller C50 and C52 TAG peaks; the C54 TAG peak could not be detected. Only small amounts of animal products likely occur in residues 61-1b (12MQ 5) and 61-3b (12MQ 7) but the elevated level of 18:0 in residue 49-4b (12MQ 20) suggests proportionately more animal products contributed to this residue.

D.5.4 Low Fat Content Residues

The level of medium chain saturated fatty acids (the sum of C12:0, C14:0 and C15:0) in residue 62-5b (12MQ 9) is high, 17.61%. Levels of medium chain saturated fatty acids greater than 10% are associated with the decomposed cooking residues of plant roots, greens and most berries. Both the plant sterol β-sitosterol and the animal sterol cholesterol occur but the distribution of TAGs suggests the residue was dominated by plant products because the C48 TAG peak was much larger than the C50 TAG peak and the C52 and C54 TAG peaks were not detected.

D.5.5 Residues with High Levels of C18:0

Residue 69-1b (12MQ 10) is characterized by C18:0 levels of 48.40%. High levels of C18:0 are typical of the residues of large herbivores, such as deer, bison and moose, but javelina meat and the seed oils of certain tropical plants, such as sotol, produce similar residues. The level of C18:1 isomers, or fat content of this residue, is quite low, less than 10%. Both the plant sterol β-sitosterol and the animal sterol cholesterol occur, however, only the C48 TAG peak was detected, so the residue is likely dominated by plant products.

D.5.6 Residues Representing Other Possible Plant and Animal Combinations

Residue 41-4b (12MQ 15) has a C18:0 level of 23.81% and the level of medium chain saturated fatty acids is 16.80%. Elevated levels of C18:0 are associated with the presence of animal products or tropical oil seeds and elevated levels of medium chain saturated fatty acids are associated with the decomposed cooking residues of plant roots, greens and most berries. This residue appears to represent a low fat plant and animal/tropical oil seed combination. Both the plant sterol β-sitosterol and the animal sterol cholesterol were detected. Azelaic acid also occurs in residue 41-4b (12MQ 15); this short chain dicarboxylic acid is associated with the oxidation of unsaturated fatty acids (Regert et al. 1998). Unsaturated fatty acids are most abundant in seed oils so it is possible that these residues in part reflect the processing of plant seeds. The level of C18:1 isomers is low, only 4.09%, so either the seeds had a very low fat content or the seed processing component of the residue has degraded. Dehydroabietic acid may occur, indicating the possible presence of conifer products.

D.5.7 Residues with Insufficient Fatty Acids

Nine residues had insufficient fatty acids to attempt identification (Table D-6) but two, residues 41-6b (12MQ 16) and 41-2b (12MQ 18) may be contaminated with modern lipids and are discussed in the next section. There is evidence of both plant and animal products in residues 15-1b (12MQ 1), 15-2b (12MQ 2), 15-5b (12MQ 4), 61-4b (12MQ 8), 69-2b (12MQ 11), 69-3b (12MQ 12) and 41-3b (12MQ 14). The plant sterol β-sitosterol and the animal sterol cholesterol were detected in all extracted residues. Azalaic acid, which may indicate plant seed processing, occurs in residue 15-1b (12MQ 1). The conifer biomarker dehydroabietic acid occurs or may occur in all residues, except residue 69-3b (12MQ 12). The C48 TAG peak was much larger than the C50 TAG peak in residue 41-3b (12MQ 14) and only the C48 TAG was present in residues 15-1b (12MQ 1) and 15-5b (12MQ 4). These TAG distributions suggest that all three of these residues primarily consisted of plant products. No TAGs were detected in the other four residues.

D.5.8 Residues with Contamination from Modern Lipids

Levels of the fatty acid C18:3ω3 in four residues, 41-6b (12MQ 16), 49-1b (12MQ 17), 49-2b (12MQ 18) and 49-3b (12MQ 19), were close to or exceeded 5%. This is cause for concern because this polyunsaturated fatty acid is unlikely to survive in an archeological context and is probably evidence of contamination. The relative fatty acid compositions of 49-1b (12MQ 17) and 49-3b (12MQ 19) were calculated with all fatty acids and again without C18:3ω3 (Table D-5). The inclusion or exclusion of C18:3ω3 did not greatly alter the residue characterizations. The level of C18:1 isomers in residue 49-1b (12MQ 17) falls on the border between medium fat content and moderate-high fat content foods (described above). The presence of the plant sterol β-sitosterol was confirmed and stigmasterol may occur as well. The animal sterol cholesterol was also detected. Azelaic acid, which may indicate the residue was derived from plant seeds, was also present. The ratio of C48, C50, C52 and C54 TAG peaks was 21: 12: 5.1 and 1.0, which similar to that of a plant distribution. This residue appears to largely result from the preparation of plant seeds, but traces of animal products occur.

Residue 49-3b (12MQ 19) is very similar to residue 49-1b (12MQ 17), except that it is more highly decomposed. The relatively lower levels of mono-unsaturated C18:1 isomers in this residue results in relatively higher levels of saturated fatty acids, such as C14:0, C16:0 and C18:0. The presence of β-sitosterol, cholesterol and azelaic acid was confirmed. Dehydroabietic acid, the biomarker for conifer products, may occur as well. The ratio of TAG peaks was similar to that of a plant distribution with a large C48 TAG peak and progressively smaller C50 and C52 TAG peaks; the C54 TAG peak could not be detected. Residue 49-3b (12MQ 19) likely represents a highly degraded residue resulting from the preparation of plant seeds with traces of animal products.

The two other residues, 41-6b (12MQ 16) and 49-2b (12MQ 18), contained insufficient fatty acids to attempt identification. The plant sterol β-sitosterol and the animal sterol cholesterol were detected in both residues. Stigmasterol may occur in residue 49-2b (12MQ 18) and the C48 TAG was present, which suggests the residue was derived from both plants and animals, but plant products were likely dominant. The biomarker dehydroabietic acid may occur in residue 41-6b (12MQ 16) but no TAGs were detected. Residue 41-6b (12MQ 16) contains traces of both plant and animal products and conifer products may occur as well.

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APPENDIX E

TXDOT CHIPPED STONE PROTOCOL VERSION 2.1

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Chipped Stone Analytical Protocol

TxDOT Archeological Studies Program

This protocol specifies the observations to be made with respect to chipped-stone artifacts during fieldwork and analysis. It is TxDOT's position that data should be collected with problem-oriented research in mind, but that is not to say that it needs to be used in the context of the study that it is collected in - just that it needs to be systematically reported so that future researchers have access to the data for the purposes of developing innovative research designs. The specific observations included within this protocol have been selected because they have proven valuable for addressing important questions of prehistory, and because they can be feasibly accomplished in most laboratory settings within a reasonable time frame. The implementation of this protocol will not undermine the collection of additional data so long as the need for additional data can be justified with respect to specific research needs. We recognize that reasonable disagreement is possible with respect to those choices.

The following discussion of procedures is designed as a guide for using the data coding key that is part of the TxDOT chipped stone protocol. Data coding is important to the process of recording standardized observations within the proposed state-wide database that will facilitate inter-site comparisons and allow researchers to more readily address regional-scale research questions. It is TxDOT's intent that this protocol be used when analyzing any form of chipped stone tool or core. This portion of the protocol does not address the analysis of groundstone tools or chipped stone non-tools (e.g. symbolic forms).

I. 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. 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.

1. Technology

Technology, as used here, relates to the suite of techniques used to produce a lithic implement. The primary distinction at this level is between (1) chipped-stone, and (2) groundstone, although minor categories may be considered. This will be used to separate lithic artifacts at the broadest analytical level. TxDOT anticipates the development of a groundstone protocol in 2009.

2. Group

At the next lower taxonomic level, lithic objects classified as chipped stone (non-debitage) may be separated into two distinct groups. The first group is *Tools*, and includes objects that represent or were intended for (in the case of performs) direct functionality. The second group is *Non-tools*, representing objects of indirect functionality (ex. cores), or objects of an instructional, symbolic or artistic nature (ex. Early Archaic multi-notched lithics). For the purposes of this protocol, only those artifacts grouped as chipped-stone tools are considered.

3. Subgroup

Tool subgroup identifies the primary technique of manufacture. Chipped-stone tools are classified into one of three subgroups: (1) simple detachment-based; (2) complex detachment-based; and (3) core-based. Detachment-based tools are derivative of larger cores. Simple detachment-based tools are classified as either blades or flakes, and are used with modest to no modification following detachment. Complex detachment-based tools undergo substantial modification prior to use. Such tools most commonly originate as macro-flakes or macro-blades detached from a sizable core. The form is then reduced through bifacial or unifacial percussion and, unlike simple detachment-based tools, proceeds through several identifiable reduction stages prior to use. Core-based tools are constructed from material cores (most often in the form of tabular or nodular cobbles) rather than detachments. Such tools are reduced through bifacial or unifacial percussion and proceed through several identifiable reduction stages prior to use. Differentiating between core-based and complex detachment-based tools may not be possible. Complex detachment-based tools can often only be distinguished from core-based tools when they retain characteristics of their origin. These may include a remnant bulb of percussion, striking platform, or (more typically) identifiable ventral surface.

4. 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.

5. 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.

6. 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.

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.).

7. Subtype / Identity

The identity of a tool form (its subtype) corresponds to how it is commonly identified within the classical typological system. Thus, a projectile may be identified as Angostura, Bell, Clovis, Dalton, Ensor, etc. For tools classified as flakes and blades, the appropriate identity will most often be "not applicable" (an exception would be a Clovis blade).

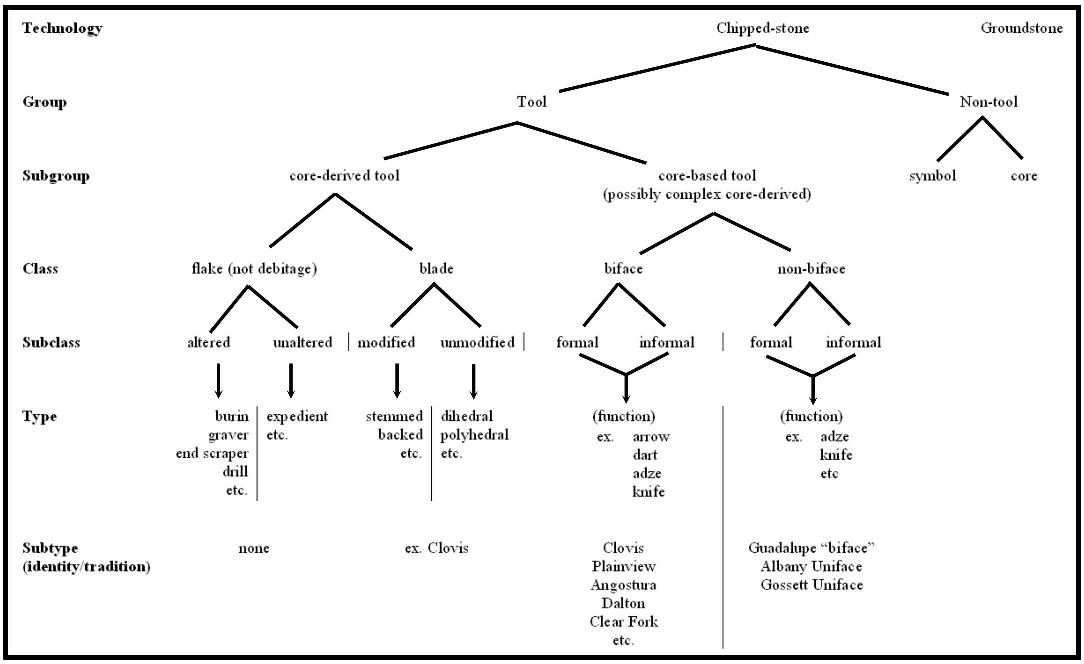


Figure 1: Artifact taxonomy for chipped stone tools based on technological attributes and reduction characteristics.

