

34RM507,
A Late Archaic Site in Western Oklahoma

by Karin J. Rebnegger

with contributions by Debra Green

Luther Leith

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Department of Archaeology

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Abstract

Archaeological site 34RM507 is located adjacent Higgins Creek, a small tributary to the Washita River in Roger Mills County, western Oklahoma. Surface collections there included artifacts diagnostic of a late Archaic encampment. Initial visits to the site resulted in the impression that the location had some contextual integrity. Consequently, the site was briefly tested. This work, and thorough studies of profiles exposed along the site's west edge, revealed that the extant deposits were greatly reshuffled and redeposited since late Archaic people camped there. Radiocarbon dates support the conclusion that this occupation occurred some 1900 years ago.

The detailed recording of profiles along the site's west edge also revealed the accumulation of nearly 25 feet of sediments. Much of this accumulation consisted of alternating layers of fine silt and shaley gravel. Radiocarbon dates from select layers indicate these accumulated between 2500 and 1600 years ago. Later, erosion cut gullies (that eventually refilled) 1900, 1400, and 1000 years ago. The recovery of land and some aquatic snails from many of these layers enabled a study of these invertebrates as proxy records of vegetation niches and the environment. This study ascertained that the location was slow to recover from the warm, dry climate prevalent between 8000 and 4000 years ago but that grasslands similar to today's were becoming established after 2000 years ago.

Despite the lack of contextual integrity, artifacts from site 34RM507 were intensively studied to gain perspectives on the lithic technology of the late Archaic inhabitants. A rather consistent series of large projectile points implicates no mixing from late prehistoric times. Located near two "lagged-out" deposits of Ogallala Formation gravels, site 34RM507 attests to the intensive use of Ogallala quartzite by late Archaic bison hunters. Moreover, this site is actually part, an activity area (?), of a complex of nearby spots utilized by these people. Finally, site 34RM507 is but one of a series of locations frequented along the Dempsey Divide by these people. Profiles and associated radiocarbon dates from such sites reveal that late Archaic bands were here during a dry, erosional interval, one that favored their trapping bison in deep gullies and winter camping adjacent spring-fed streams.

Acknowledgments

This research began as a class project. Don Wyckoff talked me into it, and I am so glad that he did because I have enjoyed every minute of it. Likewise, Pete Thurmond contributed so much to this endeavor. Thank you both.

It took nearly three years to go through the thousands of flakes and chipped stone tools from this site and nearly another three years to get this monograph formatted and edited for publication. A review of the Table of Contents or a quick scan of the texts shows this product was the result of combined labors. I am especially thankful to Deb Green and Luther Leith, relatively new graduate students who were trying to learn how to do archaeological research responsibly. Both have contributed chapters that help understand the changing settings of western Oklahoma's Roger Mills County.

I could not have completed this project without the help of many graduate students and other volunteers who assisted with collecting artifacts at the site, mapping it, and testing it between 2000 and 2002. In particular, my thanks go to Beau Schriever, Scott Lancaster, Warren Lail, K.C. Kraft, Scott Sundermeyer, Brice Obermeyer, Paul Gattis, Wendell Nelson, and Debra Green. A weekend test excavation was greatly enhanced by several volunteers from the Central Oklahoma Chapter of the Oklahoma Anthropological Society.

A special acknowledgment goes to fellow student Stance Hurst. Stance has been invaluable as we tried to better understand Ogallala quartzite and how prehistoric people managed to work it. I especially appreciate Stance's thoughts and help as we conducted experimental heat-treating of this fascinating (and almost unbreakable) material. Don and Jane Menzie graciously let us have numerous bonfires on their property southeast of Norman.

Jeff Indeck allowed access to late Archaic artifacts collected by Jack Hughes and now stored at the Panhandle Plains Museum in Canyon, Texas. Thank you so much, Jeff.

Again, Pete Thurmond was key to all the work reported herein. He made it possible to visit the site frequently as I learned how to really study an archaeological site and record it. He helped with mapping the site, recording the profiles, and providing me with information and artifacts from previous studies at 34RM507 and other important sites on the Thurmond Ranch. And, he funded parts of the project, thus making it possible to visit the Panhandle Plains Museum, acquire the particle size information reported by Debbie Green, and obtain the radiocarbon dates that help explain the chronology of the setting. Pete's wife, Suzie, was also an important part of our research; she was gracious hostess and fed us on more than one occasion.

Finally, I would not have been able to do anything without a gifted teacher like Don Wyckoff. He taught me about lithic artifacts and pointed me in the right direction many times. It is truly special to have a caring and knowledgeable teacher who is always willing to help students in every way possible.

Karin J. Rebnegger

Introduction

Karin J. Rebnegger

One cannot really appreciate the stone working ability of the people who manufactured these artifacts until one has tried to fashion similar artifacts from the same material. After no few attempts, I never developed beyond a complete inability to break the stone, let alone make an artifact from it. Frank Leonhardy (1966:29) referring to Ogallala quartzite use by Archaic occupants of site 34GR12.

