Folsom Lithic Procurement, Tool Use, and Replacement at the Lake Theo Site, Texas

Briggs Buchanan

ABSTRACT

Folsom technological organization is examined from the perspective of the Lake Theo site (41BI70). Lake Theo is a stratified, multi-component site located on the southern Plains. Lake Theo is unique in that it is the only Folsom bison kill on the southern Plains located in proximity to a high-quality chert source (Tecovas jasper). Analysis of the Folsom lithic assemblage recovered from the site focuses on defining patterns of raw material procurement, tool use, and manufacture. The results suggest lithic stores of transported chert were depleted and points and tools replaced over a number of retooling events. At the site, local raw materials were used expediently to aid in the processing of the kill and in the production of tools for future use. Tools transported to the site were made primarily of Edwards and Alibates chert. The assemblages of Edwards and Alibates exhibit different degrees of depletion and suggest a visit to Edwards quarries was made subsequent to a visit to Alibates quarries. It is postulated that Folsom groups may have hunted annually on the southern High Plains and traveled south and east toward the Edwards Plateau during the winter months.

Keywords: Paleoindian, Folsom, Technological Organization, Southern Plains.

Paleoindian Folsom sites dating between 10,200 and 10,900 B.P. (Haynes et al. 1992) are found throughout the Plains of North America. Folsom assemblages are distinctive, characterized by unique projectile points, fluting debris, and economical use of raw material to support highly mobile, focused exploitation of bison (Amick 1994). The distinctive nature of Folsom artifacts has allowed for the accurate recognition of Folsom occurrences in unstratified or mixed contexts. Documented Folsom points and sites, however, are relatively rare in occurrence (Largent et al. 1991). On the southern Plains in particular, Folsom is represented by only a relatively limited number of sites in sealed stratigraphic context (Barbour and Schultz 1941; Bement 1999a; Boldurian 1990; Harrison and Killen 1978; Hester 1972; Hill and Hofman 1997; Johnson 1987). Of these, the Lake Theo site (41BI70), located in Briscoe County, Texas, is unique in that it is the only site in the region located within a kilometer of a high-quality chert source (Tecovas Jasper). Lake Theo also is significant because both bison butchering and a potential campsite are reported (Harrison and Killen 1978; Harrison and Smith 1975). Lake Theo, therefore, provides a useful perspective for the examination of Folsom resource procurement.

The Lake Theo Site is a well-stratified site containing Folsom, Plainview and Archaic period occupations. Excavations at Lake Theo, conducted in 1974 and 1977 (Harrison and Killen 1978; Harrison and Smith 1975), concentrated on exposing a bison (Bison antiquus) bone bed in the Folsom level and a portion of the adjacent buried occupation. Nearly 3,000 lithic artifacts were recovered during excavations; however, only a select portion of the tools were reported and assigned to a specific occupation. The limited provenience information associated with the collection has severely restricted the interpretative potential of this important site. This study used available provenience information to reconstruct stratigraphic position and could confidently assign only 7% of the entire assemblage to the Folsom occupation.

The analysis of the assemblage focuses on examination of patterns of raw material procurement, tool use, tool manufacture, and the delineation activity areas at the site. Tools recovered from
the bonebed consist of damaged transported tools and expediently produced butchering implements made of local raw materials. Artifacts defined as transported, consisting of Edwards and Alibates artifacts, and as locally made, consisting of Tecovas chert and quartzite, were identified in the assemblage. Tools made of Edwards are significantly more abundant compared to Alibates and Tecovas tools and occur preferentially within the bonebed where they were either discarded or lost. Spatial analysis demonstrates that some processing activities along with tool production using local materials took place in the area surrounding the kill. Analysis of the debitage suggests that Tecovas chert was used for tool production and the recovery of several broken Tecovas preforms and points suggest points were manufactured for future transport.

The points found at the site are almost exclusively made of Edwards, suggesting that weapons were refurbished at an Edwards quarry prior to the occupation at Lake Theo. Alibates tools in the assemblage primarily are maintenance tools and represent an earlier visit to an Alibates quarry. As suggested by Hofman (1991), it is surmised from the Lake Theo data that the southern High Plains was visited annually by Folsom hunters in the summer and fall and in winter months groups probably moved south and east to the Edwards Plateau where lithic stores were refurbished.

These results are used to address expectations derived from Ingbar (1992) and Bement’s (1999b) modifications to Hofman’s (1992) model of Folsom technological variability on the southern Plains. Similar to the pattern described at the Hanson site in Wyoming (Ingbar 1992), the Lake Theo assemblage exhibits a pattern of segmented reduction. Ingbar (1992:187) suggests that this pattern is not only very predictable among Folsom sites but is widespread across the Plains as a result of many groups practicing similar mobility regimes. Data from Lake Theo provide additional evidence that Folsom groups from Wyoming to Texas practiced similar planned reduction strategies between raw material sources in an effort to have tools and raw materials on hand for a number of anticipated kills before returning to lithic source areas.

**PHYSIOGRAPHIC SETTING**

Lake Theo is located within what is now Caprock Canyon State Park on the Rolling Plains of Texas (Briscoe County) near the eastern escarpment of the southern High Plains (Figure 1). The site is situated on a Holocene terrace at the southern edge of Lake Theo, an artificial lake formed by the damming of Holmes Creek. Holmes Creek, a low-order tributary of the Red River, heads in the High Plains escarpment.

Archaeological materials were found along the eroding edges of the terrace that contains the site (Figure 2). The terrace is composed of a series of late Quaternary alluvial, floodplain, and eolian deposits. A number of soils have formed within these sediments, providing a complementary pedologic and geologic record of the late Quaternary.
Figure 2. Map of the Lake Theo site showing the location of the 1974 (shaded) and 1977 excavation units (numbered) and trenches (adapted from Harrison and Killen 1978:23, courtesy of the Panhandle-Plains Historical Museum, Canyon, Texas).

(Johnson et al. 1982). Geologic evidence suggested flowing water was maintained throughout the late Pleistocene and Holocene (Holliday 1997). The eastern escarpment of the southern High Plains forms the transition between the High Plains section of the Great Plains physiographic province and the Osage Plains section of the Central Lowland province (Figure 3; Fenneman 1931; Hunt 1974). The area, including southwestern Oklahoma and north-central Texas east to the escarpment of the southern High Plains, is known locally as the Rolling Plains. To the west, the south-
ern High Plains (Llano Estacado) is a broad plateau covering approximately 130,000 km$^2$ (Figure 1). Escarpments along the east, north, and west edges delineate the boundaries of the southern High Plains. To the south, the southern High Plains merges without any topographic demarcation with the Edwards Plateau (Holliday 1995). The southern High Plains has a virtually featureless constructive surface formed by thick Pleistocene eolian deposits of the Blackwater Draw Formation (Reeves 1976). These sediments overlie the Miocene-Pliocene alluvial and eolian sediments of the Ogallala Formation. The regional bedrock consists of Paleozoic and Mesozoic sedimentary rocks, deposited across a foundation of Permian and Triassic-age red beds (Meade et al. 1974). The sediments composing the southern High Plains are severely eroded and exposed along the eastern escarpment in a series of reentrant canyons, forming what is commonly referred to as the “breaks” (Rathjen 1973). It is within this ecotone that the site is situated.