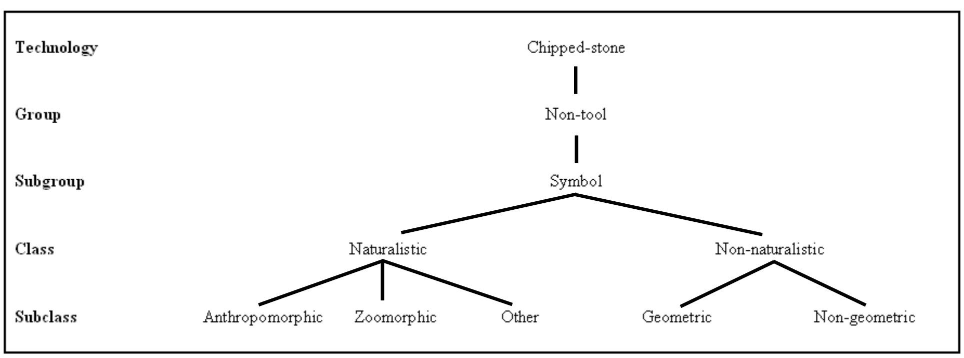


Figure 2: Artifact taxonomy for chipped stone objets with primarily non-utilitarian, symbolic purpose.

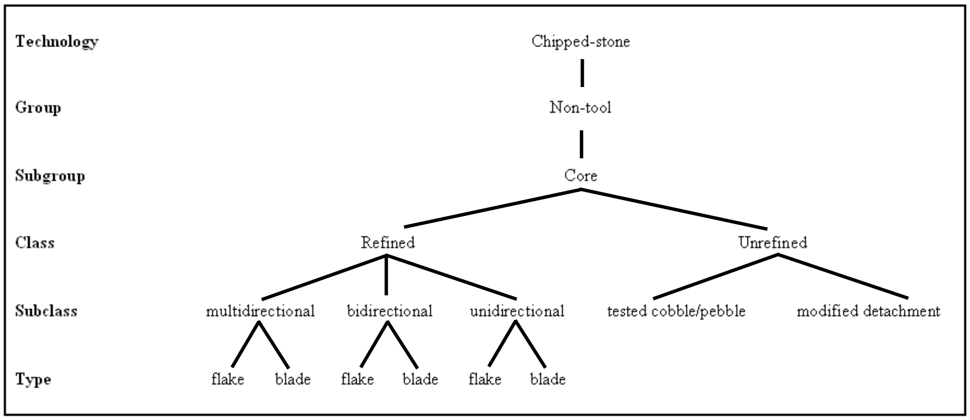


Figure 3: Taxonomy for chipped stone cores. These are not tools, but rather the objective piece from which tool forms are extracted.

II. Metric Information

8. Max length

Record the maximum observed length of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

9. Max width

Record the maximum observed width of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

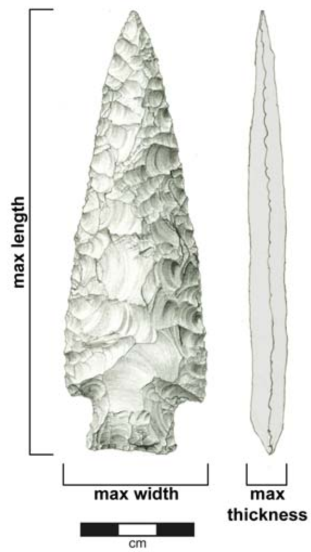


Figure 4: Metric measurements recorded directly from tool.

10. Max thickness

Record the maximum observed thickness of the tool form to the nearest whole millimeter. Do not project or estimate unrepresented portions of the tool form. Using calipers, take this measurement directly from the tool.

11. Weight

Record the weight of the tool to the nearest whole gram.

12. Edge angle

The edge angle of the tool should be recorded as an average measure along the used margin of the form. This should be recorded to the nearest 5° interval. Measurements should be made using a goniometer and recorded directly from the tool. Some extrapolation is acceptable where the edge has been blunted from use and the original angle can be determined.

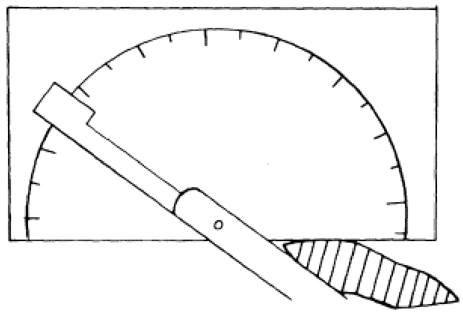


Figure 5: Edge angle can be recorded with the use of a goniometer. As the exact angle may vary across the length of the use edge, it is sufficient to record edge angle to the nearest 5° increment.

III. Attributes

13. Stage

Linear reduction models assist in determining the stage of manufacture an artifact reached within an idealized trajectory. Linear reduction models provide a framework for understanding the functional and behavioral relationships among related sets of artifacts (Collins 1975; Goode 2002; Patterson 1977, Shafer 1983, 1985; Sollberger 1977; Tsirk 1979), and are typically based on theoretical abstractions or on experimental replication (Crabtree 1966). Classifying tools in accordance with a linear reduction scheme allows for a more precise study of manufacturing concerns, and it provides a conceptual model for determining the degree of morphologic variation that finished trajectories may be expected to exhibit. When assessing trait or design variability, it will be most productive to compare finished tool forms that have not been extensively remodeled through recycling efforts. The criteria for determining stage of manufacture used in this work closely follow that of Black et al. (1997).

Five stages in the life cycle trajectory of tools are recognized in this protocol: (1) initial package reduction, (2) blank preparation, (3) preform shaping and thinning, (4) final edge trimming and sharpening, and (5) rejuvenated forms. Assessing manufacturing stage is not a wholly objective enterprise (Goode 2002). Lithic reduction is a linear process, and its separation into discrete units of activity is necessarily subjective. Also, the fragmentary nature of some artifacts, the retention of trace amounts of surface cortex on finished forms, and variability in production patterns due to raw material variability and individual skill all contribute to the occasional difficulty in assigning production stage. However, observing this process in stepwise fashion provides a useful proxy measure for detecting potentially important variations in the organization of lithic resource exploitation.

The first stage of the linear reduction model, *initial package reduction*, reflects the beginning steps of tool manufacture and includes preliminary reduction efforts such as cortex removal, mass thinning, and initial shaping. At this stage, objective pieces typically retain some cortex on one or both faces and reduction is dominated by hard-hammer percussion. Tool forms in their initial production stage are generally irregular in outline, exhibit unrefined edges, and do not provide an indication of the intended manufacturing trajectory. However, tools may be employed as crude "choppers" even at this early stage (Goode 2002: 36). Most expedient tool forms will be assigned to this reduction stage.

The second category, *blank preparation*, is characterized by the production of a less generalized form with a limited set of possible final trajectories. Tool forms in this stage of manufacture, called "blanks" (Crabtree 1972), typically exhibit little if any cortex, although completed tools may exhibit traces of cortex on occasion. As blanks, tools receive further reduction of mass through thinning, which is accomplished with some hard-hammer, but primarily soft-hammer percussion. Blanks require refinement of lateral margins, which may appear sinuous on bifacial forms. Incipient stems may be initially observed at this stage.

The third category, *preform shaping and thinning*, is characterized by the artisan's full commitment toward a single or very limited number of morphological forms, producing what is commonly called a "preform" (Crabtree 1972b). Preforms exhibit a significant reduction in thickness when compared to blanks, and soft-hammers are used almost exclusively for purposes of reduction. Cortex is rare on these late stage forms. Artifacts categorized as performs approximate their final design and generally lack only refinement of lateral edges and minor facial thinning. Edges are nearly straight and exhibit minor sinuosity. This is the final stage of production to use direct percussion.

The fourth category, *final edge trimming and sharpening*, includes artifacts that are very near or have reached the end stage of their manufacture. Tools within their final production stage require minor reduction along their margins, which is accomplished exclusively through pressure flaking and indirect percussion. Notching, edge grinding, and final stem preparation are completed at this stage. Artifacts having reached their end stage presumably represent tools that were discarded (often due to breakage), cached, lost, or otherwise abandoned. Finished forms require no additional production efforts, and commonly exhibit use-related edge modification (use-wear). Edges have not been remodeled through refurbishing efforts.

The final category, *rejuvenated forms*, describes artifacts that exhibit pronounced edge retouch or remodeling, a marked reduction in size, or evidence of adaptation to a secondary production trajectory in response to failure or discontinuation of the initial tool form. Tool rejuvenation and other forms of recycling provide important information regarding the perceived value of the resource.

00.	[Indeterminate]	03.	[Preform]
01.	[Initial Reduction]	04.	[Final Stage]
02.	[Blank]	05.	[Rejuvinated]

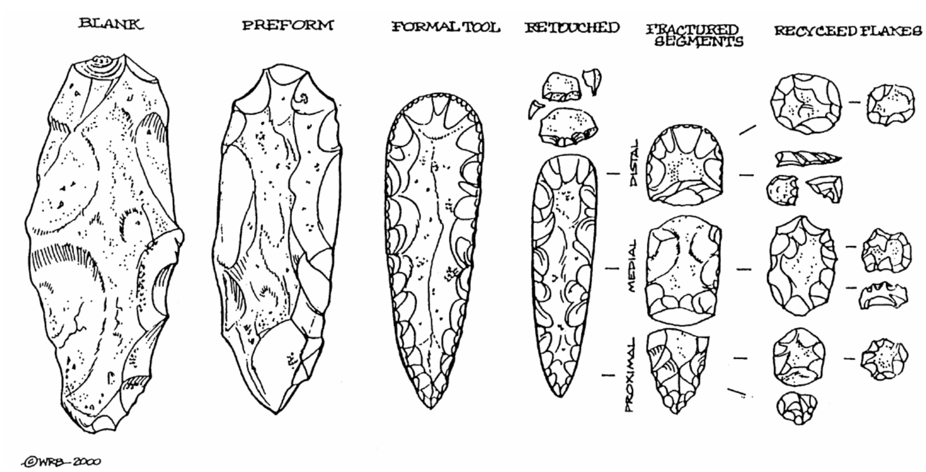
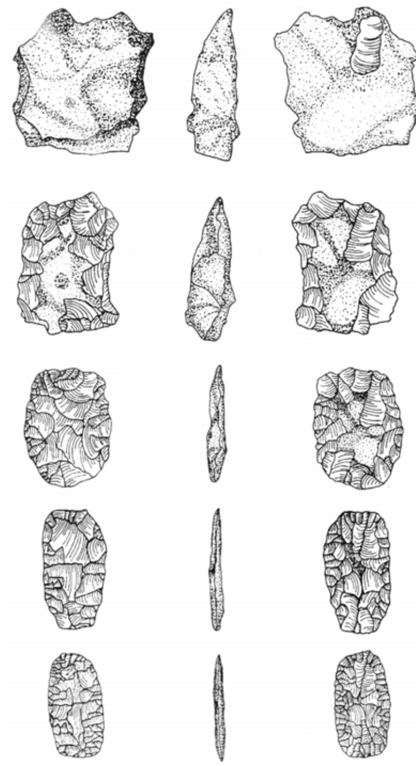


Figure 6: In the illustration above, "retouched" and "fractured segments" are generally represented by Stage 5 (rejuvenated forms) in the TxDOT Chipped Stone Analytical protocol. However, it should be noted that "fractured segments" will often be identified as belonging to a perform of finished tool, and should be categorized appropriately. The final category, "recycled flakes," would be difficult to identify as deriving from an original formal tool in most instances, and many objects of this character would be included in the lithic assemblage as debitage. Such objects should only be identified as rejuvenated forms when the analyst is certain that a precursor form existed.