The Archaic period on the Southern Plains spans over 6000 years and began about 7500 BP, and it has been divided into Early, Middle, and Late segments by archaeologists (Boyd 1997; Hofman and Hays 1989; Wyckoff 1992). The Late Archaic segment is usually dated from 4000 BP to 1500 BP. For most of this time nomadic hunters and gatherers roamed the Southern Plains hunting bison with darts and atlatls while inhabitants of the Southeast and Southwest had begun to use the bow and arrow, produce pottery, and domesticate various plants. But Late Archaic people on the Southern Plains depended upon bison and local wild plants. Their tools included corner-notched dart points and a variety of other flaked tools (D. Hughes 1977; J. Hughes 1955). Bison kill sites have been documented, tested, and excavated, but few camp sites have been even tested (Beene and Peter 1997; Quigg et al. 1993; Thurmond 1991a). On the Southern Plains, this Late Archaic manifestation has been called the Little Sunday or Summers Complex, but both of these archaeological constructs were developed without extensive excavations or artifact collections. A Late Archaic site in Roger Mills County, Oklahoma, has provided us with unique opportunities to study the lithic technology of these spear-using bison hunters, the landscape on which they camped, and the changing environment in which they lived.

The site reported herein was first located in the early 1980's on the Thurmond Ranch by the landowner, Pete Thurmond. Subsequently, diagnostic artifacts were continually collected. The site was extensively surface collected in 1986, but these artifacts remained unanalyzed. In the spring of 1999, while enrolled in the Lithic Technology class at the University of Oklahoma, I took on the analysis of this apparent lithic workshop as a class project. A small surface collection made during a class field trip created the basis of my study; using a total mapping station we recorded the provenience of each artifact. I developed a map and did a basic analysis of the collected materials. In the fall of 2000 I was given the opportunity to continue to investigate the lithic technology manifest at this site. The collection from 1986 was added to this study, and another small surface collection was made. A map more detailed than the first was also created. Testing was planned to improve our understanding of the habitation deposits. We knew that the inhabitants of this site left an extraordinary amount of information behind and that it was

just waiting to be gleaned from the scattered artifacts.

Site 34RM507 was initially considered a lithic procurement camp, but the map we produced depicted a site that was not just a workshop but a habitation area that was occupied for some time. There were two large concentrations of fire cracked rock, lots of debitage, and a profile of a pit and a possible hearth. These latter were visible in the sides of the adjacent arroyo. It was going to make an excellent research project. It would provide information about these people's camps and their lithic technology. Archaeologists would finally understand more about these Late Archaic bison hunters in western Oklahoma. Until this study, most information about these people came studies of bison kill sites, and these provided little information about their stone tool technology because only a few projectile points and resharpening flakes were ever recovered. While a few camp sites and bison processing areas were recorded, only occasionally (Leonhardy 1966; Tainter 1979) were the recovered artifacts thoroughly analyzed to determine the lithic reduction processes. At all of these sites it was noted that the worked material was predominantly Ogallala quartzite and Alibates agatized dolomite. Recovered tools were categorized, and these types were used for many years by archaeologists to identify and define this Late Archaic culture on the Southern Plains (Boyd 1997; Hofman 1977; Hofman and Hays 1989; D. Hughes 1977, 1984, 1989; J. Hughes 1989; Thurmond 1991a; Wyckoff 1992).

Before testing was undertaken, Pete Thurmond, Don Wyckoff, and Debra Green cleaned a profile on the arroyo wall adjacent the site. They determined that the sediments most likely had accumulated rapidly and in cycles, gravelly layers followed by silty layers and no sign of soil development. To establish this rapid accumulation, sediment samples containing charcoal were collected for dating, and Green collected samples from each layer for particle size analysis. The results from the dates clearly depicted rapid accumulation. Because of evidence for extensive sediment accumulation the integrity of the site came into question. The eventual testing of site 34RM507 proved that this so-called camp site was, in fact, a highly disturbed site. A pit-like profile visible in the arroyo wall turned out to be a gully that continued northeast through the site. The fire-cracked rock concentrations were no more than locations where water erosion had