Today, Lake Theo is located within the Llano Estacado Extension of the High Plains climatic region, an area classified as dry, mid-latitude, and semi-desert (Bomar 1995; Strahler and Stahler 1983). The southern High Plains climate is semiarid and continental, with relatively uniform gradients in precipitation and temperature across the region (National Oceanic and Atmospheric Administration 1982). Most of the precipitation, ranging from 35 cm to 50 cm (Bomar 1995), occurs during spring and summer thunderstorms. Mean annual temperature ranges from 13˚C (56˚F) in the northwest to 18˚C (64˚F) in the southeast (Bomar 1995). Annual precipitation and temperature vary considerably from year to year. Climatic conditions in the immediate vicinity of Lake Theo vary somewhat from the regional means with slightly lower precipitation and higher temperatures (Carr 1967).

**HISTORY OF RESEARCH AT LAKE THEO**

Diagnostic Folsom artifacts were located on the surface of the then privately-owned Lake Theo site and reported to members of the Panhandle-Plains Historical Museum (PPHM) who reconnoitered the site in October 1972. During the visit to the site, more Folsom artifacts were collected from the surface (Harrison and Smith 1975). Preliminary excavations on the private property in 1974, conducted by PPHM (Harrison and Smith 1975), revealed a bison kill/butchering locale on the northern edge of the terrace (Figure 2). The bonebed yielded several Folsom points and a variety of butchering tools. Above the Folsom bonebed, excavations uncovered Plainview and Archaic Period occupations, the extent of which remained undefined. Twenty-four 5-ft$^2$ (1.5-m$^2$) units were excavated, the majority of which were located in a block where the densest concentration of bone was exposed. In addition to the main block of units, seven units, spaced across the terrace, were excavated in an effort to delineate the extent of the Folsom occupation. Excavated matrix was passed through 1/4” screen mesh of which “... approximately half was worked through a 1/8” screen” (Harrison and Killen 1978:22). The distinct soil horizon that contained the Folsom bonebed was used as a marker for the Folsom occupation in the other excavation units.

Based on the recovery of mandibles, a minimum of 12 bison were killed and butchered at the site (Harrison and Smith 1975:74). Evidence from dentition studies by Todd et al. (1996) indicated...
Fall mortality. The configuration of the bonebed appeared to the excavators as if the bones were deposited in a swale more than 12 m long, running in a northwest to south-southeast direction. The bonebed was buried under 30 to 100 cm of sediment. The bones were in poor condition, exhibiting evidence of crushing, weathering, and chemical diagenesis (Harrison and Smith 1975:73). Preliminary analysis of the bone by Baxevanis (1997) revealed evidence of subaerial weathering, root etching, and carnivore gnawing. The subaerial weathering and carnivore activity suggests the bones were exposed for a period of time before burial. These taphonomic processes and problems with post-extraction deterioration contributed to the destruction of the majority of cortical surfaces, making identification of cultural modifications difficult. However, several of the bones exhibit cut marks and helical fractures (Baxevanis 1997).

During excavation of the bonebed an unusual feature constructed from bison bone was located (Harrison and Smith 1975). The feature was inadvertently cut in half during removal of part of the bonebed for a museum display. The feature consisted of a thoracic vertebral spine, a right femur, left and right tibiae, and three left mandibles placed distal-end down (except for the femur) in a pit. The bones were aligned in a circle, approximately 30 cm in diameter, within the pit that extended 30 cm below the level of the bonebed. Other artifacts recovered from excavation of the upper portion of the feature include a highly-deteriorated atlas, cuneiform, and a flake tool (A917-99) along with two small flakes (Harrison and Smith 1975:75-76). A skull fragment found above the feature suggested to the excavators that the feature might have been capped with a skull prior to deterioration (Harrison and Smith 1975:82). The feature was interpreted as a post-kill ritual. Other evidence for ritual activity on the southern Plains during the Folsom period is limited to a painted bison skull from the Cooper site (Bement 1999a).

Excavations were continued for a second field season in 1977, the goal of which was to define and expose more of the Folsom occupation (Harrison and Killen 1978). A total of 30.5 ft² (1.5 m²) units and two backhoe trenches were excavated. Most of the units were excavated along the western edge of the site (Figure 2). Recovered materials from the Folsom level in these units include bone fragments, lithic tools, and debitage. The two backhoe trenches, aligned east-west and north-south and both more than 20 m long, were used to remove the overburden above the Folsom level on the southern terrace (Figure 2). Lithic tools and debitage primarily were recovered from the trenches.

Stratigraphy and Radiocarbon Dating

The terrace that contains the site is composed of a series of late Quaternary alluvial, floodplain, and eolian deposits. A number of soils have formed within these sediments, providing a complementary pedologic and geologic record spanning the late Quaternary. Initial research described a generalized stratigraphic sequence and is reconstructed based on unit profiles from the 1974 excavation (Figure 4). The Folsom bonebed was found in the bottommost layer, described as “...tightly compacted dark brown sand” (Harrison and Smith 1975:73). The interpretation of the site’s stratigraphy was modified during the 1977 excavations. Five stratigraphic zones were described. Harrison and Killen’s (1978) Zone 5 corresponds to the Folsom level and was described as a “strong brown sandy loam.” Two profiles on the northern edge of the terrace were described using standard Soil Conservation Service nomenclature and sampled for analysis in 1981 (Johnson et al. 1982). Ten stratigraphic units and five superimposed soils were delineated (Figure 4). The Folsom bonebed is within a buried B horizon of the second stratigraphic unit (S2). The bonebed is buried in what is described as fine-grained overbank alluvium (Holliday 1997:159). Weakly developed argillic and calcic horizons were present in the buried B horizon containing the Folsom material. The higher organic carbon content and overall thickness of the buried A horizon above the Folsom occupation suggests rapid accumulation of organic materials on a slowly aggrading surface (Johnson et al. 1982).

The original radiocarbon dates reported from the site were on bone apatite from the Folsom level that yielded ages of ca. 8000 and 9400 B.P. (Harrison and Killen 1978: addendum). However, additional radiocarbon dates on humates and the geologic and pedologic evidence suggested to Johnson and others (1982) that the dates were er-
roneous. A radiocarbon sample from the lower half of the A horizon, corresponding to the Plainview occupation immediately above the Folsom occupation, was dated to ca. 10,000 B.P. A sample from the upper half of the same A horizon dated to ca. 9400 B.P. (Figure 4; Johnson et al. 1982). Humates from buried soils above and below the Plainview and Folsom stratigraphic unit yielded dates of ca. 5500 B.P. and ca. 11,000 to 11,900 B.P., respectively (Caran and Baumgardner 1986).

THE FOLSOM LITHIC ASSEMBLAGE

The number of lithics included in the analysis of the Folsom assemblage was limited due to a lack of provenience information associated with the majority of artifacts in the Lake Theo collection. Provenience information for lithic artifacts was recorded on excavation level forms. It is assumed that all tools identified during excavation were piece-point plotted, however, it is unknown if thedebitage sample mapped in place represents all thedebitage associated with the Folsom occupation. Non-diagnostic lithics without proper provenience could not be included in the analysis because they could not be assigned to one of the three or more subsequent occupations of the site. The majority (93% of 2,940 total) of lithics in the Lake Theo collection did not have any associated provenience information and were not included in this analysis.

Artifacts with associated vertical provenience, but lacking stratigraphic information, were plotted on unit profiles where possible to reconstruct the level from which they were recovered. Only 216 (7%) artifacts of the total lithic assemblage had associated provenience information where the stratigraphic unit from which they were recovered could be reconstructed. Of the 216 artifacts with provenience, 164 (76%, or 6% of total) were assigned to the Folsom occupation and were examined in this analysis. The Folsom assemblage consists of 40 tools and 124 pieces of debitage. The remaining 52 artifacts with provenience were from the overlying occupations at the site, the majority of which are associated with the Plainview occupation. Additionally, 23 lithic artifacts listed in the Lake Theo excavation reports (Harrison and Killen 1978; Harrison and Smith 1975), are missing from the collection and not included in this analysis. The missing tools include one biface from the 1974 excavation and 22 tools, including five scrapers, three gravers, two utilized flakes, and one scraper-graver, from the 1977 excavation.