Figure 7: In the reduction sequence to the right, "stage one: blank" and "stage two: edged biface" each would be classified under Stage 2 (blank preparation) of the TxDOT Chipped Stone Analytical protocol. Similarly, "stage three: thinned biface" and "stage four: perform" would be classified as Stage 3 (perform shaping and thinning) under the TxDOT Chipped Stone Analytical protocol. The "stage five" shown here relates to Stage 4 of the TxDOT protocol.



14. Portion

A significant number of tools are recovered in a fragmentary state and it is important to record the portion represented. Identify partial forms as "fragments" when too little of the tool remains to determine what part of the tool is represented. As it is occasionally difficult to determine whether a piece corresponded to a proximal or distal segment, even when it was clear that one or the other is represented, an "indeterminate" category has been included.

00.	[Indeterminate]	06.	[Proximal]
01.	[Complete]	07.	[Lateral edges missing]
02.	[Distal]	08.	[Fragment]
03.	[Distal-medial]	09.	[Barb / shoulder]
04.	[Medial]	10.	[Ear / tang]
05.	[Proximal-medial]	11.	[Stem]

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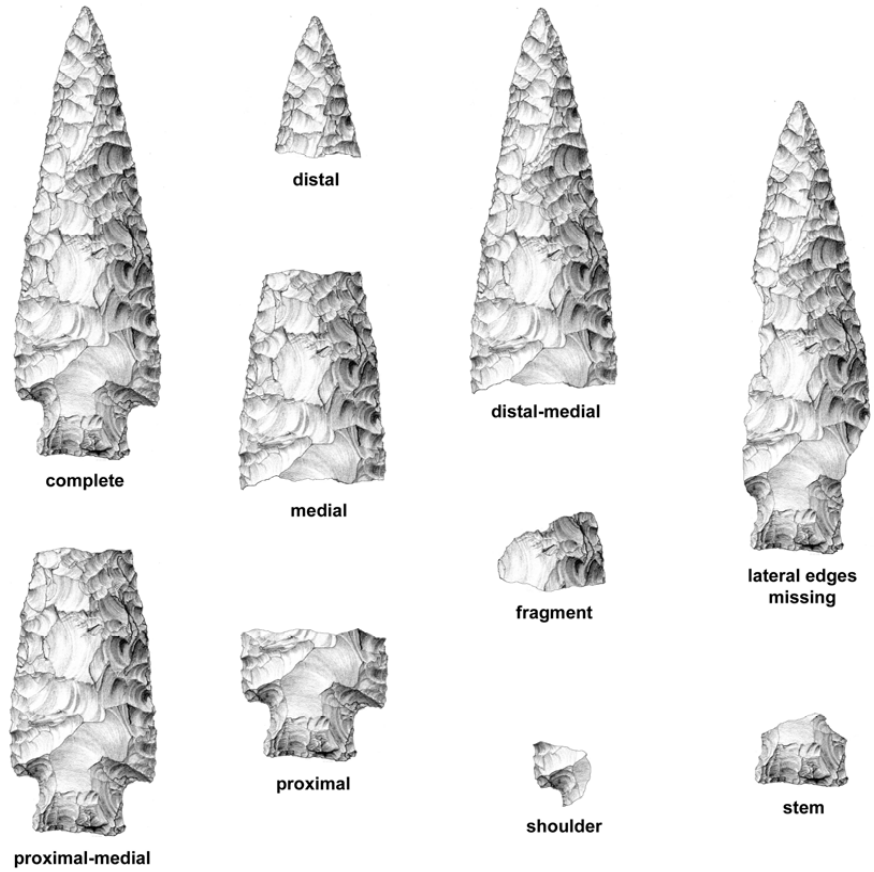


Figure 8: Chipped stone tools are more often discovered in a broken state. Recording the portion of the tool that was recovered is necessary for adding context to metric measurements.

15. Failure / Discard

Determining the reason why a particular tool form was discarded is seldom a straightforward endeavor. Oftentimes such a determination cannot be made at all. However, where a cause of discard can be determined, valuable insights regarding production specialization and standardization, raw material conservation, use context, and cultural ideology may be gleaned.

The context of tool discard can be identified as production-related, use-related, and incidental. Production-related discard occurs when tools are discarded during manufacture as the result of technical mistakes or material deficiencies. Use-related discard can result from stress or impact fractures, excessive dulling, material exhaustion, use-loss, or caching. Tool forms may also be lost unintentionally. Each mode of discard will have distinct implications for the likelihood of artifact recovery.

Several factors are also known to complicate determinations of discard cause. Secondary tool modification and material recycling may complicate determinations of failure, as can patina development. Excessive thermal alteration can also present an obstacle for assessing the probable cause of original discard as it is often difficult to determine the point at which the object was altered. Artifacts can be subjected to excessive heat following their discard, as when affected by modern or ancient surface fires. The over-firing of raw material blanks or preforms may also have contributed to fire-damage.

Production-related Discard

Several authors have previously described snap or bending fractures (Crabtree 1972:60; Whittaker 1994:213; and Tsirk 1979:84). This fracture results when the lithic material is subjected to bending forces that exceed the material's elastic limits. Snap fractures often occur during tool production due to the knapper's failure to provide the objective piece with adequate support as it is reduced. In so doing, vibrations radiate throughout the tool form with each percussive strike, causing a fracture at the point where the elasticity of the material can no longer absorb the vibrations (Whittaker 1994: 213). Bending fractures can also occur quite commonly as the result of tool use. Use derived bending fractures manifest as lateral truncations that often display a rolled or lipped edge along one side of the termination (Shafer 1985: 283). When a rolled lip is observed, it often indicates that the tool was subjected to excessive torque during use. Snap fractures may also derive from material flaws, such as cavities or crystalline inclusions, which cause disharmony in the radiation of percussion waves through the material, or simply produce areas of weak structural integrity (see discussion of material flaws below). Step and hinge fractures present analogous difficulties for tool production or recycling, and while morphologically distinct, they are formed through similar circumstances. They are treated as a single category of failure in this protocol. A step fracture happens when the outward force is too great causing the flake to bend to the point of breaking. This is typically caused by hitting the core with a motion that is too fast which pulls the flake way faster than the propagation through the core; thus causing the snap to occur (Crabtree 1972: 92; Whittaker 1994: 109). Step fractures are similar to snap fractures with regard to the fracture mechanics of brittle solids in that they result in the truncation of material due to the unchanneled dispersion of percussive force. Hinge fractures occur when inadequate percussive force is applied to reduction efforts, preventing the flake from traveling the desired distance (Whittaker 1994: 109). However, rather than the flake being prematurely truncated as in step fractures, hinge fractures are characterized by the full termination of the flake. This termination occurs earlier than the intended point of egress, producing a rounded or blunt break and a disproportionate distribution of material mass that impedes further reduction efforts (Crabtree 1972: 68). Further reduction efforts often produce stacked step fractures or continued hinging, resulting in the inability to further reduce medial areas or to rejuvenate worn-out tool forms (Whittaker 1994: 109). Although they are morphologically dissimilar, the causes of hinge and step fractures, as well as the ensuing impediments for material reduction, are nearly equivalent (Whittaker 1994: 109). While step and hinge fractures often occur in the production of stone tools, they may also occur through tool use. Flakes may be inadvertently removed when tools come into contact with other materials as they are used in various tasks. Regardless of the trajectory stage, step and hinge fracture present a challenge to future reduction efforts, and may necessarily result in discard.

Failure and discard may also occur during reduction and rejuvenation efforts as the result of platform loss. The loss or collapse of a workable striking platform is often the consequence of improper reduction techniques or unanticipated fractures that leave no viable surface on which to strike and remove a desirable flake. Platform loss can occur during efforts to remove excessive mass from the medial areas of cores, preforms, and recycled tools, and may result in the inability to remove a desired mass without compromising the dimensional requirements of the desired trajectory.

Material flaws generally manifest as mineral inclusions or cavities that differ compositionally from the package material. Irregular cleavage planes constitute another material obstacle that can impact the success of manufacturing efforts. When encountered, these flaws can produce anomalous fractures that complicate or preclude further reduction efforts. Common material flaws include macrocrystalline quartz, calcite, or fossil inclusions, as well as solution cavities and thermally-induced fractures. Production failures resulting from unanticipated thermally-induced fractures should be classified as "excessive heat" rather than "material flaw."

Cotterell and Kamminga (1979) describe overshot (*outrepassé*) failures as those that that result from the application of excessive percussion force, and which cause the fracture path to dive into the objective piece and remove more than the intended mass. Such fractures often occur during the bifacial thinning of blanks and preforms, or in the removal of blades from prepared cores. While failures of this type are most frequently observed during primary production, they may also occur during rejuvenation efforts. Discard will generally be motivated by excessive medial thinning or unrecoverable compromise of the objects design.

Perverse fractures, as defined by Crabtree (1972b: 82), are a spiral or twisting break that initiates at the point of percussion and follows through the object, causing its segmentation. In terms of causation, perverse fractures are the result of a hair-line fracture that resulted from a previous blow. The spiral perverse fracture picks up the old fracture thus resulting in failure. These differ from snap/bending fractures as they are not the result of excessive vibration, but result from a poor choice of striking angle and/or percussion force (as well as a bit of bad luck) that results in the plane of fracture traveling through rather than across the objective piece.

When more than one failure trait is expressed by an artifact, record the most significant cause for failure. For example, if a snap fracture resulted during production due to a fossil or crystalline quartz inclusion within the material, record material flaw as the cause of failure. In conjunction with other features of the assemblage, this information may potentially reveal preference patterns in raw material usage vis-à-vis specific tool classes, correlations between tool forms and discard patterning, and idiosyncratic differences in production skill.

Use-related Discard

Stone tools may be lost in their use-context in myriad ways. Points attached to an errant arrow may be lost or broken; as well they may be carried off embedded in game that was not subsequently subdued. Tools can also be continuously curated and used to the point of material exhaustion. Objects may also be cached in the process of ritual activity, such as when placed in burials. The motives for use-related discard may only be definitively discerned in a limited number of cases. Points with distal spalling, perhaps combined with a stress fracture above the hafting element, may be understood to have suffered an impact fracture. Tools recovered within a burial context may be identified as cached. Heavily recycled forms that cannot practically be further reduced through percussion or pressure flaking to yield an acute edge angle may be identified as exhausted tools. However, complete forms with light or no use-wear are commonly recovered at sites in contexts that do not explicitly indicate caching. When a discard motivation is ambiguous, "indeterminate" should be selected among the alternatives provided below.

Incidental Discard

Incidental discard includes actions that removed objects from their systemic context by means other than manufacturing error, caching, or use (see Schiffer 1972), such as through dropping or misplacing them. However, this category of discard is a theoretical construct, the objective identification of which cannot be systematized. Thus, it is not included as an analytical option for assessing discard.