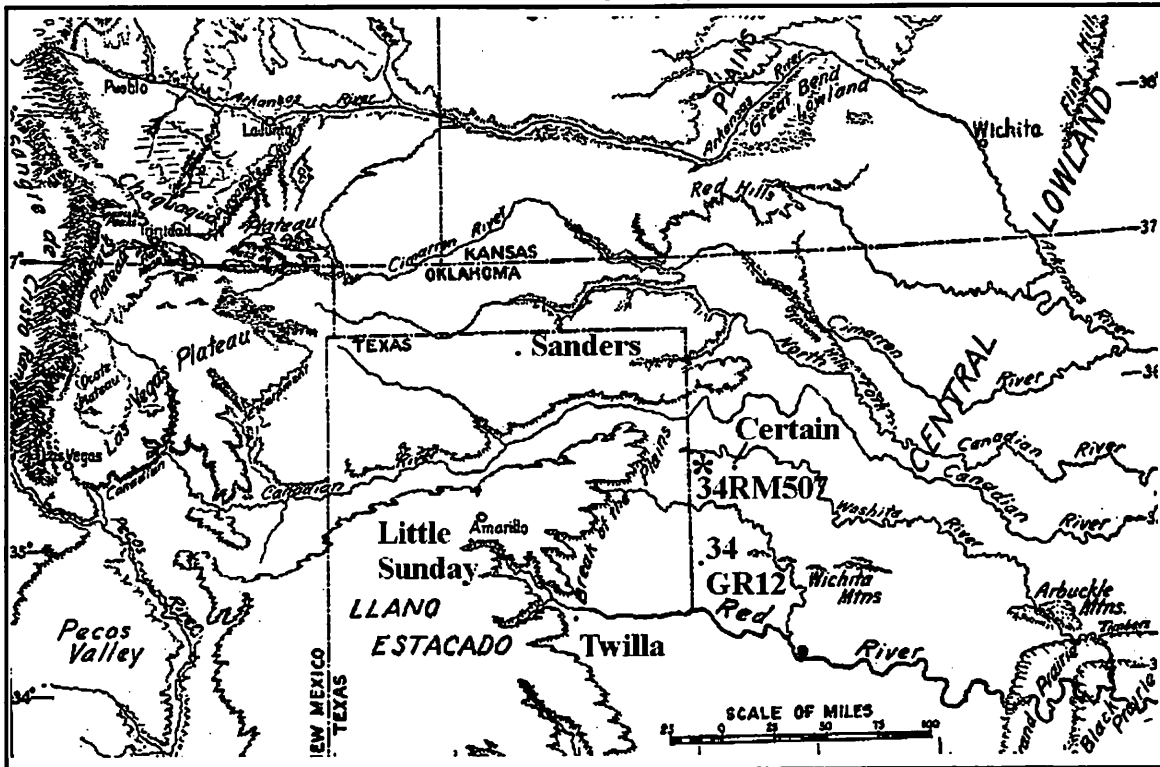


Figure 1. Location of site 34RM507 and other related Late Archaic sites on the Southern Plains. Adapted from a map (Fig. 2) drawn by Guy-Harold Smith for Fenneman (1931:6).

dropped heavy stones while dragging smaller rocks and flakes farther from their original locations. I still wonder why it never dawned on any of us that if all or most of the Late Archaic bison kills are buried by 3-8 feet of sediments in old arroyos then a site on a knoll couldn't be perfectly untouched by erosion.

Site 34RM507 is still valuable for research on the stone tool technology of these Late Archaic people. Using information from Late Archaic sites already studied, the many chipped stone materials from 34RM507 help identify lithic reduction techniques and tools created by these people. Moreover, the combination of the geoarchaeological findings and a recent study of fossil snails in the alternating silt layers under the site adds important information on the changing landscape and environment preceding the site's use by these people. Thus, the special studies by Debra Green and Luther Lieth are integrated into this monograph.

Late Archaic Archaeology on the Southern Plains

Much of the work on Late Archaic bison hunters has taken place in the Texas panhandle with some recent research in western Oklahoma. Many of the reported sites are the locations of bison kills and camps, although rockshelter and butchering sites are known as well. A kill site, Twilla (Fig. 1), in the Texas panhandle was among the first of the sites to be recorded and tested (Tunnell and Hughes 1955). Jack Hughes (1955) related the Twilla site and other bison kill sites in the Texas panhandle to Little Sunday (Fig. 1), a Late Archaic

camp site. He characterized the people of his *Little Sunday complex* as those who depended on local materials for chipped stone tools and who supplemented their hunting subsistence pattern with gathering. The materials they worked included Potter chert (Ogallala Formation gravels, and most likely quartzite), Tecovas chert, and other local stone such as Alibates agatized dolomite. The stone tools identified and attributed to the complex included corner-notched dart points (Ellis and Regugio types), hide scrapers, choppers, end scrapers, Clear Fork gouges, and milling and grinding stones.

Then, in the 1960's, Frank Leonhardy identified a Late Archaic camp site, the Summers site (34GR12, Fig. 1) in southwestern Oklahoma. This site's artifacts were assigned to the *Summers complex* and they were interpreted as the material culture of people who utilized dart points of the Marshall, Lange, Gary, Ensor, Marcos, and Bulverde types. Other chipped stone implements in this complex included oval knives, other bifaces, scrapers, Clear Fork gouges, and choppers. These were all made from local materials, usually quartzite from the Ogallala Formation (Leonhardy 1966).

In the last 25 years more than 40 sites have been discovered during archaeological surveys in the region, and while some have only been recorded, others have been tested and radiocarbon dated (Boyd 1997). These sites all share a common denominator: broad bladed, corner-notched dart points, other tools made from local stone, and bison bones. Boyd (1997) expanded the Little Sunday complex by bringing to-

gether many of the archaeological sites throughout the Southern Plains. I believe site 34RM507 fits into Boyd's construct, but I draw heavily on Leonhardy's assessment of the few artifacts recovered from the Summers site because they are very similar to those found at 34RM507. I also find his descriptions align very well with my understanding of the technology of these Late Archaic people.