TECHNOLOGICAL ORGANIZATION AND FOLSOM VARIABILITY

Technological organization is approached as the manner in which a specific technological strategy has been structured around the variability of resources (Binford 1979). Organization includes the selection and procurement of raw materials and strategies for making, using, transporting, maintaining, and discarding tools and the materials needed to make tools (Nelson 1991). Behavioral ecology can operate as the general explanatory...
framework for technological organization and provides theoretical rationale for behavioral mechanisms invoked in such models. Behaviors associated with technological organization are assumed to include some cost (time, energy, opportunity costs) and are linked to success in subsistence procurement providing benefit. Because natural selection favors organisms that maximize net fitness results it is assumed that the more efficient or optimal behaviors, in this case associate with technology, will be favored among the set of feasible existing strategies (Smith and Winterhalder 1992). Technological strategies in particular may be responsive to subsistence risk (probabilistic variation in returns; Stephens and Krebs 1986:128) and when the focus is on the pursuit and capture of mobile game, technological strategies may incur relatively increased costs in terms of transport, tool flexibility, and weapon reliability (Jochim 1981; Torrence 1989; Wiessner 1982).

The need to transport tools and raw material to use locations is a major constraint on the size and design of transported gear. The transportation of tools by mobile individuals, their “personal gear” (Binford 1977, 1979), is highly constrained by the size and weight of the raw materials that can actually be carried on a continual basis (Kuhn 1994; Shott 1986). Transported toolkits usually consist of a limited number and variety of tools that are lightweight and resistant to breakage. Due to the limitations presented by a transported toolkit, high conservation is expected to ensure that the proper number and kind of tools are available when needed. The strategy of planned transportation of tools to use locations has been characterized as a curated strategy (Binford 1973). Curation is a continuous property, measuring the relationship between a tool’s maximum available use and the actual use completed when discarded or lost (Shott 1996). Transported or curated tools should exhibit evidence of extensive use prior to discard and the corresponding debris should consist mostly of small resharpening flakes (Nelson 1991).

In contrast to curation, expedient strategies are characterized by minimal technological effort and are utilized when sufficient amounts of raw materials are on hand (Binford 1977). Expediency in the production of lithic tools implies not only abundance and availability of raw material but also the availability of time (Torrence 1989). In terms of a hunting strategy focused on mobile game, tools needed to procure game most likely are not made on the spot. Expedient tools are manufactured, used, and discarded at the location in which they are needed. Expedient strategies may include anticipating the placement of activities near a lithic source area embedded within the operation of other activities (Binford 1979). Expedient tools are produced for immediate tasks and, therefore, are designed less formally and should reflect their actual use when discarded. The occurrence of unretouched and marginally retouched flakes (Parry and Kelly 1986), percussion core reduction techniques, and cores in different stages of reduction not included in the transported toolkit are expected residual materials from an expedient strategy (Nelson 1991). Viewing expedient and curated strategies as fixed types limits the interpretative ability of the concepts because in reality technological organization is not represented entirely by one strategy. Expedient and curated technologies may even operate simultaneously as planning options vary according to current and anticipated risk.

Models of Folsom technological organization on the southern Plains are derived from the principles outlined above (Boldurian et al. 1987; Amick 1994, 1996; Hofman 1991, 1992). Folsom technology is characterized by a reliance on high quality raw materials and the use of bifaces to serve as efficient cores and tools (Kelly 1988). Folsom technology is viewed as responsive to the procurement of mobile bison and concomitant high mobility resulting in a curative approach to lithic transport (Boldurian 1990; Hofman 1991, 1992; Ingbar 1992). Hofman’s (1992) approach to this Folsom model assumes that hunters needed particular forms and sufficient numbers of tools to procure bison, an unpredictable resource. Toolkits are assumed to have been prepared at lithic sources in anticipation of future hunting episodes and discarded at the next source area for new tools. Between restocking at sources, a number of kill events and subsequent retooling activities may occur that deplete the amount of raw material and the form of tools in the toolkit. Following this scenario, the greatest conservatism in lithic use is expected to occur relatively close to a lithic source area when toolkits have been replenished. This is because
another visit to a lithic source area may be several weeks in the future and an unknown number of kill/retooling events may be anticipated before a lithic source is visited again.

To solve the problem of having a limited amount of raw material on hand and the need for an adequate number of points and tools for successful kill and processing events, Hofman (1992) hypothesizes the use of a large, generalized biface. Based on Kelly’s (1988) idea of a multipurpose biface, the model assumes bifaces are used as cores, implements, and eventually reduced to projectile points. Hofman (1992) suggests that any formal tools in the transported toolkit may follow a pattern of use and replacement via blanks derived from generalized bifaces. Bement (1999b) has added an important caveat to Hofman’s model in stressing that examination of only projectile points may lead to a faulty estimation of a group’s lithic stores. Bement (1999b:119) suggests that examination of the non-point tool assemblage in tandem with the projectile point assemblage should provide a better estimate of the degree to which lithic stores have been depleted because points may not necessarily be replaced after every kill event. Depleted lithic stores in this case only may be reflected in the non-point tool assemblage.

Several expectations for variability in Folsom toolkits follow from Hofman’s (1992) model of the segmented reduction of different tools. A number of projectile points are lost or broken after each kill event and subsequently repaired or replaced, changing the configuration of points in an assemblage. The number and size of bifacial cores in a toolkit is depleted continually through a sequence of kill/retooling events. Due to the reduction of large bifaces as cores and their eventual use as a variety of tools, evidence of the larger forms in the archaeological record is expected to be rare. The number of flake blanks derived from bifacial cores increases as cores are depleted after kill events.

Hofman’s (1992) model discusses expectations for technological variability at sites distant from lithic source areas, such as the Shifting Sands, Lipscomb, and Cedar Creek Folsom sites. As expected a strongly differentiated pattern of raw material utilization occurs at these activity locales. A unique aspect of the Lake Theo site, however, is its proximity to a high-quality chert source (Tecovas Jasper). Ingbar (1992) discusses expectations for the lithic assemblage from the Hanson site; a Folsom camp-workshop located near a chert source on the northern Plains of Wyoming. Ingbar (1992:174) hypothesizes that if Folsom raw material procurement is embedded within a mobility framework then discarded toolkits at or near lithic source areas should exhibit the same pattern of segmented reduction as discarded tools at activity sites far from source areas. With raw material available close by depleted or broken equipment made from non-local sources should be discarded for fresh equipment made from locally available materials. Ingbar’s (1992) analysis of the Hanson assemblage demonstrates a differential pattern of raw material utilization as expected and he suggests that this pattern is widespread across the Plains resulting from many groups with similar mobility regimes. This pattern is not considered to be uniquely Folsom, but, extraordinary to the degree in which it is expressed. Lake Theo is in a similar setting as the Hanson site and provides an opportunity to test the expectations of the Folsom model and to test the geographical extent of the expected pattern.

**METHODOLOGY**

Analysis of the lithic assemblage is structured in an effort to infer dynamic behaviors involved in technological organization. To infer behaviors associated with technological organization, all classes of lithic artifacts are analyzed and related to analogical concepts (Amick et al. 1989). Analogical concepts are used to link modern processes, described through experimental and ethnographic observations, with patterning in the archaeological record to infer behavior.