00.	[Indeterminate]	04.	[Hinge / step]	08.	[Excessive heating]
01.	[Snap / end shock]	05.	[Overshot (outrepasse)]	09.	[Exhausted]
02.	[Impact / bending]	06.	[Material flaw]	10.	[Cached]
03.	[Perverse]	07.	[Platform loss]		

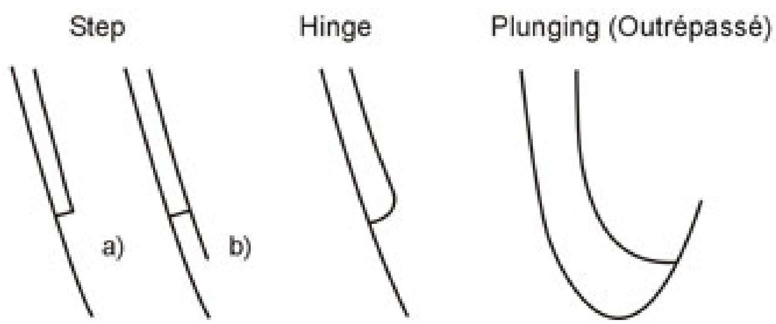


Figure 9: These terminations are often observed on bifacial blanks and preforms that were discarded in the process of manufacture. For the purposes of the protocols, step and hinge fractured are recorded as a single category of failure as the result in a very similar obstruction to the knapper.

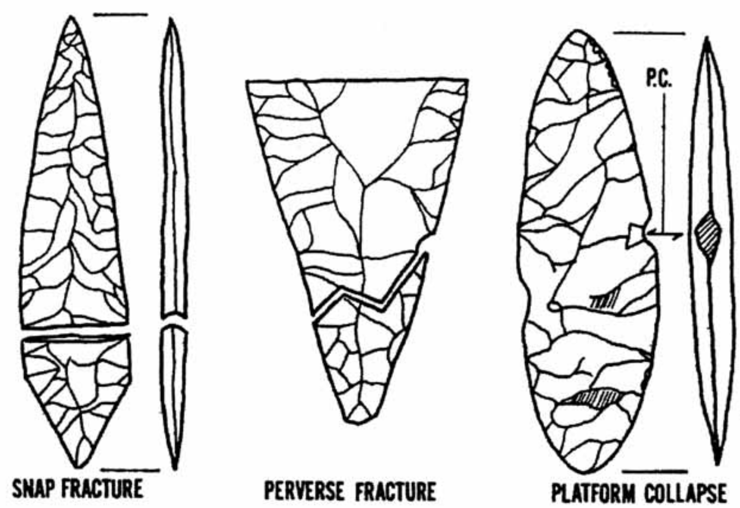


Figure 10: These terminations illustrate additional failures that may render the objective piece unusable or incapable of further reduction and recycling.

16. Alteration (choose dominant form)

Material alteration addresses the transformation of structural and compositional properties that occurs as the result of natural and cultural processes. Natural processes include chemical and mechanical weathering, often resulting in patina or material decay. Thermal alteration is an example of material alteration through cultural processes.

An accurate assessment of thermal alteration is often inhibited by artifact size, patina formation, and unfamiliarity on the part of the researcher with some of the lithological variability expressed by select raw materials. Lithic raw materials typically undergo significant and detectable lithological changes with prolonged exposure to heat. Such changes are often desirable and may be deliberately generated by tool producers through controlled firing. Heat-treated materials may be more easily worked by the artisan as the process renders low-quality materials more knappable (albeit while making them more brittle and decreasing their durability).

The identification of heat-treated materials brings culture process and the details of economic activity to the fore. Nonetheless, it is frequently difficult to distinguish purposefully treated materials from those that were incidentally burned. Incidental firing occurred in antiquity through controlled vegetation burns, as well as the occasional burning of middens or other cultural deposits. Historic-age and modern incidental firing may have resulted from burning off surface vegetation when preparing land for cultivation of pasture.

Lithic assemblages often exhibit other forms of material alteration that can obscure the study of raw material properties. The most common of these is the development of a weathering rind that is often identified as a white patina. The rind may be semi-translucent to opaque and is typically less than 3mm in thickness. The development of a yellow to reddish brown "stain" may also develop on lithic artifact surfaces in iron-rich soils. The chemical processes that lead to the development of black (often dark blue) patinas is not completely understood. They most often occur in inundated deposits. Carbonate deposits and pigment staining occur rarely, the former being most common in coastal areas and the latter more common in ritual contexts.

00. [Indeterminate]	03. [Black patina]	06. [Carbonate build-up]
01. [Thermal]	04. [Oxide staining (yellowing)]	99. [Other]
02. [White patina]	05. [Pigment staining]	

17. Edge morphology (D & L & R)

Please indicate the shape of the working edge of the tool. Measuring from a line strung between edge termini, an edge is characterized as very convex if the distance from the cord to the maximum outward projection of the edge is greater than or equal to 5mm. Similarly, an edge is considered convex if the distance from the cord to the maximum outward projection of the edge is between 4.9mm and 2mm. Edges are considered straight if the maximum inward or outward projection of the edge from the cord is no more than 1.9mm. An edge is considered concave if the distance from the cord to the maximum inward projection of the edge is between 4.9mm and 2mm. An edge is characterized as very concave if the distance from the cord to the maximum inward projection of the edge is greater than or equal to 5mm. An edge is considered recurved if the maximum outward projection of the edge from the cord is greater than or equal to 2mm, and the maximum inward projection of the edge from the cord is also greater than or equal to 2mm.

00. [Indeterminate]	03. [Convex]	06.. Very Convex
01. [Straight]	04. [Recurved]	07. Very Concave
02. [Concave]	05. [Serrated]	99. [Not applicable]

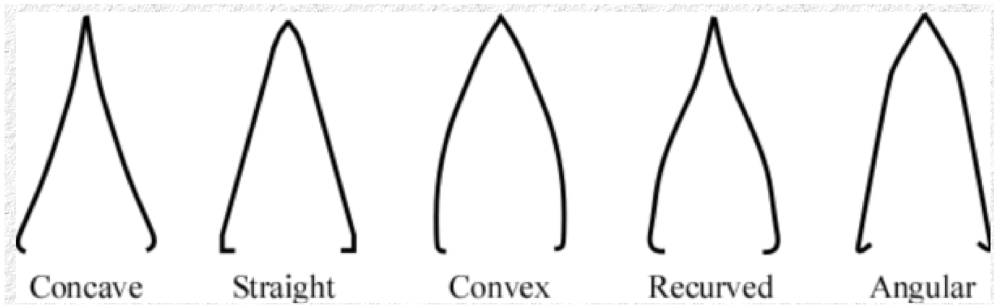


Figure 11: Edge morphology has its greatest utility in characterizing projectile points, darts, and knives.

18. Flake scar pattern

Flake scars are the impressions that remain on the face of a flaked stone artifact which are produced by the detachment of flakes during tool manufacture. The pattern of flake removal may offer important insights relating to the distribution of design templates and techniques of manufacture, as well as offer a means by which to observe variability in production design at different spatial scales.

00. [**Indeterminate**] a flaking pattern cannot be determined.
01. [**Collateral**] a flaking style that is characterized by parallel flakes emanating from opposing edges which meet in the center of the blade, forming a median ridge.
02. [**Horizontal transverse**] a flaking style that is characterized by horizontal, parallel flake scars emanating along one edge, traveling across the face of the blade, and terminating at the opposing edge.
03. [**Oblique transverse**] a flaking style that is characterized by long, diagonal, parallel flake scars emanating along one edge, traveling across the face of the blade, and terminating at the opposing edge.
04. [**Random**] flake removals do not reflect an aesthetic template in their distribution or alignment.
99. [**Not applicable**] (expedient flake tools are one form of tool that will not exhibit a flake scar pattern).

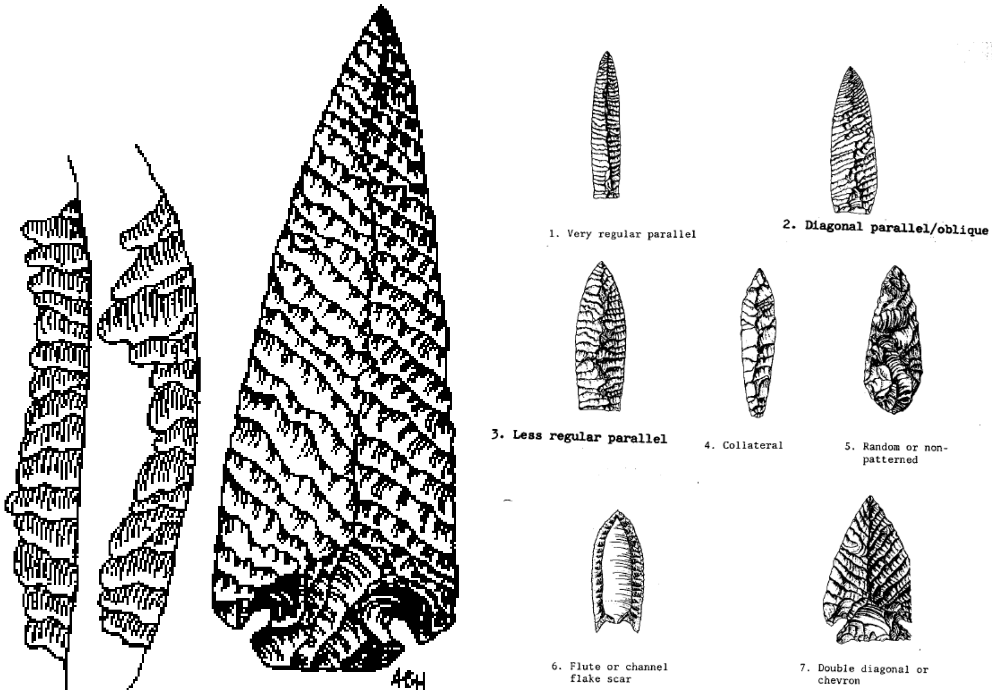


Figure 12: Patterns of flake removal in edge construction, potentially related to flaking technique, tool function, aesthetic display, and social identity.

19. Edge construction type

Edge construction type references the location and form of preparatory edge construction on the objective piece. There are a variety of ways in which an edge may be constructed on a chipped stone object. The most basic choice is between bifacial and unifacial constructions. Such choices carry implications for accurately assigning tools to a subgroup, distinguishing between techniques used during production, assessing the foci of use, and determining the angle of the resulting edge. Variability may also occur among subtypes, potentially alluding to differences in raw material access, tool function, or nuances of social identity. For example, while the lateral margins of some Perdiz points are bifacially constructed, others exhibit unifacially beveled edges. The constructed working edge(s) of a tool may be characterized using the following descriptions:

00. [Indeterminate]
01. [Bifacial-distal]
02. [Bifacial-bilateral]
03. [Bifacial-unilateral]
04. [Bifacial-distal-bilateral]
05. [Bifacial-distal-unilateral]
06. [Bifacial-circumferential]
07. [Unifacial-distal]
08. [Unifacial-bilateral]
09. [Unifacial-unilateral]
10. [Unifacial-distal-bilateral]
11. [Unifacial-distal-unilateral]
12. [Unifacial-circumferential]
13. [Other]
99. [Not applicable]

20. Proximal edge grinding

☐ Not Observed

☐ Observed

IV. Wear Patterning

The following use-wear observations can be made macroscopically using an 18-20X jeweler's loop, and is considered low-power magnification. Low-power magnification is assumed to imply magnification between 18x-power and 100x-power. This portion of the protocol has not been designed for high-power magnification and Scanning Electron Microscopy. Use-wear characterization using low-power magnification has been shown to successfully identify the range of motion an object was used in, and, to a lesser degree, the hardness of the contact material. High-power magnification is generally needed to accurately identify contact material and detect finer details of object use. The low-power use-wear characterization advocated here will find its greatest utility in quantifying the presence or absence of use, identifying the area of use on a specific piece, and in identifying variability in use among specific artifact types and subtypes. The use-wear categories described below are not mutually exclusive – tools may exhibit more than one form of wear.