Except for the Certain site in western Oklahoma (Fig. 1), the Late Archaic bison kills are all in the Texas panhandle. The Certain site is the most recently excavated, and it has yielded radiocarbon dates ranging from 1760 to 1400 BP. These recent dates appear most reliable because many of the previously dated sites were assessed before development of AMS dating technology. The Certain site dates come from bone samples and may be slightly inaccurate (Bement and Buehler 1994; Buehler 1997). Dates from such Texas sites as Twilla (Fig. 1) and the nearby Bell, Collier, and Strong sites range from 2400 to 1000 BP. This includes a problematic date from the Strong site; without that date the range extends only to 1400 BP, which seems more acceptable for the Late Archaic (Boyd 1997). All bison kills are situated in arroyo fills, so it appears the bison were herded into arroyos where they were trapped and killed (D. Hughes 1977; J. Hughes 1989).

Open camps and rockshelters in the region have been located during surveys. Boyd (1997:243) notes that these habitation sites are widely dispersed, even more so than the bison kills. The people that occupied them obviously moved around between bison hunts. These sites, as noted above, have usually been documented only on surveys and tested under less than pristine conditions due to deflation caused by erosion. The dates for these sites range through the Late Archaic period and into the following Woodland cultural period, in essence from 4000 to 600 BP. Because so few dates are represented, most of the Late Archaic chronology has been developed from artifact comparisons (Boyd 1977). Many camp sites are located on the Dempsey Divide area that lies between the Washita River and the North Fork of the Red River (Thurmond 1991a). Thurmond (1991a) argues that the inhabitants of this locality not only used it to obtain knappable stone from exposures of Ogallala Formation gravel but also camped near the spring-fed creeks. These drainages supported abundant vegetation that could have been utilized not only as food but also for shelter and fuel by Late Archaic hunters and gatherers (Thurmond 1991a; Thurmond et al. 2002).

Besides the bison kills and camps, burials are also known for these Late Archaic people (Boyd 1997; Gettys 1991; Thurmond 1991b). The few reported burials are scattered over the Texas panhandle and western Oklahoma. A few of these are accompanied by lunate shaped ground stone objects that may have been used for atlatl weights, or maybe for personal adornment (Thurmond 1991b). One burial found in Roger Mills County, Oklahoma, provides evidence of vio-

lence, but it is not clear whether it is between fellow bison hunting residents or with interlopers to the territory (Boyd 1997; Gettys 1991).

The evidence for these Late Archaic hunters and gatherers is scattered and sparse. Yet, as more sites are discovered, the picture of their lifeway is becoming more evident. They clearly depended on bison, traveled and spent time in diverse ecological settings from the Red Bed Plains to the Caprock Canyonlands, and utilized particular local lithic material to make a variety of stone tools, including rather distinctive corner-notched dart points. The rich and dynamic diversity of this region certainly matched well with the needs of these nomads.

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34RM507 Site Description and History of Research

Karin Rebnegger

Archaeological site 34RM507 is located on the south side of the Washita River in Roger Mills County, Oklahoma (Fig. 2). More precisely, the site is four miles south of the Washita River. Here, rolling, north sloping uplands have eroded from the Permian age Doxey shale. Site 34RM507 covers less than an eighth of an acre of west sloping ground now vegetated with bunch grass, broomweed, and patches of low catclaw acacia. The site is bordered, and partially exposed, on the west by a high bank that is the east side of a short arroyo where it joins Higgins Creek, an intermittent tributary of the Washita River.

Site 34RM507 was evident from numerous flakes and pieces of angular, apparently fire-cracked, rock readily visible where the ground cover was sparse. These flakes and fractured rocks were derived from quartzite, silicified siltstone, and other rock cobbles common to the Ogallala For-

mation, the Tertiary (Miocene and Pliocene) age outwash deposits from the Rocky Mountains. Underlying the High Plains from South Dakota south, the Ogallala Formation is well documented on the Southern High Plains of eastern New Mexico, western Texas, and westernmost Oklahoma (Dutton et al. 2001; Reeves and Reeves 1996). There, the Ogallala Formation consists of alluvial fans, often overlapping, of sand and gravel (Reeves and Reeves 1996). Just a couple of miles south of site 34RM507 lower portions of the Ogallala Formation are preserved along the Dempsey Divide, the upland ridge separating the Washita River watershed from that of the North Fork of the Red River (Thurmond 1991).

Given the predominance of Ogallala-derived stone utilized at site 34RM507, this location may have selected because of its proximity to sources of such stone. In fact, site 34RM507 is one of several prehistorically utilized spots at