To facilitate the analysis of technological organization, the source area for each artifact was determined where possible. The nature and distribution of lithic resources within a region has been cited as one of the critical factors that affects the organization of technology (Bamforth 1986) and identification of specific sources is necessary in determining the selection, procurement, and possible origin of variability within assemblages. The distribution of lithic sources on the southern Plains is highly uneven and localized (Holliday and Welty 1981), making sourcing possible and relevant.
Within the southern Plains region, five major geologic units contain rocks suitable for tool manufacture: Quartermaster Formation, Dockum Group, Dakota Formation, Edwards Group, and Ogallala Formation (Holliday and Welty 1981). Of particular importance in this study are the three primary high-quality cherts available from these units: Alibates agate from the Quartermaster Formation, Tecovas jasper from the Dockum Group, and Edwards chert from the Edwards Group. Primary outcrops of Alibates occur along the northern edge of the southern High Plains in the Canadian River drainage, approximately 115 km northwest of Lake Theo (Hofman 1991:341). Tecovas source areas are located near the eastern edge of the southern High Plains in the vicinity of Lake Theo. A prehistoric Tecovas quarry site (PPHM site A545) is documented 1.2 km from Lake Theo and 17 other Tecovas quarry sites have been located in the area surrounding the site (Hughes and Willey 1978). Edwards is found in Cretaceous limestone deposits that occur in the eastern portion of the Edwards Plateau of Central Texas. The outcrop of Edwards nearest to Lake Theo is approximately 200 km southeast of the site near Abilene, Texas (Hofman 1991:341).

Other raw materials commonly found in prehistoric lithic assemblages and relevant to this study include chalcedony, quartzite, and sandstone. Sources for chalcedony, a rock consisting of fibrous quartz, have not been identified in the region. Quartzite occurs in the vicinity of Lake Theo within the Dockum Group. All quartzite artifacts recovered from the site exhibit various shades of red, brown, and white and are assumed to have derived from exposures in proximity to the site. Quartzite does not possess the same fracture qualities as chert, but is superior for certain types of tasks, usually heavy-duty chopping or scraping activities. Sandstone also occurs locally, although not suitable for tasks requiring sharp edges, and has been recovered from prehistoric sites where it is inferred to have been used for grinding or abrading tasks.

The analysis of tools, intentionally flaked and utilized artifacts consisting of unifaces and bifaces, included determinations of production, form, and function. Additionally, cores and non-flaked tools such as abraders were included in this analysis. Analysis of tool production included recording evidence of platforms or flake remnants, location and percentage of cortex, and the number and orientation of flake scars. The length, depth, and character of tool retouch were recorded where applicable. Examination of tool form is used to document variation within and between tool types. Tool function is inferred using attributes related to morphology, low-power (up to 100x) use-wear analysis (Odell and Odell-Vereecken 1980) to determine presence or absence of wear (Newcomer et al. 1986, 1988; Vaughn 1985:23), and edge angle (Wilmsen 1974). Linear dimensions were recorded for all specimens. Additional dimensions were recorded for projectile points, including width and depth of basal concavities, dimensions of flutes, and length of edge grinding.

Debitage analysis is relevant to defining the nature of activities at a site and how the organization of tool production systems may have related to other aspects of cultural activity (Collins 1975), as debitage can register the kinds and amounts of tool production and use that tools themselves may not (Shott 1994). Attributes of weight and size are recorded for all flakes (sensu Crabtree 1972) and weight is recorded for all debris. Flake features, such as platform lipping, bulbs of force, and undulations, are used to orient specimens for dimensions to be properly recorded. Raw material type and source location where applicable are recorded for all debitage. Type of striking platform is determined to identify reduction strategies employed (Frison and Bradley 1980). Properties of flake formation, particularly initiation, are defined to indicate basic flake types and possible modes of detachment (Cotterell and Kamminga 1987).

**ANALYSIS RESULTS**

The Folsom lithic assemblage from Lake Theo consists of 14 projectile points, 2 preforms, 24 tools, 67 flakes, and 57 pieces of debris. Chert tools and debitage were used almost to the exclusion (88%) of other raw material types (Table 1). A chi-square analysis of the frequencies of raw material types demonstrates there is no significant difference between tool and debitage proportions of different raw materials ($\chi^2 = 7.73$, $df = 3$, $p = .052$). The equivocal significance level is due primarily to the number of sandstone tools ($d = 2.18$ for sandstone tools, the only significant adjusted standard-
As sandstone flaking is rare and the tools that are represented are ground or abraded, a significant abundance of sandstone tools compared to debitage is reasonable.

Chert from three known sources, Tecovas, Alibates, and Edwards, comprise 93% of the chert assemblage (Table 2). Tecovas artifacts, as expected due to the proximity of quarries, are represented in the largest proportion (64%). Tecovas artifacts are represented primarily by debitage. Artifacts made of Edwards (19%) rank second in terms of representation, followed by Alibates (10%), even though Alibates quarries lie approximately 85 km closer to the site than Edwards Formation outcrops. Nearly two-thirds of the Edwards artifacts recovered were tools. Chert artifacts not identifiable to a specific source constitute the smallest portion of the assemblage (7%) and consist of debitage.

To determine if differences in the frequencies of cherts from the various source areas are significant across general artifact type (debitage compared to tools), a chi-square test for homogeneity of proportions is presented (Table 2). The null hypothesis is that there are no differences in the frequencies of different cherts, other than those expected as a result of sample size. The p-value for the chi-squared test is highly significant, which leads to the rejection of the null hypothesis ($X^2 = 40.19$, $df=3$, $p = .000$). Additionally, two cells with expected counts of less than five in the approximation produces more conservative results (Drennan 1996:195; Sokal and Rohlf 1995:702). The data strongly indicate there are differences in the types of chert represented in debitage and tools. Examination of the adjusted standardized residuals of the chi-square values indicates that Edwards debitage is significantly underrepresented and Edwards tools are significantly over-represented in the assemblage (Table 2). This dichotomous representation of Edwards

### Table 1. Raw material distribution for all debitage and tools.

<table>
<thead>
<tr>
<th>Chert</th>
<th>Chalcedony</th>
<th>Quartzite</th>
<th>Sandstone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debitage</td>
<td>113</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Tools</td>
<td>32</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>145</td>
<td>3</td>
<td>14</td>
</tr>
</tbody>
</table>

### Table 2. Chi-square analysis of the frequency of debitage and tools by chert source.

<table>
<thead>
<tr>
<th>Artifact Type</th>
<th>Raw Material Type</th>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
<th>$X^2$ Value</th>
<th>Adjusted Standardized Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debitage</td>
<td>Edwards</td>
<td>10</td>
<td>21.04</td>
<td>5.79</td>
<td>-2.46*</td>
</tr>
<tr>
<td></td>
<td>Alibates</td>
<td>9</td>
<td>11.69</td>
<td>0.62</td>
<td>-0.80</td>
</tr>
<tr>
<td></td>
<td>Tecovas</td>
<td>84</td>
<td>72.48</td>
<td>1.83</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>10</td>
<td>7.79</td>
<td>0.62</td>
<td>0.80</td>
</tr>
<tr>
<td>Tools</td>
<td>Edwards</td>
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<td>5.96</td>
<td>20.46</td>
<td>4.89***</td>
</tr>
<tr>
<td></td>
<td>Alibates</td>
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<td>3.31</td>
<td>2.19</td>
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<td>Tecovas</td>
<td>9</td>
<td>20.52</td>
<td>6.47</td>
<td>-3.60***</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>0</td>
<td>2.21</td>
<td>2.21</td>
<td>-1.53</td>
</tr>
</tbody>
</table>