Edge modification is not always the product of material use. Other natural and cultural processes, such as trampling and archeological excavation, 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 processes obviously affect the recognition of some patterns of wear more than others, and may be particularly relevant for detecting true use-wear on simple detachment-based tools. Distinguishing use-derived flake terminations along the lateral margins of tools is perhaps the most equivocal functional assessment; although Odell and Odell-Vereecken (1980) state that the patternlessness of such incidental attrition is detectable and, thus, can be distinguished from actual use-wear with a high level of accuracy. Tools may exhibit a form of polish in deflationary zones derived from aeolian processes, and may exhibit battered edges within fluvial deposits. Given the possibility that edge modification derived from trampling or other processes, "attrition" use wear should only be record for artifacts that exhibit both a distinct, clustered pattern of edge alteration and worn or polished facets in the area of proposed use. While this undoubtedly underestimates the actual amount of use-wear exhibited throughout the assemblage, it substantially increases the accuracy with which positive determinations were made.

The degree of expedient tool use within an assemblage provides one means by which the level and importance of material conservation may be evaluated. Regions characterized by a scarcity of utilitarian lithic raw materials have been shown to exhibit higher levels of material recycling. Careful attention to and recording of use-wear may also provide important information related to spatial and temporal variability expressed within tool classes, types and subtypes.

21. Flaking attrition

Material mass is often removed from the working edge of a tool during the process of use. Much of this attrition is in the form of small flake removals that typically exhibit feathered or stepped terminations. Accurate recording of use-derived attrition requires an analyst to distinguishing these removals from trimming flakes that are detached along a tool's edge in the final preparation stage prior to use. Use-derived attrition can often be distinguished from preparatory trimming as it creates a more obtuse edge angle in the area of use than is expected based on observing edge characteristics elsewhere on prepared, but unused portions of the tool. Use-derived attrition may also remove areas of polish that have developed along tool margins, which may also produce sharper facets that contrast in the area of use with more polished and rounded facets.

Data is coded to record the presence and location of flaking attrition as its distribution on a tool form is a significant indication of tool function. Observations shall be recorded as follows:

00. [Not present] Use if flaking attrition is not observed.
01. [Bifacial-distal] Use if the working edge of a tool is located along the distal margin and attrition is observed on each face (dorsal and ventral).
02. [Bifacial-bilateral] Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals on both faces.
03. [Bifacial-unilateral] Use if only one lateral margin (left or right) exhibits use-derived attrition and the attrition has resulted in removals on both faces.
04. [Bifacial-distal-bilateral] Use if both lateral margins and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on both faces. This option will be select if one of the lateral margins exhibits unifacial attrition.
05. [Bifacial-distal-unilateral] Use if only one lateral margin (left or right) and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on both faces.
06. [Bifacial-circumferential] Use if the lateral margins along the entire circumference of the tool form exhibit use-derived attrition and the attrition has resulted in removals on both faces.
07. [Unifacial-distal] Use if the distal margin exhibits use-derived attrition and the attrition is observed on only one face.
08. [Unifacial-bilateral] Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals on only one face.
09. [Unifacial-unilateral] Use if only one lateral margin (left or right) exhibits use-derived attrition and the attrition has resulted in removals on only one face.
10. [Unifacial-distal-bilateral] Use if both lateral margins and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on only one face.
11. [Unifacial-distal-unilateral] Use if only one lateral margin (left or right) and the distal margin exhibit use-derived attrition and the attrition has resulted in removals on only one face.
12. [Unifacial-circumferential] Use if the lateral margins along the entire circumference of the tool form exhibit use-derived attrition and the attrition has resulted in removals on only one face.
13. [Unifacial-bilateral-oppositional] This form of attrition is most typically found on tools used as drills or awls. Use if both lateral margins exhibit use-derived attrition and the attrition has resulted in removals along the opposing margins of each face.
14. [Other] Use if none of the above apply and enter a description in the text box provided.

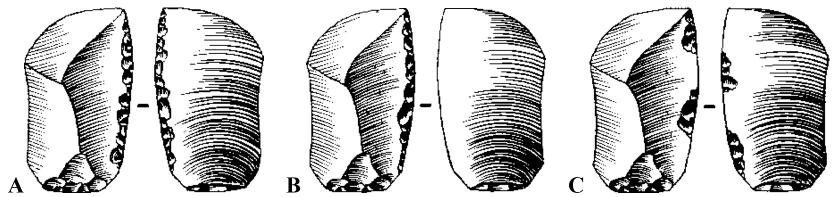


Figure 13: Examples of lateral edge flaking attrition. (A) bifacial-unilateral; (B) unifacial-unilateral; (C) platform abrasion and (likely) post-depositional removals.

22. Crushing 23. Smoothing

Crushing and smoothing describe the form of wear attained through battering, grinding, or polishing. The tool is typically blunted through battering or abrasion against a hard contact material in the process of use. Crushed working surfaces may be a normally achieved trait with little effect of tool utility, such as with hammerstones. Alternatively, crushed surfaces may be an undesired consequence of use and material attrition that necessitates edge resharpening. Smoothing is typically the result of intensive abrasion and is commonly observed on tools used for grinding, polishing, or burnishing (uncommon among chipped-stone tools). Once identified, the distribution of this wear should be recorded using one of the following descriptions:

00. [Not present] Use if attrition through crushing or smoothing is not observed.
01. [Distal]
02. [Distal-lateral]
03. [Unilateral]
04. [Bilateral]
05. [Facial Smoothing]
06. [Facet Smoothing]
07. [Circumferential]
08. [Primary Proximal]
09. [Secondary Proximal]

24. Polish

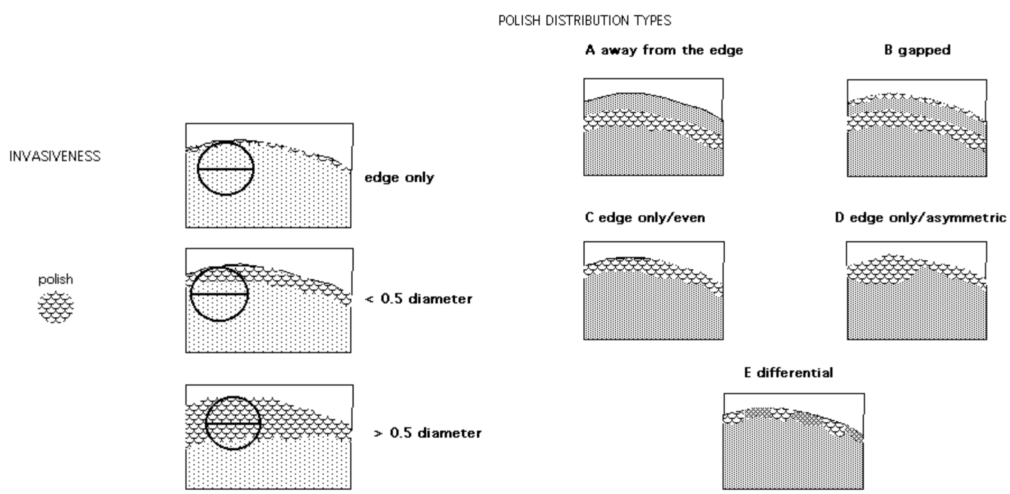
The use-wear category "polish" describes lustrous areas on the tool, typically located at the distal or lateral margins, but occasionally noted on medial surfaces. Record polish as "shallow" when it is restricted to within 5mm of an edge. Define polish as "deep" when it extends beyond 5mm from the edge of its origin.

The origin of polish is not well understood despite having been 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 specific tool forms were utilized in a defined set of prescribed behaviors, researchers have had considerable success in correlating patterns of polish distribution and composition with the specific activities that generated its development. 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 specific patterns of polish development do not correlate well with isolable tasks on multifunctional tools (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) observed will provide a range of functional possibilities and limitations for how the tool was used in a particular cultural and techno-environmental setting.

Three processes other than primary contact during use may cause the development of a lustrous sheen, and they should not be recorded as use-derived polish. The first, hafting polish, develops through secondary, use-associated contact. Hafting polish is formed through the tools contact with a hafting element or fastening material. Hafting polish, when present, will typically manifest on both lateral and medial surfaces nearer the proximal end of a tool. Hafting can also be associated with worn, ground, or otherwise blunted lateral margins. Evidence for hafting should be nominally recorded separately from use-wear (see #26 below).

The second process that inhibits the detection of use-derived polish is thermal alteration. In extreme cases, lithic material will become vitrified through over-exposure to heat, producing a lustrous sheen that covers the surface of the artifact and resembles use-derived polish. Grinding, the third process, is a specialized manufacturing technique that results in the development of a luster across the ground surface. The luster forms through the extensive abrasion required in the production process rather than from use.

00. [Not present] Use if use-derived polish is not observed.
01. [Shallow distal <5mm]
02. [Deep distal >5mm]
03. [Shallow lateral <5mm]
04. [Deep lateral >5mm]
05. [Unifacial-medial]
06. [Bifacial-medial]
07. [Bipolar]
08. [Proximal]



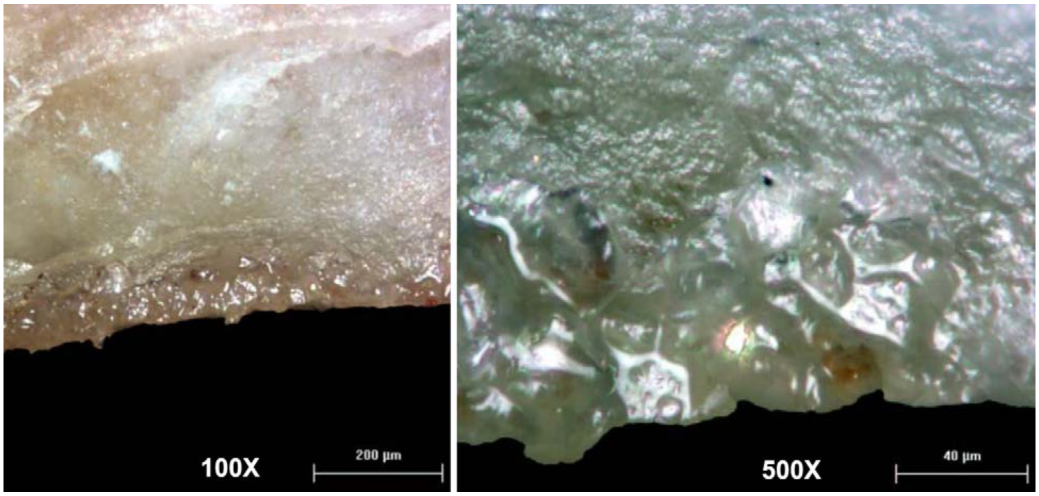


Figure 14: Patterns of polish formation and distribution related to use wear. The formation of polish is dependent on the nature of the tool construction material, nature of the contact material, and duration of use.

25. Etching / pitting

Etching and pitting refer to striations or small cavities produced through abrasive contact (Semenov 1964). As with polish, such markings may occasionally derive from production techniques, although this is generally only a concern for tool forms featuring ground or pecked and ground bits. Etching and pitting are better studied microscopically. The macroscopic techniques used in this study are useful for detecting moderate to deep scarring and abrasion that are characteristic of working soils with a significant sand content, but they may have less utility in detecting wear left from working in clayey soils. Striations (etching) may be located along either the distal or lateral margins of the tool. When located at the distal margin they most often run perpendicular to the edge. The extent to which they proceed from the distal margin across the face of a tool can provide some measure of how far the tool penetrated into a contact material. When located along the lateral margins striations more typically run parallel the edge. Striations may be created through quarrying, soil working, planing, polishing, grinding, or any extended lateral movement across a hard or abrasive surface.