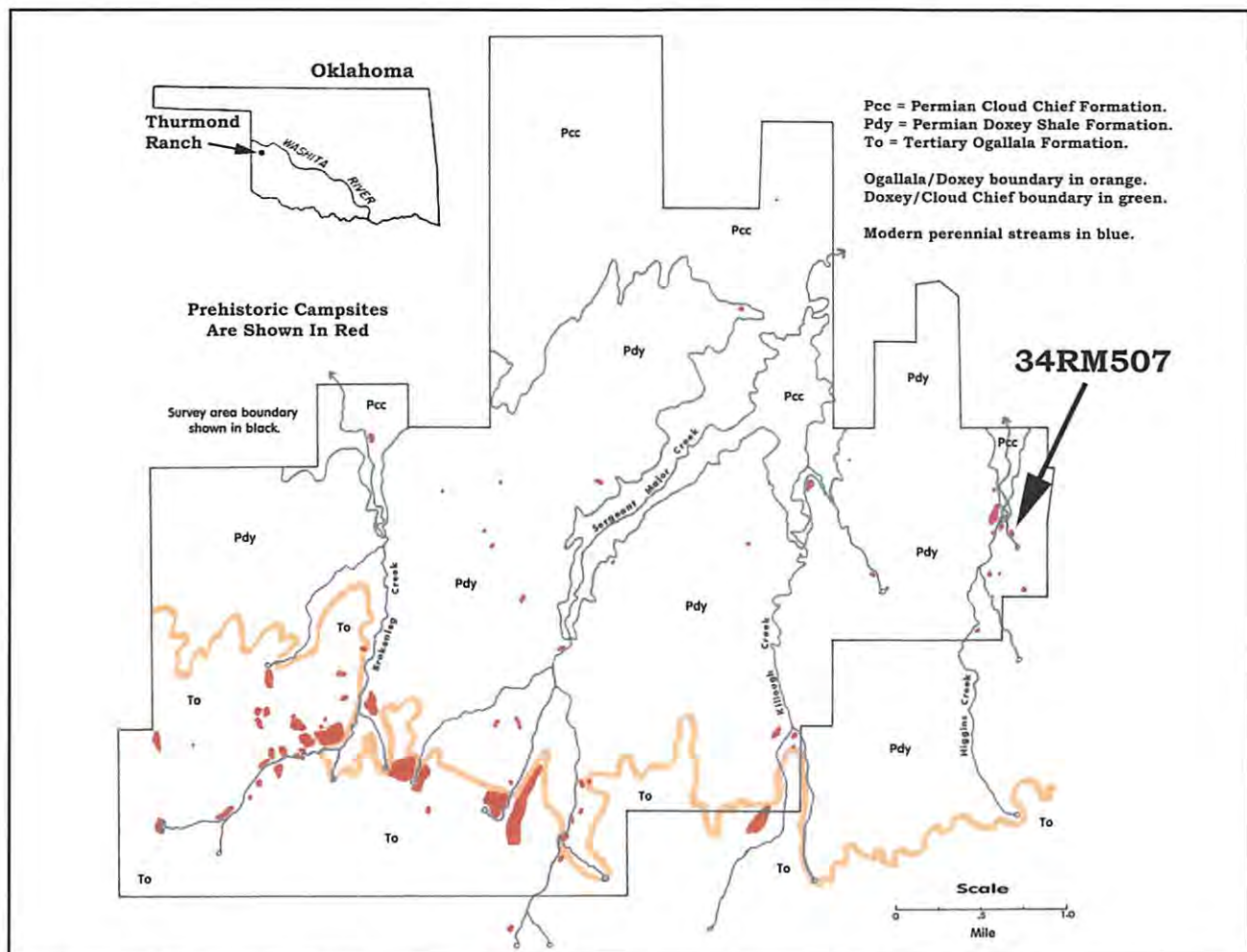


Figure 2. Location of site 34RM507 in the Washita River watershed of Roger Mills County, western Oklahoma.

this locality. Five such locations occur within 1000 feet of site 34RM507 (Fig. 3). Approximately 500 feet northeast of 34RM507 is a small exposed occurrence of Ogallala gravels (34RM734; Fig. 4), and another exposure (34RM812) of these gravels is across the creek to the west (Fig. 3). Also present west across the creek from the site is another archaeological site, 34RM334, where flakes and tools, including corner-notched dart points like those from 34RM507, have been found (Fig. 3). All in all, site 34RM507 is part of a setting where hunter-gatherers camped, obtained knappable stone, and worked it to various stages suitable for the next hunting-gathering tasks.

History of Site Research

The history of investigation of site 34RM507 is important because many Late Archaic sites may not only be de-

flated, as noted by Boyd (1997), but in secondary context.

Pete Thurmond and Michael Moore recorded site 34RM507 in March of 1986. Pete, who is the landowner, had previously located the site while surveying his ranch just southeast of Cheyenne, Oklahoma. Thurmond and Moore's surface collection from the site revealed it was some sort of camp as well as a lithic workshop near a deposit of Ogallala gravels. The recovered projectile points resembled those of reported Late Archaic sites on the Southern Plains, in particular sites of the Little Sunday complex. The collected material included one projectile fragment, bifaces and biface fragments, cores, debitage (including flakes and blocky debris), ground stone, and faunal remains. Most of the material represented by these artifacts were Ogallala quartzite,