$X^2 = 40.19$

Critical Value $(3, .05) = 7.815$

*Note: Adjusted standardized residual values followed by * indicate statistical significance at the .05 level and *** indicate statistical significance at the .001 level. A negative residual indicates fewer than expected artifacts while a positive number indicates greater than expected artifacts.
Seven of the points, six made of Edwards and one of Alibates, were recovered from the bonebed. The seven points recovered from the bonebed include two complete points, three distal segments, one mesial fragment, and a basal ear. The smallest of the complete points (A917-40; Figure 5a) was resharpened heavily with only 7.5 mm of a functioning distal tip remaining above its ground lateral edges. The other complete point (A917-79; Figure 5b) from the bonebed also appears to have been resharpened. The other Edwards points are fragments that probably were broken during the kill event or subsequent processing of the kill and discarded or lost. The Alibates point (A917-46 & 49) is represented by two refitting fragments recovered from within the bonebed approximately 2.5 m apart. The two fragments, split by a transverse fracture, form the medial and distal portion of a point. The point is larger in all dimensions than the other Folsom points and is roughly lenticular in cross section and appears unfluted. Grinding on the specimen’s lateral edges suggests the fracture occurred above a haft and a small impact fracture on its distal tip indicates the artifact was used as a point.

Table 3. Distribution of tool types by raw material type or source.

<table>
<thead>
<tr>
<th>Tool class</th>
<th>Number</th>
<th>E</th>
<th>A</th>
<th>T</th>
<th>C</th>
<th>Q</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projectile point</td>
<td>14</td>
<td>11</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Preform</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Biface</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>End-side scraper</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Convex side scraper</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Combination scraper-graver</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Combination notch-graver-denticulate</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Utilized flake</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Core</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Hammerstone</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Total</td>
<td>40</td>
<td>17</td>
<td>6</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: E=Edwards; A=Alibates; T=Tecovas; C=Chalcedony; Q=Quartzite; S=Sandstone.
Table 4. Lake Theo projectile point data.

<table>
<thead>
<tr>
<th>Artifact (A917-)</th>
<th>General Provenience</th>
<th>Material</th>
<th>Condition</th>
<th>Length</th>
<th>Width</th>
<th>Thickness</th>
<th>Weight</th>
<th>Basal Width</th>
<th>Basal Concavity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface T</td>
<td>3</td>
<td>29.25</td>
<td>23.48</td>
<td>4.18</td>
<td>2.65</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Surface E</td>
<td>4</td>
<td>14.68</td>
<td>15.94</td>
<td>2.60</td>
<td>0.55</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Bonebed E</td>
<td>3</td>
<td>32.31</td>
<td>22.34</td>
<td>4.37</td>
<td>3.71</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Bonebed E</td>
<td>1</td>
<td>29.57</td>
<td>18.52</td>
<td>3.56</td>
<td>2.69</td>
<td>17.81</td>
<td>1.53</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Bonebed E</td>
<td>2</td>
<td>14.79</td>
<td>13.45</td>
<td>2.69</td>
<td>0.51</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>46+49</td>
<td>Bonebed A</td>
<td>6</td>
<td>58.68</td>
<td>28.01</td>
<td>5.20</td>
<td>8.72</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>Bonebed E</td>
<td>1</td>
<td>46.20</td>
<td>20.62</td>
<td>4.46</td>
<td>4.92</td>
<td>19.48</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>93</td>
<td>Bonebed E</td>
<td>4</td>
<td>11.61</td>
<td>14.25</td>
<td>3.13</td>
<td>0.50</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>103</td>
<td>Bonebed E</td>
<td>6</td>
<td>48.73</td>
<td>25.82</td>
<td>4.05</td>
<td>5.58</td>
<td>-</td>
<td>-</td>
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<tr>
<td>114</td>
<td>Surface E</td>
<td>1</td>
<td>35.64</td>
<td>20.62</td>
<td>3.60</td>
<td>3.03</td>
<td>18.58</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>Surface T</td>
<td>3</td>
<td>23.78</td>
<td>24.96</td>
<td>3.44</td>
<td>2.55</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>Test unit E</td>
<td>5</td>
<td>30.27</td>
<td>20.19</td>
<td>3.57</td>
<td>2.28</td>
<td>20.19</td>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>530</td>
<td>Surface E</td>
<td>2</td>
<td>14.84</td>
<td>20.18</td>
<td>3.62</td>
<td>1.39</td>
<td>18.82</td>
<td>1.88</td>
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<td>531</td>
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<td>29.13</td>
<td>23.43</td>
<td>4.42</td>
<td>4.44</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Note: All measurements in millimeters or grams. Material: E=Edwards; A=Alibates; T=Tecovas; Condition: 1=complete; 2=proximal; 3=mesial; 4=distal; 5=mesio-proximal; 6=mesio-distal.
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was broken transversely across its midsection and subsequently used in the haft as a scraping tool, as indicated by the pattern of use-wear and 70° angle of the distal edge. Two medial fragments (A917-1 and A917-115; Figure 6b, 6c) made of Tecovas were found on the surface south of the bonebed suggesting that some point production occurred at or near the site. Both Tecovas point fragments were ground on their lateral edges, indicating they were completed points prior to breakage.

Variability in projectile point size is difficult to assess given the small sample (n = 3) of complete points. Comparison of the corrected coefficient of variation for linear dimensions taken on the points demonstrates that length is the most variable of dimension (Table 5). Comparison of basal measurements, using a sample of five complete bases, indicates that basal concavity is most variable and basal width the least variable of the mea-

Table 5. Folsom point variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Range</th>
<th>X</th>
<th>s</th>
<th>cv</th>
<th>cv*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>3</td>
<td>29.57-46.20</td>
<td>37.14</td>
<td>8.42</td>
<td>22.7</td>
<td>24.6</td>
</tr>
<tr>
<td>Width</td>
<td>3</td>
<td>18.52-20.62</td>
<td>19.92</td>
<td>1.21</td>
<td>6.1</td>
<td>6.6</td>
</tr>
<tr>
<td>Thickness</td>
<td>3</td>
<td>3.56-4.46</td>
<td>3.87</td>
<td>0.51</td>
<td>13.1</td>
<td>14.2</td>
</tr>
<tr>
<td>Basal concavity</td>
<td>5</td>
<td>1.53-3.06</td>
<td>2.27</td>
<td>0.63</td>
<td>27.6</td>
<td>29.0</td>
</tr>
<tr>
<td>Basal width</td>
<td>5</td>
<td>17.81-20.19</td>
<td>18.98</td>
<td>0.90</td>
<td>4.8</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Note: n=number of observations; X=mean; s=standard deviation; cv=coefficient of variation; cv*=corrected coefficient of variation.
surements. These findings complement the results of Judge’s (1973) analysis of Folsom points from the Rio Grande Valley of New Mexico. Judge (1973:171-172) suggests that basal width is the least variable dimension due to standardization of the hafting element. Flute scars are present on 11 of the 14 points, including the three complete points and eight of the point fragments. Three points, one complete and two fragmented, exhibit two flutes on one face. All but one of the points is fluted on at least one face.