00. [Not present] Use if attrition through etching or pitting is not observed.
01. [Shallow distal <5mm]
02. [Deep distal >5mm]
03. [Shallow lateral <5mm]
04. [Deep lateral >5mm]
05. [Unifacial-medial]
06. [Distal-medial]
07. [Circumferential]
08. [Medial-bifacial]
09. [Bipolar]

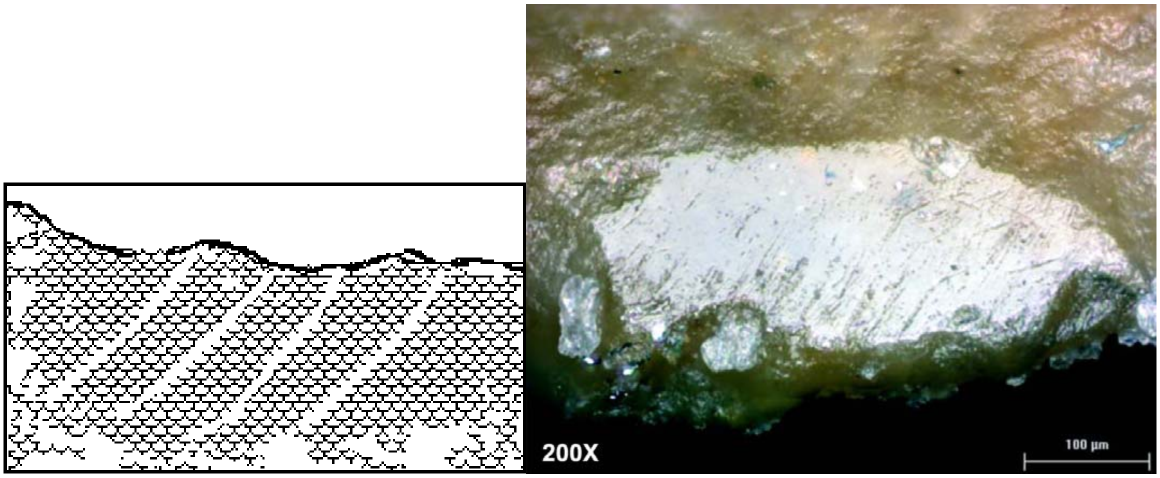


Figure 15: Development of lateral scars (or striations) developed on the working edge of the tool derived from abrasive and repeated contact between the tool form and contact material.

26. Hafting evidence

Hafting may be identified through lateral edge dulling toward the proximal end of the tool form, polish along the proximal lateral margins and proximal facial facets, and the residual presence of a masticate such as asphaltum. Note the presence or absence of this evidence.

☐ Not Observed
☐ Observed

V. Raw Material

27. Lithology

The lithologic character of raw materials should be identified to the best, most accurate extent reasonable. The lithic analyst should specifically identify materials only to the extent that they are certain that the information provided is accurate. The most common raw materials have been coded for use. Materials not included in the list provided should be coded as "other" and specifically identified in the text field provided.

01. Unidentified Silex
02. Microcrystalline Quartz
03. Macrocrystalline Quartz
04. Chalcedony
05. Jasper
06. Chert
07. Chert-Chalcedony Blend
08. Dolomite
09. Agatized dolomite
10. Fossilized Wood
11. Limestone
12. Silicified Limestone
13. Quartzite
14. Novaculite
15. Rhyolite
16. Basalt
17. Serpentine / Greenstone
18. Steatite (soap stone)
19. Granite
20. Marble
21. Gneiss
22. Schist
23. Silt-stone
24. Obsidian
25. Manning Fused Glass
26. Ironized sandstone
27.

96. Unidentified Sedimentary
97. Unidentified Igneous
98. Unidentified Metamorphic
99. Other

28. Source identification

The source areas provided below represent those commonly identified in available literature, but the list is by no means exhaustive (see Banks 1990; Turner and Hester 1999). The identification of lithic raw material source is intended to provide a means to address issues of resource mobilization. However, many issues exist in accurately identifying source areas. For example, Uvalde Gravels contain a good amount of Edwards Chert. The raw material source area should be identified to the most accurate level possible without unsupportable speculation. It is expected that raw material source areas will not generally be identifiable.

In general, raw material sourcing is assessed using visual identification for chert, chalcedony, and quartzite artifacts as chemical characterization studies have not been reliable in determining source areas. Successful identification of specific resource outcrops is often impossible, but some confidence regarding the general can be gained by matching artifacts (formal tools and debitage) to geological samples taken from individual resource outcrops (ex. Edwards, Alibates, Maravillas, Ogallala). Relevant criteria to consider in matching archaeological materials to geological samples include lithology, material hardness, relative grain size, color, the presence or absence of banding and other irregularities, and the presence and composition of micro-fossils and other inclusions (cf. Morrow 1994). In most instances, determining the area of procurement depends on artifact mass as only large pieces will retain enough compositional character to distinguish between geographically discrete resource areas.

00. Unidentifiable
01. Alibates (Llano Estacado)
02. Antlers Formation
03. Burro Mesa (Trans-Pecos)
04. Bexar County chert
05. Callahan Divide
06. Caballos Mountain
07. Central Mineral Region (Llano Uplift)
08. Georgetown Cherts
09. Edwards Chert
10. Manning Fused Glass
11. Markely Conglomerate
12. Pisgah Ridge
13. Rio Grande Gravels
14. Tecovas Formation (cherts and jaspers)
15. Yegua Gravels (quartzite and petrified wood)
16. Uvalde Gravels
17. Catahoula
97. Unidentified local
98. Unidentified regional
99. Unidentified exotic
100. Other

VI. Projectile point data

29. Point Class

00. Not Applicable
01. Corner Notched
02. Side Notched
03. Stemmed
04. Triangular
05. Lanceolate

30. Point Data

Table 1: Shaded rows have automatically populated data and should not be manually entered.

	Corner Notched	Side notched	Stemmed	Triangular	Lanceolate	Measurement	Description
	X	X	X	X	X	point length	**same as question #8 above**
	X	X	X	X	X	point width	**same as question #9 above**
	X	X	X	X	X	point ratio	Tool width divided by tool length
30a.	X	X	X	X	X	blade length (L)	
29b.	X	X	X	X	X	blade length (R)	
30c.	X	X	X	X	X	base/stem length or basal inflection	
30d.	X	X	X			base/stem width	
30e.	X	X	X		X	neck thickness	
30f.	X	X	X		X	neck width	May be the same as #30d in stemmed forms, and the same as #9 in Lanceolate forms.
30g.	X	X				notch depth (L)	
30h.	X	X				notch depth (R)	
	X	X				notch ratio	Average notch depth divided by width of point
	X	X	X	X	X	base to blade ratio (length)	29e divided by 30a
	X	X	X			base to blade ratio (width)	29f divided by 30b
	X	X	X			base/stem ratio	0 (indeterminate), 1 (short; <= 0.7), 2 (proportionate; >0.7 & <1.3), 3 (long; >=1.3)
30i.	X	X	X			base form	0 (indeterminate), 1 (convex), 2 (straight), 3 (concave), 4 (notched), 5 (pointed), 6 (bulbar)
30j.			X			stem form	0 (indeterminate), 1 (contracting), 2 (parallel), 3 (expanding), 4 (asymmetrical)
30k.				X	X	distal base form	0 (indeterminate), 1 (convex; >=1mm), 2 (straight; <1mm & >-1mm), 3 (concave; <-1mm)
30l.			X		X	lateral base/stem form	0 (indeterminate), 1 (contracting), 2 (parallel), 3 (expanding – exhibits tangs), 4 (asymmetrical)
30m.	X	X	X	X	X	blade curvature (L)	0 (indeterminate), 1 (very convex; >=5mm), 2 (convex; <5mm & >=2mm), 3 (straight; <2mm & >-2mm), 4 (concave; <=-2mm), 5 (recurved; <-2mm & >2mm)
30n.	X	X	X	X	X	blade curvature (R)	0 (indeterminate), 1 (very convex; >=5mm), 2 (convex; <5mm & >=2mm), 3 (straight; <2mm & >-2mm), 4 (concave; <=-2mm), 5 (recurved; <-2mm & >2mm)
30o.	X	X	X			shoulder angle (L)	
30p.	X	X	X			shoulder angle (R)	
30q.			X			shoulder junction	0 (indeterminate), 1 (curved), 2 (angular), 3 (straight)
30r.				X		base angle (L)	
30s.				X		base angle (R)	
	X	X	X	X	X	index of symmetry	

TXDOT PROTOCOL FOR DEBITAGE ANALYSIS

Research Methods: Debitage

There is a great deal of information that may be gained from the study of debitage in archaeological assemblages, and researchers have debated the utility of various classes of information, as well as their situational applicability, accuracy, and level of efficiency (Ahler 1989; Andrefsky 1998; Baumler and Downum 1987; Johnson 1989; Magne 1989; Sullivan and Rossen 1985). The analytical process described here provides a useful synthesis of attribute analysis and mass analysis that captures the maximum amount of critical basic data for large collections within a workable time frame while allowing a wide range of research questions to be addressed.

Within this protocol, no linear measurements are recorded for individual artifacts (i.e. flake length, width, thickness, and curvature; platform angle, width, and thickness). Such measurements rarely lend themselves to addressing important or innovative research questions. They also require a large amount of time to collect when analyzing sizable collections and this time investment is invariably unwarranted when assessed against the amount of useful information returned.

Metric Attributes (Number and Weight)

In the interest of analytical efficiency, there is also no good reason to weigh individual flakes. Counts and weights will be assessed for artifact groupings (analytical assemblages) that are created through the analytical process.

Minimum Number of Nodules (MNN)

An assessment of MNN is designed to record the minimum number of individual packages of raw material (nodules) that contributed to a specific analytical assemblage. This may be relevant for determining the number/volume of tools produced, the number of individuals participating in the production activity, raw material preferences, or the degree of deflation, comingling, or disturbance reflected in the assemblage being analyzed. This assessment should be based on observations of raw material type and material properties, and may be augmented through the use of ultraviolet fluorescence. Analysts should consider the effects of differential patination and thermal alteration on observable raw material features when assessing MNN. Analysts should favor lumping over splitting in determining MNN (additional nodules should only be recorded when flakes within an analytical assemblage can not have been derived from the same source package).

Form (Completeness – flake vs. frag vs. shatter)

Sullivan and Rozen (1985:759) have advocated using the analytical categories “complete flake”, “broken flake”, “flake fragment”, and “debris” for the study of flake assemblages, and have illustrated the tendency for each to be represented in different proportions at various stages of manufacture (see also Baumler and Downum 1987). There are many variables that undermine the utility of this approach. Landscapes used for pasture or cultivation, particularly in near-surface deposits, are highly susceptible to trampling and to disturbance by agricultural machinery. Either agent will distort the ratio of complete to broken flakes in such contexts. The movement of artifacts in vertic soils or within contexts characterized by erosion and re-deposition, root disturbances, and ancient cultural disturbances such as area maintenance (to name only a few) are equally likely to affect this ratio. Interpreting manufacturing stage through the percentage of whole vs. broken flakes requires preservation of integrity, in both individual specimens and the original composition of the assemblage, with little post-depositional alteration. Due to the rarity of such an occurrence, the interpretive worth of the categories advocated by Sullivan and Rozen find their greatest utility when used with experimental assemblages.