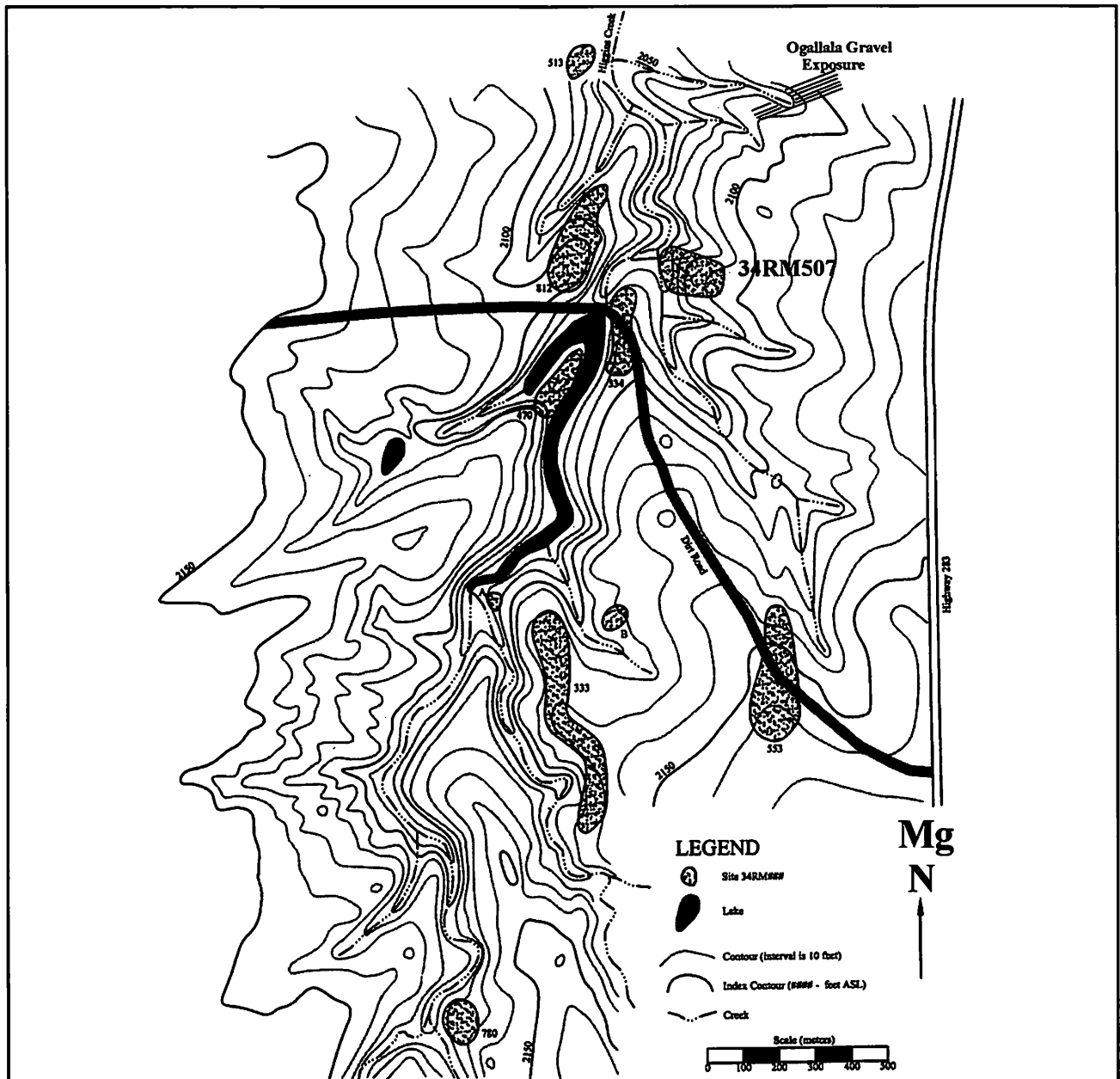


Figure 3. Locations of the series of sites along Higgins Creek near site 34RM507.

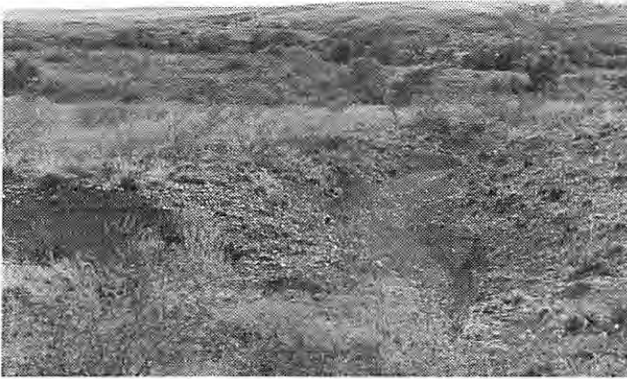


Figure 4. Looking southwest at a lagged out exposure of redeposited Ogallala gravels just northeast of site 34RM507 (see Fig. 3). Photo taken in 1999.



Figure 5. Looking west at site 34RM507 during the 1997 visit by the O.U. Lithic Technology class.



Figure 6. Looking north during flagging of artifacts at site 34RM507 by 1999 O.U. Lithic Technology class.



Figure 7. Students flagging artifacts along the erosional cut in the northwest part of the site during the 1999 visit.

along with some of Alibates chert, silicified wood, and some other unknown cherts. The 765 artifacts (which included those collected by Thurmond when he first found the site in 1985) were catalogued with loose provenience and placed in categories such as artifact type and flake type. Unfortunately, the artifacts were not further analyzed, and the collection remained untouched after being catalogued.