Two fractured preforms, possibly broken during fluting, were recovered from the site. One was made of Tecovas chert (A917-132) and recovered adjacent to the bonebed; the other (A917-382) was made of chalcedony and recovered in the north-south trench. Six bifaces were recovered from the site, half of which were made of Edwards. The biface fragments made of Edwards were recovered from within or adjacent to the bonebed. The other bifaces were recovered from the east-west trench and a unit on the western edge of the site. Two of the Edwards bifaces (A917-64 and A917-70; Figure 7a, 7b) appear to be fragments from larger bifacial implements. The bifaces are both thin (4.00 mm and 5.29 mm, respectively) and have edge angles of approximately 30˚, both tools may have been used for cutting tasks requiring a very sharp edge such as the filleting of meat (similar to ultrathin bifaces described in Root et al. 1999). One of the broken bifaces (A917-64; Figure 7a) exhibits use-wear in the form of a notch on the fractured edge indicating the biface was used as a tool after breakage. The biface may have been intentionally broken in an effort to recycle a flawed piece or to create different tools. Root et al. (1999) document the reuse of bifaces in this manner in the Bobtail Wolf collection from North Dakota. The other Edwards biface (A917-1395) was found in sediments adhering to bone from the bonebed during stabilization efforts of the collection (Baxevanis 1997). This biface, made from a flake still retains the striking platform from which it was detached. Edge angle and edge damage suggests the biface was used for cutting tasks. A proximal fragment of a Tecovas biface (A917-172) may have been broken during the initial stages of thinning and regularizing (Frison and Bradley’s [1980:46] stage 2); a transverse fracture along its midsection ended the reduction. A thick Tecovas quartzite biface fragment (A917-267) also was fractured during initial reduction. The final biface (A917-516) originally was identified as an Eden point by the excavators (Harrison and Killen 1978:53), but the heavy reworking and fractured nature of the biface makes identification difficult.

Three end scrapers and a convex side scraper were recovered from the site. An end scraper
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(A917-97) and the convex side scraper (A917-343; Figure 8a) are made of Edwards and recovered from the bonebed and a unit on the western edge of the site, respectively. The Edwards end scraper is a small proximal fragment. The convex side scraper is a large flake exhibiting multiple, overlapping retouch episodes. The other end scrapers (A917-171 and A917-517) were made of Alibates. One was a proximal fragment recovered from the east-west trench and the other was a complete specimen recovered from a unit on the western edge of the site. Both scrapers were made from thick flakes and exhibit evidence of resharpening.

Four multifunctional tools, three combination scraper-gravers and a notch-graver-denticulate tool, were recovered. One scraper-graver (A917-99; Figure 8b) is made of Edwards and was recovered from the bonebed. The other tools, scraper-gravers made of Tecovas (A917-311) and of Alibates (A917-312), were recovered from units on the western edge of the site. The multifunctional notch-graver-denticulate (A917-170; Figure 8c), made of Alibates and recovered from a unit on the western edge of the site, exhibits at least eight functional units including four notches, two gravers, and two serrated edges.

Only three utilized flakes were recognized in the collection. The paucity of utilized flakes may be due to the small debitage sample. A large utilized flake (A917-94) made of Tecovas quartzite was recovered from the bonebed. Cortex is present along a thin edge of the dorsal surface of the flake and a slightly serrated edge along the opposite edge of the flake suggests it may have been used for sawing or cutting tasks. The remaining utilized flakes (A917-220 and A917-270) are made of Tecovas and were recovered from units on the western edge of the site. One of the utilized flakes (A917-270) is a large (107 mm by 39 mm) primary flake exhibiting a crushed platform and slight use-wear along one margin.

Two artifacts identified as chopping implements were recovered from the bonebed. Chopping implements are large tools inferred to have been employed in heavy-duty tasks and exhibit extensive use-related edge damage. One chopper (A917-96; Figure 9a) is a split Tecovas quartzite cobble and the other (A917-104) is a Tecovas chert implement. Both implements have one damaged edge opposite a cortical surface. The utilized edges exhibit numerous large step-terminated flake scars and angles exceeding 60°. Only two cores were recovered from the site. Both are made from local material, one is made of Tecovas chert (A917-180/12; Figure 9b) and the other is of quartzite (A917-257/4), and exhibit multidirectional flake scars. The cores were found in units along the western edge of the site. Other tools recovered include a

Figure 8. (a) side-scraper A917-343; (b) multifunctional tool A917-99; (c) multifunctional tool A917-170.
DEBITAGE

A total of 124 pieces of debitage, 67 flakes and 57 pieces of debris, constitute the debitage assemblage. The debitage consists predominantly of chert (91%) with a small proportion of quartzite (7%) and chalcedony (2%). The most abundant chert represented is Tecovas (74%; Table 6). A chi-square analysis was employed to determine if significant differences exist between flakes and debris of the source-identified chert artifacts. The null hypothesis is that there is no difference. The chi-

Table 6. Distribution of debitage by raw material type or source.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>E</th>
<th>A</th>
<th>T</th>
<th>Q</th>
<th>C</th>
<th>SU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flakes</td>
<td>67</td>
<td>6</td>
<td>5</td>
<td>48</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Debris</td>
<td>57</td>
<td>4</td>
<td>1</td>
<td>36</td>
<td>3</td>
<td>0</td>
<td>13</td>
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<td>Total</td>
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<td>10</td>
<td>6</td>
<td>84</td>
<td>10</td>
<td>2</td>
<td>12</td>
</tr>
</tbody>
</table>

*Note: E=Edwards; A=Alibates; T=Tecovas; Q=Quartzite; C=Chalcedony; SU=Source Unknown.*
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Table 7. Average flake dimensions by chert source.

<table>
<thead>
<tr>
<th>Chert Source</th>
<th>n</th>
<th>mean Length (sd)</th>
<th>mean Width (sd)</th>
<th>mean Thickness (sd)</th>
<th>Thickness (sd)</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edwards</td>
<td>6</td>
<td>8.47 (4.20)</td>
<td>6.88 (2.95)</td>
<td>1.20 (0.48)</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>Alibates</td>
<td>5</td>
<td>19.42 (12.27)</td>
<td>12.47 (7.24)</td>
<td>2.63 (1.97)</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>Tecovas</td>
<td>48</td>
<td>27.43 (13.93)</td>
<td>24.80 (12.37)</td>
<td>4.74 (2.68)</td>
<td>211.6</td>
<td></td>
</tr>
</tbody>
</table>

Note: All measurements in millimeters and grams. sd=standard deviation.

To determine if significant differences exist in the mean length, width, thickness, and weight of chert flakes from the Tecovas, Edwards, and Alibates sources one-way analysis of variance (ANOVA) tests were performed on each variable. The results suggest that significant differences exist between the mean length, width, and thickness of chert flakes from each chert source (Table 8). No significant difference was found between the mean weights of chert from the three sources. Multiple comparisons of the means using the Bonferroni adjustment method ($FER = 100[1-a/c]$%) was used to determine which means were different in the significant ANOVA tests. In all three significant cases, length, width, and thickness, there is sufficient evidence to conclude that the means of Tecovas flakes are significantly larger than Edwards flakes, but insufficient evidence to con-

Figure 10. Flake length plotted against weight by chert source.

square value of 1.593 is less the critical value of 5.99, suggesting that the null hypothesis cannot be rejected at a significance level of .05 ($X^2 = 1.593$, $df = 2$, $p = .451$). That is, the data suggest there is no significant difference in the frequency of flakes or debris across chert artifacts identified to a particular source.