This protocol does not require that only those flakes within an assemblage that retain a striking platform (whole and proximal flakes) be included for data collection and analysis. While this would reduce spurious data produced through post-depositional processes, distal flake fragments may be excluded from analyses by most statistical packages.

Size-grade Analysis

Sort all debitage by size-grade using nested sieves with 1-inch, ¾-inch, ½--inch, and ¼-inch apertures. Size-grade analysis offers an alternative to taking standard metric measurements of maximum flake length, width, thickness (cf. Andrefsky 1998: 96-100) that substantially increases the efficiency with which large samples may be studied (Ahler 1989). When combined with supplementary data, such as the percentage of dorsal cortex present and platform type, size-grade analysis provides researchers with valuable information regarding production trajectory, the method and organization of raw material procurement, technology of production, production efficiency, and the level of material curation (Ahler 1989; Baumler and Downum 1987; Behm 1983; Bradbury and Franklin 2000).

01. [1-inch sieve]
02. [3/4-inch sieve]
03. [1/2-inch sieve]
04. [1/4-inch sieve]

Cortex Percent

Perhaps the most common use of cortex observations in debitage analysis is for assessing the stage of manufacture represented by the flake assemblage. Researchers commonly use one of two models of assigning meaning to the percentage of cortex present. The first uses the relative amount of cortex present on each flake to place the individual piece within a linear reduction model, under the assumption that only flakes produced during the initial phases of tool manufacture will exhibit a high percentage of dorsal cortex. Andrefsky (1998:111) refers to this as the "triple cortex" approach, and it can be recognized by the identification of *primary*, *secondary*, and *tertiary* (or *interior*) flakes. As researchers Sullivan and Rozen (1985:756-757) have pointed out, however, there is little standardization among those employing the triple cortex approach, such that the flakes designated as *primary* may be required to have as much as 100 percent dorsal cortex or be permitted to exhibit as little as 50 percent. Similarly, the percentage of dorsal cortex required to identify a *secondary* flake ranges between 100 and 0 percent depending on the researcher, while the percentage of dorsal cortex required for the identification of a *tertiary* flake ranges from between 0 and 25 percent (Sullivan and Rossen 1985:757). As a significant number of *tertiary* flakes -which are often regarded as evidence of final stage manufacture- are produced in the initial phases of core reduction, the traditional classification of debitage into primary, secondary, and tertiary flakes has very little analytical worth.

Ahler (1989:90) has pointed out that the presence of cortex in a lithic waste assemblage, as well as the utility of information gleaned from its study, will vary according to the nature of the raw material, how it was quarried, the reduction technology employed, and the stage of manufacture represented by the assemblage. Also, the presence of cortex at any reduction stage is dependent on the initial presence of cortex prior to reduction (Andrefsky 1998:113-114). The nature of raw material outcrops, the method of quarrying employed, and the technology of production affects the viability of using cortex percent as an indicator of production stage. Even under the best of circumstances, cortex percent may only provide data relevant to broadly distinguish early reduction stages from later stages (Mauldin and Amick 1989:71). Debitage is able to more accurately inform reduction stage and artifact class when classified according to size, percentage of cortex represented, and platform type. The following size categories should be used for classifying debitage.

Cortex Percentages

00.	[0%]	02.	[26-50%]	04.	[76-100%]
01.	[1-25%]	03.	[51-75%]		

00. [0%]
01. [1-25%]
02. [26-50%]
03. [51-75%]
04. [76-100%]

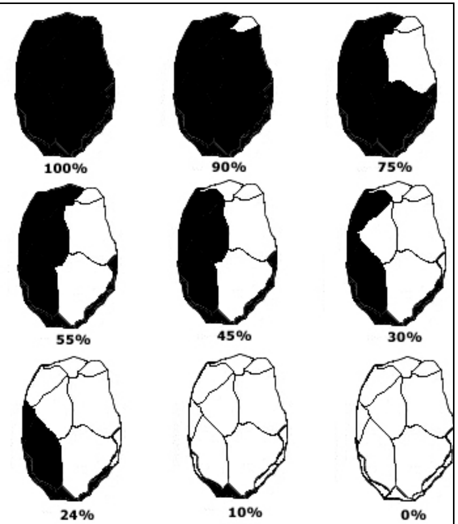


Figure 16: The graphic above illustrates both a quantifiable and a qualitative means by which to measure or estimate the amount of remnant dorsal cortex on a lithic flake.

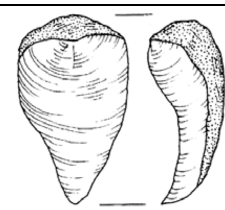
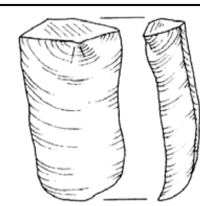
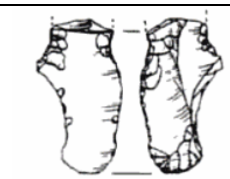
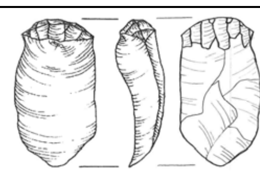
Platform Type

The striking platform of a flake is the point of contact where the percussor initiated the flake detachment. The morphology of the platform can yield valuable information pertaining to the stage of manufacture represented by the flake, which in turn reflects the presence, character, and organization of activity areas. Platform morphology can also inform production technology (Andrefsky 1998).

Platform types should be recorded as indeterminate, cortical, flat, complex, abraded, faceted, multifaceted, and rejuvenated (cf. Andrefsky 1998:93-96). Cortical platforms are those that retain some amount of unmodified cortex, and are generally attributable of early production stages. Cortical flakes also generally, but do not necessarily, exhibit dorsal cortex beyond the platform. Flat striking platforms exhibit a smooth, un-faceted striking surface. Flakes detached from unidirectional cores generally exhibit flat platforms (Andrefsky 1998:94), although flakes with flat striking platforms may also be produced in the early stages of bifacial core reduction. Faceted striking platforms exhibit one or more facets, reflecting the removal of previous flakes from the same general area. Although researchers have had some success in determining manufacturing stage using facet counts (Mauldin and Amick 1989; McAnany 1988), time constraints and unresolved ambiguity in directly correlating facet count with manufacturing stage in an uncontrolled archeological sample undermine the desirability of including this finer resolution. A simple distinction between single-faceted platforms and multifaceted platforms is advocated in this protocol. Flakes that exhibit bifacial mass removal, often referred to as bifacial thinning flakes, are categorized as having complex platforms. Abraded platforms are those that exhibit attrition caused by purposeful edge preparation procedures. Such platforms are generally rounded or ground in appearance, and often exhibit multiple tiny step fractures. Marginal abrasion is a common practice for preparing a striking platform, and serves as a method of altering the direction of percussor force, which produces a more predictable flake removal (Andrefsky 1998:96; Whittaker 1994). Abraded platforms are produced in all phases of tool manufacture, but are more common in later stages of production. Finally, rejuvenated platforms reflect tool resharpening and often display remnant use wear along a focal margin. Assemblages dominated by rejuvenated platforms indicate tool maintenance rather than tool production.

Indeterminate identifications generally result from poorly represented (fractured) or wholly absent platforms, or from poor resolution caused by heavy patina. To be clear, it is not desirable to record platform width and thickness or the number of facets present on the dorsal surface of flakes. These attributes are not efficiently recorded through mass analysis procedures, and the information they provide may be ascertained through other means, such as multivariate analysis incorporating the percentage of dorsal cortex present with flake size and platform type.

00. [indeterminate]
01. [cortical] flakes with cortex observed on striking platforms are produced in the initial stage of package reduction.
02. [flat] a single facet, caused by characterizes the striking platform.
03. [faceted] two facets are observed on the platform. Assemblages dominated by flakes with double faceted platforms are generally produced in early stage blank production.
04. [multifaceted] multiple facets are observed on the platform. Assemblages dominated by flakes with multifaceted platforms are generally produced through work on later stage preforms.
05. [abraded] the platform exhibits ground margins
06. [complex] complex platforms are bifacial.
07. [rejuvenated] rejuvenated platforms are indicative of recycling and will typically exhibit worn edges and remnant polish.
08. Missing

Platform Type	Platform Description	Illustration
missing	Flakes are defined as having missing striking platforms if they are flake fragments or shatter that are missing the proximal segment of the flake that includes the point of fracture initiation.	
cortical	Flakes with cortex observed on striking platforms are generally produced in the initial stage of package reduction.	
flat	A single facet, caused by a single previous flake removal, characterizes this type of striking platform. Flat (single faceted) platforms are common in early stages of decortification, and are common to blade manufacture when combined with notably abraded edges.	
dihedral-faceted	A surface having or formed by two intersecting faces. Assemblages dominated by flakes with double faceted platforms are generally produced in early stage blank production.	
multifaceted	Multiple facets are observed on the platform but only along one face of the object. Light abrasion may or not be present. Assemblages dominated by flakes with multifaceted platforms are generally associated with later stages of biface reduction but can also be present in early stage biface reduction.	
abraded	Abraded platform exhibit grinding that may obliterate facet ridges and/or exhibit platform edge smoothing/rounding visible to the naked eye or under low power magnification. Heavily abraded platforms are often “dull” or smooth to the touch. Abraded platforms serve to strengthen a platform edge allowing for the application of greater force loads thus increasing successful flake propagation and decreasing platform failure by crushing or collapse.	
complex	Complex platforms exhibit pressure or light percussion scars on the proximal-dorsal flake surface originating from the platform edge. These scars are typically associated with precision platform preparation (i.e., isolation and orientation) of late stage bifaces where manufacturing failure rates increase proportional to width to thickness ratios.	

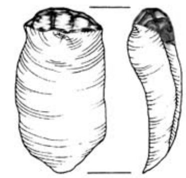
rejuvenated	Rejuvenated platforms are indicative of recycling and will typically exhibit worn edges and remnant polish.	
indeterminate	In some instances, the platform type will not be determinable even when the striking area is present. This is typically caused by crushing of the platform at the instant of production, or by post-depositional weathering.	

Figure 17: 10-20x magnification (hand lens or loop) is recommended for viewing platforms on debitage in the ¼ - ½ inch size grades.

Thermal Alteration

Thermal alteration is used here to describe the process of purposefully subjecting lithic materials to a heat source as a means to affect raw material properties. Lithic raw materials typically undergo significant and detectable lithological changes with prolonged exposure to heat. Such changes are often desirable and may be deliberately generated by tool producers through controlled firing. Heat-treated materials may be more easily worked by the artisan, thus rendering low-quality materials more useful (albeit while making them more brittle and decreasing their durability).

An accurate assessment of thermal alteration is often inhibited by artifact size, patina formation, the production of comparable attributes through incidental fire exposure, and unfamiliarity on the part of the researcher with the lithological variability expressed by select raw materials in their natural state. The identification of heat-treated materials can bring culture process and the details of economic activity to the fore. For example, the presence of thermal alteration in combination with an assessment of platform type and cortex representation can indicated the trajectory stage at which the objective piece was heat-treated. Nonetheless, it is frequently difficult to distinguish purposefully treated materials from those that were incidentally burned. Given the inherent difficulty with distinguishing between materials were purposefully heat-treated (cultural process) as opposed to fire-affected (incidental alteration resulting from both natural and cultural processes), debitage should be recorded as thermally altered, not altered, or indeterminate with regard to alteration conservatively and through incorporation of ancillary data. Identifying alteration on pieces with insufficient mass is unreliable, and so all small-sized debitage that is not minimally captured by a ½-inch mesh sieve should be recorded as indeterminate. If a piece has been determined to be altered its context and association should be considered (e.g. if other artifact classes for the same context similarly burned the piece is more likely to have been incidentally fire affected).