Don Wyckoff's lithic technology classes had visited the site in 1997 (Fig. 5) because the site manifested a wide range of chipped stone artifacts, and it was a good opportunity for students to see a likely lithic workshop. Diagnostic artifacts such as projectile points and bifaces were collected by the classes when found, and notes were made about the site. In January of 1999, I visited the site as a field trip for the lithic technology class (Figs. 6 and 7). As our group flagged surface artifacts, a hearth was discovered exposed in a profile northwest of the main concentration of artifacts. Two bifaces and a charcoal sample were collected from and adjacent this buried hearth (Figs. 8 and 9). With these indications of context, I became interested in the site's potential for a class project.

After being convinced by Wyckoff that this site's surface collection would make a very good small project, I went out to map the site and collect more artifacts. Little did I know that 765 artifacts silently awaited me in Pete Thurmond's lab. My mapping and collecting took place in February of 1999. Warren Lail and Pete Thurmond helped with contour mapping the site and collected artifacts as we point provenienced them with a total mapping station. During this field work we discerned three distinct areas: 2 concentrations of fire-cracked rock (possible hearths) and 1 location where chipped stone materials were very dense. Once finished, I learned about the large collection made in 1986 (at Pete's lab), so I took both collections back to Norman to work on for my class project. I now had 395 artifacts to add to the already extensive 1986 collection and the one made by the 1996 lithic class. Ultimately, my project involved a simple analysis that utilized the artifacts I had collected and a few diagnostics from the previous collections. These were used to identify and define the lithic reduction strategy of the inhabitants of 34RM507.

This class project piqued my interest in the site and the



Figure 8. Bifacially flaked tabular cobble of Ogallala quartzite in situ in gully wall at northwest edge of the site. Photo taken during 1999 visit to the site by the O.U. Lithic Technology class.



Figure 9. Hearth exposed in gully wall at northwest edge of the site. Photo taken during 1999 visit by the Lithic Technology class.

sparse reporting of Late Archaic knapping strategies involving Ogallala quartzite. After some consideration, it was decided that further research at 34RM507 would provide useful information on quartzite cobble processing and tool making by Late Archaic hunter-gatherers on the Southern Plains (Hurst and Rebnegger 1999). In particular, the documentation of a camp site and lithic workshop would help flesh out Late Archaic people's activities beyond bison hunting. Thus, this information would help complete documentation of the material culture of the Little Sunday complex. The goal of the additional field work was to test the site to find possible activity areas of the camp site. Also, I wanted to recover a few more artifacts relevant to discerning more than just the lithic reduction technology.

Hoping to map this site more thoroughly, I returned to the site in April of 1999 and, with the help of Beau Schriever, Stance Hurst, Pete Thurmond, and Don Wyckoff, collected and mapped over 200 more artifacts. We also investigated what looked like a storage pit now visible in the arroyo wall on the site's west edge. Due to extreme height of the arroyo wall, we decided that excavation of the pit from above would not be safe. But we did not want to leave the pit for later excavation because it was obvious that this possible habitation feature would be eroded away within a month or two. From the visible profile, it appeared that only a fourth of the pit was left, so we decided to remove it by excavating into the side of the arroyo (Fig. 10). We divided the pit into fourths for some control and collected the contents into trash bags because we did not have screens at our disposal.

Following this field work I spent a few afternoons working at the Oklahoma Archeological Survey doing flotation on the pit fill samples with the help of Kent Buehler. I carefully separated the heavy fraction and collected all the bone fragments and flakes. I also sorted the light fraction and recovered a few seeds and small fragments of charred wood. The wood fragments were too tiny to identify the species. Almost all of the seeds were uncharred and looked recent.

At this point we were beginning to question the integrity of the site. Pete Thurmond was suggesting that the pit was in fact a gully that transected the archaeological site. The presence of modern looking seeds from the base of this feature strengthened this possibility.

Given the question of site integrity, the next step was to test the site. The findings could resolve our concern about the contexts of the site. Also, I had to understand the site layout and how the fire-cracked rock concentrations (hearths) fit with the rest of the site. I hoped that these possible hearths would yield good samples of charcoal for dating. I thought that the testing would allow me to estimate better the site's size and depth. Finally, it was imperative to find the remaining margins of the possible storage pit we had partially dug in April.

We tested the site in February of 2000 with a crew of 8 graduate students and volunteers from the Oklahoma Anthropology Society. In the days before the excavation four units of metric squares were set up in various locations on the site (Fig. 11). Unit 1 was placed near the arroyo wall in order to detect the edge of the possible storage pit or a natural gully, whichever was the case. Unit 2 was placed to dissect one of concentrations of fire-cracked rock or hearths. Unit 3 was situated in a possible pristine area where the site did not appear eroded or displaced. It was possible that the site was still buried in this area as there were few artifacts on the surface. Finally, Unit 4 was set up to find the surface on which the buried hearth was visible in the profile at the site's northwest edge. Later, another unit (#5) was placed next to

Unit 2 in order to continue to trace out what was subsequently determined to be a gully. Each of these units was a 1 x 1 meter square.