Flakes
The flake assemblage (n=67) is composed primarily of chert (83%), the most common type of which is Tecovas (81%; Table 6). Comparison of flake dimensions by chert source indicates that flakes of Tecovas are the largest and most variable in size and represent the largest total weight (Table 7; Figure 10). Flakes from distant sources, Edwards and Alibates, are smaller in size and represent approximately 2% of the total chert weight.
ated by bending, an initiation associated with soft-hammer or pressure flaking (Table 9; Cotterell and Kamminga 1987). Edwards flakes mostly exhibit reduced platforms, a common preparation technique for pressure flaking (Table 10; Frison and Bradley 1980). Five of the six Edwards flakes were recovered from sediment adhering to bones removed from the bonebed. The sediment was left adhering to the bones over the past two decades and was removed during recent stabilization efforts of the collection (Baxevanis 1997). The Edwards flakes probably were detached in resharpening episodes during processing of the kill. Platform types on the Alibates flakes are more varied but indicate later stages of removal (Table 10). The Tecovas flakes probably represent various stages of core reduction and tool manufacture as represented by the various initiation types, platform types, presence of cortex, and variable length to width ratios (Figure 10).

Debris

Of the 57 pieces of debris, the majority was identified as Tecovas chert (63%; Table 6). Examination of the total weight of debris by raw material source indicates that Tecovas chert is the largest proportion in terms of weight (Table 11). Debris made of local raw materials (Tecovas chert and quartzite) comprises the largest proportion of the total debris weight (75.3%). Comparison of Edwards and Tecovas debris weights (omitting Alibates because only one piece of debris is represented) is undertaken using the Mann-Whitney test. The non-parametric Mann-Whitney two-sample procedure is preferable because two outliers in the Tecovas debris, still present after transformation, violate the assumptions of the t-test. The data suggest a significant difference exists between the median weights of Tecovas and Edwards debris ($W = 798.5, p = 0.0068$). The median Tecovas debris is between 0.485 and 5.636 grams heavier than the median Edwards debris.

SPATIAL DISTRIBUTION

The relationship between tool types, debitage, and raw material types, and their patterns of distribution and association between
artifacts and features of the site are examined. Two spatially and possibly functionally distinct areas of the site, the main block of excavation in the bonebed and the units on the western edge of the site and the backhoe trenches, are used to delineate areas of the site and facilitate the discussion of spatial patterning. A total of 16 tools were recognized in the bonebed and 18 tools in the adjacent buried occupation surface. Additionally, six Folsom points were recovered from the surface of the site along with a variety of non-diagnostic tools. Six different tool types were recognized in the tool assemblage from the bonebed and nine types from the adjacent buried occupation. A Chi-square analysis of the number of tools in the bonebed compared to the adjacent buried occupation by the frequency of Edwards, Alibates, and Tecovas chert types present shows that a significant difference exists ($X^2 = 12.47$, $df = 2$, $p = .002$; Table 12). A significant difference was found even though four cells had expected counts of less than five suggesting these results are conservative (Drennan 1996:195). Examination of the adjusted standardized residuals demonstrates that the bonebed has significantly more Edwards tools and the adjacent buried occupation has significantly less Edwards tools than expected.

The overall distribution of lithics reveals a number of concentrations (Figure 11). Two clusters are located in the units on the western edge of the site, one cluster is located where the trenches meet, and one cluster occurs within the bonebed. The tools discarded or lost within the bonebed include numerous projectile points and butchering tools consisting of choppers, scrapers, utilized flakes, and bifacial knives (Figure 12). The majority of points and tools occur within the densest concentration of bone. The points almost exclusively are made of Edwards, with one exception made of Alibates. Impact scars were present on four of the points within the bonebed. The butchering tools are large, expeditiously produced choppers and utilized flakes made of locally available Tecovas chert and quartzite. The choppers were probably employed for butchering tasks such as separating joints or cutting through muscle masses. The debitage recovered

<table>
<thead>
<tr>
<th>General Provenience</th>
<th>Raw Material Type</th>
<th>Observed Frequency</th>
<th>Expected Frequency</th>
<th>$X^2$ Value</th>
<th>Adjusted Standardized Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonebed</td>
<td>Edwards</td>
<td>11</td>
<td>6.5</td>
<td>3.12</td>
<td>2.04*</td>
</tr>
<tr>
<td></td>
<td>Alibates</td>
<td>1</td>
<td>3</td>
<td>1.33</td>
<td>-1.23</td>
</tr>
<tr>
<td></td>
<td>Tecovas</td>
<td>1</td>
<td>3.5</td>
<td>1.79</td>
<td>-1.44</td>
</tr>
<tr>
<td>Adjacent buried</td>
<td>Edwards</td>
<td>2</td>
<td>6.5</td>
<td>3.12</td>
<td>-2.03*</td>
</tr>
<tr>
<td>occupation</td>
<td>Alibates</td>
<td>5</td>
<td>3</td>
<td>1.33</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>Tecovas</td>
<td>6</td>
<td>3.5</td>
<td>1.79</td>
<td>1.44</td>
</tr>
</tbody>
</table>

$X^2 = 12.47$

Critical Value $(2, .05) = 5.991$

*Note: Adjusted standardized residual values followed by * indicate statistical significance at the .05 level. A negative residual indicates fewer than expected artifacts while a positive number indicates greater than expected artifacts.*
from the bonebed is limited. The majority of flakes are made of Edwards and are small flakes detached during tool use or resharpening.

The other artifact concentrations are composed of a wider variety of tools used in the production of tools and the processing of bison. One concentration on the western edge of the site consists of a hammerstone, an abrader, a possible anvil, a core, a biface, a multifunctional tool, and a scraper. Tool manufacture is indicated by the presence of a hammerstone, a core, and scattered debitage and from an abrader that may have been used for grinding of tool edges during the manufacturing process. The possible anvil, a large sandstone slab, may have been used to break bison bones for marrow extraction, an activity documented from bones recovered from the bonebed (Baxevanis 1997). Numerous bone fragments were recorded in the area surrounding the sandstone slab, but analysis of the specific fragments could not be completed due to a lack of provenience information. The other concentration of tools on the western edge of the site is smaller and consists of a core, a scraper, and a biface all made of local material and suggests that tool production and bison processing also may have occurred in this area. The cluster of artifacts in the trenches consists of scrapers, gravers, and debitage.

Examination of the vertical distribution of artifacts reveals that the paleotopography of the site may have sloped from the south and west to the north and east. The vertical distribution (more than 30 cm) also suggests either the vertical movement of artifacts or the possibility of more than one occupation due to the vertical span between artifacts.

**DISCUSSION**

Identifying tools that have been transported to a site is critical to the assessment of technological organization. The Lake Theo assemblage is discussed in terms of transported assemblages (Edwards and Alibates) and a local assemblage (Tecovas) to highlight differences in raw material use.

The transported Edwards assemblage consists of points, bifaces, scrapers and combination scraper-graver tools. Tools made of Edwards were represented significantly more than Alibates or Tecovas in the entire chert assemblage. The majority (65%) of the Edwards tools recovered are weapons. Most of the Edwards tools were heavily damaged, resharpened, and exhibit extensive use.
More than half (65%) of the Edwards tools were recovered within the bonebed. Several of these tools, however, do not appear to be exhausted completely in terms of their potential utility suggesting that regardless of their remaining utility they were abandoned for new tools made of local raw material. Alternatively, loss of points within the bonebed is a possibility. Three points (two made of Edwards and one made of Alibates), of which two were distal-medial fragments that could have been reworked, were recovered within the area of highest density in the bonebed, covering approximately 56 m² (600 ft²) and containing the remains of at least 12 bison. That is a carcass density of about 0.2 bison per m², or about one bison per 5 m². The Lake Theo maximum bison density falls almost midway between the carcass densities reported for the Folsom site, described as disperse with one bison per 10 m², and the Lipscomb site, described as dense with one bison per 2 m², and suggests comparatively average carcass dispersion (Hofman 1999:126-128). It is possible that the large points recovered from the area of the highest density of bone were lost and the remaining points made of Edwards were discarded intentionally.