00. [indeterminate]
01. [thermal alteration observed]
02. [thermal alteration not observed]

Analytical Process

By combining the above attributes into criteria lists and then recording the number and aggregate weight of flakes that fit a given set of criteria, this system allows for numerous unique attribute combinations for all debitage within a given provenience. This system works efficiently for large volumes of material and produces an easily queried database.

First, flakes from a given provenience should be sorted by raw material or individual package where it is obvious that the assemblage represents the reduction of separate material packages and such packages are distinctly identifiable. Uniquely identifiable raw material groupings will represent distinct analytical assemblages within each provenience. Next, for each separate package group, sort whole and proximal flakes by size within a given spatial context. Following this, inspect flakes within the 1-inch and ¾-inch sieve size groups for evidence of use-wear (use-derived edge modification is unlikely to be reliably reflected on smaller flakes and they should not be evaluated for possible use). Remove utilized flakes for analysis under the chipped-stone tool protocol. Next, within each size group, sort flakes according to whether or not they are thermally altered (this step will not be performed for the two smallest size groups). Sort flakes within each alteration group (or size group if not separated by alteration) according to the amount of dorsal cortex that is present. From each of the cortex groups, sort flakes by platform type. Finally, count and record the total number of flakes in each of these final groupings and collectively weigh them in grams (round to the nearest gram) and record the MNN for the grouping.

Data derived from formal tool and debitage analyses are complementary. Each data set provides a more informed perspective on the other. Individually, however, each data set may make a distinct contribution with respect to illuminating a particular set of cultural processes and behaviors.

material	period	Size grade	cortex	platform	thermal alteration	edge modification
00 – indeterminate	01 – early Paleo	01 – 1”	00 – 0%	00 - indeterminate	00 - no	00 - absent
01 – local	02 – late Paleo	02 - ¾”	01 - 1-25%	01 - cortical	01 - yes	01 - present
02 – regional	03 – general Paleo	03 - ½”	02 – 26-50%	02 - flat	02 - indeterminate	
03 – exotic	04 – early Archaic	04 - ¼”	03 – 51-75%	03 - faceted.		
	05 – middle Archaic		04 – 76-100%	04 - abraded		
	06 – late Archaic			05 - complex		
	07 – transitional Archaic / early Ceramic			06 - rejuvenated		
completeness	08 – general Archaic			**Metrics**		
01 – complete	09 – late Prehistoric			• record number within each final grouping		
02 – broken	10 – Historic (general)			• record aggregate weight of final group		
03 – fragment	11 – Historic (Spanish)					
04 - debris	12 – Historic (French)		**General Period**		**Regions (from T.B.H.)**	
	13 – Historic (Mexican)		01 – Paleo Indian		1. Plateaus and Canyonlands	
	14 – Historic (Texas Republic)		02 – Archaic		2. South Texas Plains (Rio Grande)	
	15 – Historic (Confederate)		03 – Late Prehistoric		3. Mountains and Basins	
	16 – Historic (1870-present)		04 – Historic		4. Prairies and Marshlands	
	17 – General Historic				5. Rolling Plains	
					6. Timbers and Prairies	
minimum number of individual nodules					7. Pineywoods	
					8. High Plains	

TAXONOMY
1. Technology:
2. Group:
3. Subgroup:
4. Class:
5. Subclass:
6. Type:
7. Identity:

METRIC INFO / Measurements
8. Max length (mm):
9. Max width (mm):
10. Max thickness (mm):
11. Weight (g):
12. Edge angle (working edge averaged to nearest 5°):

ATTRIBUTES

13. Stage
    - 00. Indeterminate
    - 01. Initial reduction
    - 02. Early stage forming
    - 03. Late stage perform
    - 04. Finished product
    - 05. Recycled

14. Portion
    - 00. Indeterminate
    - 01. Complete
    - 02. Distal
    - 03. Distal-medial
    - 04. Medial
    - 05. Proximal-medial
    - 06. Proximal
    - 07. Lateral edges missing
    - 08. Fragment
    - 09. barb / shoulder
    - 10. ear / tang
    - 11. stem

15. Failure
    - 00. Indeterminate
    - 01. Snap / end shock
    - 02. Impact / bending
    - 03. Perverse
    - 04. Hinge / Step
    - 05. Overshot (outrepasse)
    - 06. Material flaw
    - 07. Platform loss
    - 08. Excessive heating
    - 09. Exhausted

16. Alteration
    - 00. None observed
    - 01. Thermal
    - 02. White patina
    - 03. Black patina
    - 04. Oxide staining (yellowing)
    - 05. Pigment staining
    - 06. Carbonate build-up

17. Edge Morphology [17a=L; 17b=R]
    - 00. Indeterminate
    - 01. Concave
    - 02. Convex
    - 03. Recurved
    - 04. Serrated

18. Flake Scar Pattern
    - 00. Indeterminate
    - 01. Collateral
    - 02. Horizontal transverse
    - 03. Oblique transverse
    - 04. Random
    - 99. Not Applicable

19. Edge Construction Type
    - 00. Indeterminate
    - 01. Bifacial – distal
    - 02. Bifacial – bilateral
    - 03. Bifacial – unilateral
    - 04. Bifacial – distal – bilateral
    - 05. Bifacial – distal – unilateral
    - 06. Bifacial – circumferential
    - 07. Unifacial – distal
    - 08. Unif – bilat – conforming
    - 09. Unif – bilateral – opposing
    - 10. Unifacial – unilateral
    - 11. Unif – distal – bilateral-conform
    - 12. Unif – distal – bilateral-opp
    - 13. Unifacial – distal – unilateral
    - 14. Unifacial – circumferential
    - 15. Other
    - 99. Not applicable

20. Proximal edge grinding
    - ☐ Not observed
    - ☐ Observed

WEAR PATTERNING (macroscopic)

21. Flaking
    - 00. Not present
    - 01. Bifacial – distal
    - 02. Bifacial – bilateral
    - 03. Bifacial – unilateral
    - 04. Bifacial – distal – bilateral
    - 05. Bifacial – distal – unilateral
    - 06. Bifacial – circumferential
    - 07. Unifacial – distal
    - 08. Unifacial – bilateral - conform
    - 09. Unifacial – bilateral - opposing
    - 10. Unifacial – unilateral
    - 11. Unif – distal – bilateral-conform
    - 12. Unif – distal – bilateral-opposing
    - 13. Unifacial – distal – bilateral
    - 14. Unifacial – distal – unilateral
    - 15. Unifacial – circumferential
    - 16. Other

22. Crushing 24. Smoothing
    - 00. Not Present
    - 01. Distal
    - 02. Distal – lateral
    - 03. Unilateral
    - 04. Bilateral
    - 05. Facial smoothing
    - 06. Facet smoothing
    - 07. Circumferential
    - 08. Primary proximal
    - 09. Secondary proximal

25. Polish
    - 00. Not present
    - 01. Shallow distal (<5mm)
    - 02. Deep distal (>5mm)
    - 03. Shallow lateral (<5mm)
    - 04. Deep lateral (>5mm)
    - 05. Unifacial medial
    - 06. Bifacial medial
    - 07. Bipolar
    - 08. Proximal

26. Etching / Pitting
    - 00. Not present
    - 01. Shallow distal (<5mm)
    - 02. Deep distal (>5mm)
    - 03. Shallow lateral (<5mm)
    - 04. Deep lateral (>5mm)
    - 05. Unifacial medial
    - 06. Distal medial
    - 07. Circumferential
    - 08. Medial bifacial
    - 09. Bipolar

27. Hafting evidence
    - ☐ Not observed
    - ☐ Observed
    - ☐ Not Applicable

RAW MATERIAL

28. Lithology
    - 01. Unidentified Silex
    - 02. Microcrystalline Quartz
    - 03. Macrocrystalline Quartz
    - 04. Chalcedony
    - 05. Jasper
    - 06. Chert
    - 07. Chert-Chalcedony Blend
    - 08. Dolomite
    - 09. Agatized dolomite
    - 10. Fossilized Wood
    - 11. Limestone
    - 12. Silicified Limestone
    - 13. Ortho-Quartzite
    - 14. Meta-Quartzite
    - 15. Novaculite
    - 16. Rhyolite
    - 17. Basalt
    - 18. Serpentine / Greenstone
    - 19. Steatite (soap stone)
    - 20. Granite
    - 21. Marble
    - 22. Gneiss
    - 23. Schist
    - 24. Silt-stone
    - 25. Obsidian
    - 26. Manning Fused Glass
    - 27. Ironized sandstone
    - 96. Unidentified Sedimentary
    - 97. Unidentified Igneous
    - 98. Unidentified Metamorphic
    - 99. Other

29. Major Sources
    - 00. Unidentifiable
    - 01. Alibates (Llano Estacado)
    - 02. Antlers Formation
    - 03. Burro Mesa (Trans-Pecos)
    - 04. Bexar County chert
    - 05. Callahan Divide
    - 06. Caballos Mountain
    - 07. Central Mineral Region (Llano Uplift)
    - 08. Georgetown Cherts
    - 09. Edwards Chert
    - 10. Manning Fused Glass
    - 11. Markely Conglomerate
    - 12. Pisgah Ridge
    - 13. Rio Grande Gravels
    - 14. Tecovas Formation (cherts and jaspers)
    - 15. Yegua Gravels (quartzite and petrified wood)
    - 16. Uvalde Gravels
    - 17. Catahoula
    - 97. Unidentified local
    - 98. Unidentified exotic
    - 99. Other

Questions for Middle-Level and High-Level Theory Using Debitage Data

*** Many of these questions can be best or only answered with respect to complementary data from other material classes.**

QUESTIONS

1. What is being produced? (biface, blades, expedient flakes, points, etc... may be identified by class or type).

2. What techniques were used in its production? (bifacial reduction, prismatic core, bipolar reduction, channel flaking, etc...).

3. What part of the production process is represented by the available assemblage? (stage in trajectory).

4. What function was the objective piece meant to serve? (this deduction is generally only possible when waste can be related to finished products with observable use-wear, or production failures of known function)

5. How many were being made? (flake-to-tool ratios are inherently spurious without diagnostic flakes and researchers should be cautious when addressing this issue; raw material type differences may be valuable in establishing a minimum number objects produced)

6. Who was making it? (age, gender, and social status are typically central to this issue, and the question may be best addressed –if it is indeed possible to do so- with respect to the context and composition of deposit, and its association with identified activity areas)

7. How many people were involved in creating the assemblage and what was their relationship? (this assumes that the waste actually has the meaning that we assign to it and that variation in flaking is not the result of an ancillary feature in the manufacturing process such as raw material type and quality)

8. Is this where the constituent components of the assemblage originally entered the archeological record? (the integrity of deposit should be considered with respect to natural and cultural transformation processes, including disturbances and patterns of refuse disposal)

9. Was the product for immediate use? (consider degree of material curation, production stage, environmental setting, and degree of expediency in tool design)

10. Was the material easy to come by? (consider the local availability of the raw material, as well as the degree of material curation and conservation observed in the relative percentage of use-wear observed on flakes, and the degree to which tools are recycled)

11. Was the raw material easy to use? (this assessment of raw material quality may be addressed through error rates and thermal alteration, but also in consideration of the amount of material mass that remains when expended tools are discarded)

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