Nearly all of the projectile points in the assemblage were made of Edwards and vary considerably in size. No evidence of large bifacial cores was found in the collection. The recovered Edwards bifaces were too thin to have served as cores and were probably used for light cutting tasks such as the filleting of meat. Edwards debitage was significantly underrepresented in the assemblage and flakes made of Edwards were found to be smaller in length, width, and thickness than Tecovas flakes and Edwards debris weighed significantly less than Tecovas debris. Edwards flakes are interpreted as resharpening flakes.

Tools made of Alibates include a point, a biface, scrapers, and two multifunctional tools. Alibates tools and debitage are represented in expected proportions compared to Edwards and Tecovas. Alibates tools also were recovered in expected proportions in the bonebed and adjacent buried occupation indicating that Alibates tools were used in the bison kill and subsequent processing. Alibates tools show extensive use and primarily are represented by maintenance tools (83%). Flakes made of Alibates were not significantly different in any dimension from Edwards or Tecovas flakes.
The assemblage made of local raw materials includes tools made of chert, quartzite, and sandstone. Tool types included points, preform, bifaces, a multifunctional tool, utilized flakes, core, chipping implement, hammerstone, abrader, and a possible anvil. A significant under representation of tools made of Tecovas compared to Edwards and Alibates was found suggesting that Tecovas tools may have been manufactured and then transported away from the site. All evidence of core reduction and tool production at the site is with local materials. Tools made of local raw material for immediate use in butchering and processing bison in the bonebed include a scraper-graver, utilized flakes, a chopper, and a core. The utilized flakes and choppers appear to have been utilized and subsequently discarded within the bonebed. The cores are irregularly shaped and do not indicate any specific pattern of reduction. Evidence for point manufacture at the site is limited to a few point fragments and performs. The scant evidence of point production suggests that manufacturing may have occurred closer to Tecovas outcrops. Several quarry sites have been recorded (Hughes and Willey 1978) in the area surrounding Lake Theo and detailed inspection of the quarry debris is needed to determine if Folsom point manufacture was carried out locally. Tecovas flakes were found to be significantly larger in length, width, and thickness compared to Edwards flakes and Tecovas debris weighed more than Edwards debris. Striking platforms and initiation types on Tecovas flakes indicate that various stages of core reduction and possibly tool manufacture are represented in the assemblage.

Notably, the Edwards assemblage is almost twice the size of the Alibates assemblage, yet Alibates outcrops are located approximately 75 km closer to Lake Theo than the Edwards outcrops. This reiterates the importance of examining assemblages in relation to tool-depleting events rather than in relation to straight-line distances.

Because the Alibates assemblage overall is represented by less tools compared to Edwards and primarily by resharpened and multifunctional maintenance tools, it is hypothesized that Edwards quarries were visited subsequent to Alibates quarries. The points found at the site almost exclusively are made of Edwards, indicating that hunting gear was refurbished at an Edwards quarry. At the Edwards quarry several new points and a number of tools, perhaps in the form of bifaces, were added to the toolkit, but not all Alibates tools were discarded. Relative to weapons, more Alibates maintenance tools than Edwards tools were transported to Lake Theo, suggesting points were replaced more rapidly than maintenance tools in the toolkit. The reconstructed season of death for the bison at Lake Theo indicates a fall kill. If the southern High Plains during the Early Holocene was affected by the Younger Dryas (Fiedel 1999) and subject to changing grass species and increasing seasonality (Bamforth 1988; Holliday 1995), bison may have responded with a dual dispersion strategy to maximize differential forage conditions as postulated by Epp (1988). Bement (1999a:161-165) presents some supporting evidence from the Copper site of the hypothesis that herds made use of different grassland ranges. Folsom hunters most likely visited the southern High Plains annually in the summer and fall when forage was good and herd aggregations at a maximum. A pattern of Folsom groups gearing-up at the Edwards Plateau and heading west and north in an annual round is suggested by the ubiquity and abundance of Edwards chert in Folsom assemblages on the southern Plains (Hofman 1991; Wyckoff 1999). Based on this hypothesized scenario the Folsom group or groups at Lake Theo may have refurbished their lithic supplies at Edwards quarries in the winter, hunted on the southern High Plains in the summer/fall, and arrived at Lake Theo en route back to the Edwards Plateau. The Alibates in the assemblage may have been procured during the previous fall after a pre-
vious summer hunt on the High Plains.

The organizational characteristics of the Lake Theo assemblage suggest Folsom hunters employed a type of preventative strategy to minimize potential risk involved in a procurement strategy focused on bison, an unpredictable mobile resource. Locating, pursuing, and dispatching mobile and unpredictable game is risky in terms of potential loss and variation in returns. The investment of time and energy in getting proper raw materials and producing specific tool designs can be considered responses to perceived future risk. The successful procurement of bison at Lake Theo probably resulted in a temporary alleviation of perceived risk. Constraints of high mobility are ameliorated with a successful kill and the proximity of high-quality lithic raw material allows a more expedient use of tools in the processing of the kill.

The pattern of planned reduction and conservatism with transported tools recovered from Lake Theo and the more expedient use of tools and tool replacement using local materials provides support for aspects of Hofman’s (1992) model of Folsom technological organization. Lake Theo’s proximity to a chert source is similar to the setting of the Hanson site in Wyoming. Both sites exhibit a pattern of differential raw material use. Ingbar’s (1992) suggestion that the pattern evident in the Hanson assemblage is not only very predictable, but also widespread across the Plains as a result of many groups practicing similar mobility regimes is demonstrated in the Lake Theo assemblage.

**CONCLUSION**

Only a handful of Folsom sites in good, or sealed, stratigraphic context are known for the southern Plains. Of these, Lake Theo is the only bison kill/processing site located in close proximity to a high-quality chert source. These factors allow for a unique examination of Folsom resource procurement. Although analysis was severely limited by the quality of information recovered from excavations and the resultant small size of the Folsom assemblage, some preliminary inferences could be made. Analysis of the transported toolkit revealed the assemblage was conserved over a number of retooling events. The transported tools were damaged, reworked, and exhibited extensive use. Weapons, made primarily of Edwards, were discarded or lost within the bison bonebed. Some tools were undoubtedly lost within the mass of carcasses and others were probably discarded in lieu of fresh tools. The transported toolkit is characterized by segmented reduction and a differential rate of replacement between maintenance tools and weapons. Local raw materials were employed for immediate use in processing the kill and for production of tools for future use. Most local tools were produced expediently with minimal modifications, used, and discarded with much potential utility remaining. Some evidence of tool production in the form of bifaces, preforms, and broken points of local material along with evidence from debitage suggests new tools of Tecovas were transported away from the site. The location of the Lake Theo kill near the Tecovas quarries lends support to the idea that Folsom mobility was tied not only to movement of bison herds, but also to specific high-quality lithic source areas for the direct procurement of raw materials.

**ACKNOWLEDGEMENTS.**

This paper has benefited from the comments of Eileen Johnson, Bruce Huckell, Joe Powell, B. L. Allen, and Jeff Lee. The Panhandle-Plains Historical Museum was kind enough to loan the Lake Theo collection to the Museum of Texas Tech and has demonstrated extreme patience awaiting its return. The discussions, insights, and friendship of Luc Litwinionek, Patrick Lewis, Maria Gutierrez, Marcus Hamilton, David Kilby, and especially Susan Baxevanis are much appreciated. However, I alone accept full responsibility for the content, interpretations, and any errors presented in this paper.

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