Units 1, 2, and 5 yielded artifacts in the first 10 to 20 centimeters, but few artifacts below that depth. Also, these units determined that the possible storage pit was part of a gully. Unit 3 provided information that the site was not buried and did not extend that far northeast. The excavation of Unit 4 resulted in finding the now buried surface on which the hearth was eroding, but this work recovered only one artifact from the stratum that contained the charcoal. Many samples were taken of this charcoal concentration.

While the crew was excavating the units, Pete Thurmond and Don Wyckoff finished cleaning and recording an extensive profile of the arroyo wall at the site's west edge. They had begun this profile description and recording with Debra Green in 1999 (Fig. 12). Once the arroyo wall was scraped and cleaned it was obvious that an extreme amount of erosion had occurred on the site and in the fill below the site. A large gully was found to cut through this profile, and it contained not only charcoal but also artifacts that are believed to have eroded from 34RM507. These artifacts included mussel shells, bison bone, quartzite flakes, and fire-cracked rock.



Figure 10. Looking east as Karin Rebnegger samples a possible pit exposed in the arroyo wall (West Profile #2) at site 34RM507 in April of 1999.

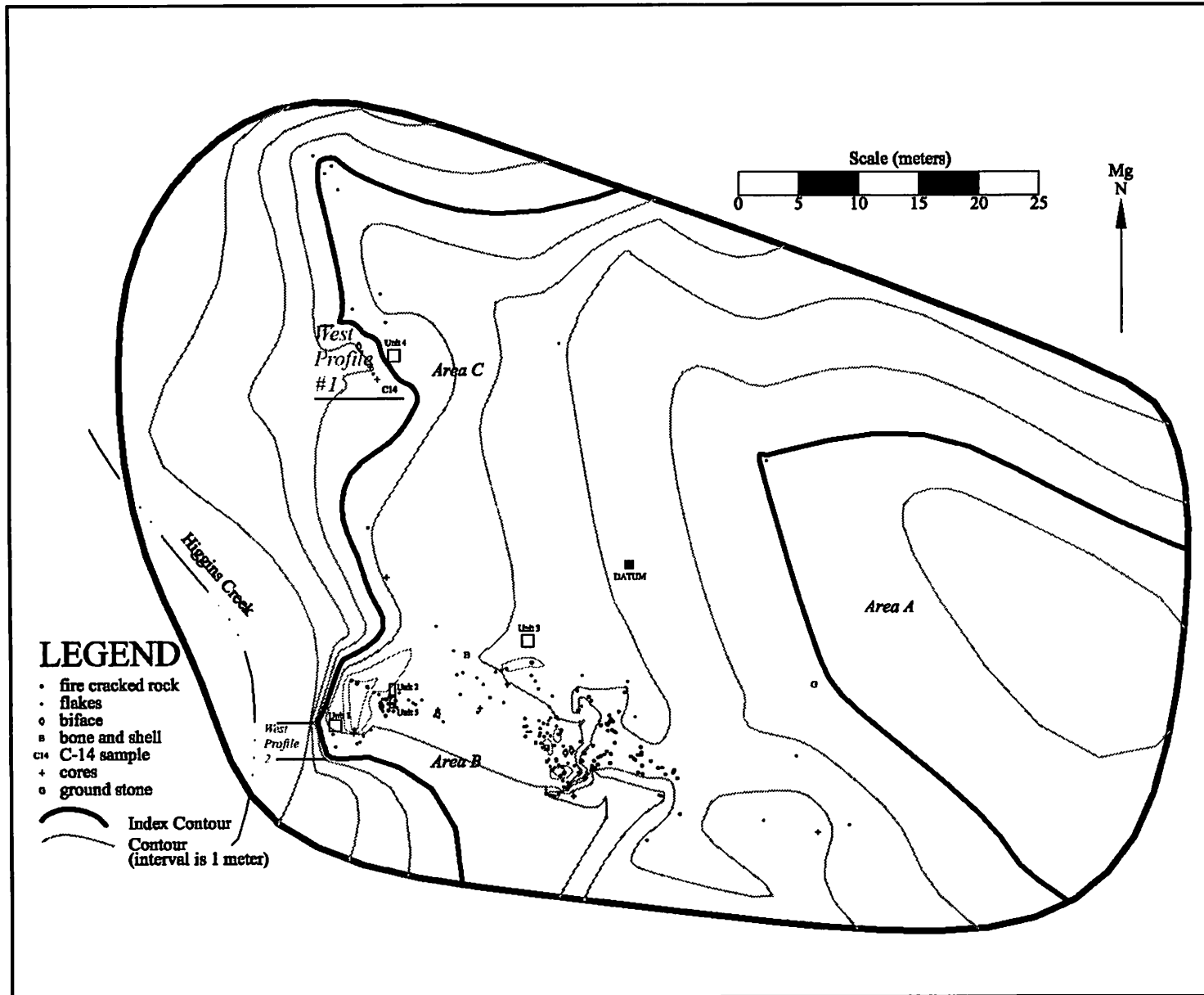


Figure 11. Contour map of site 34RM507 showing concentrations of artifacts and the locations of test squares excavated in 2002.



Figure 12. Looking northeast at the profile of stratified silt and gravel strata underlying site 34RM507. The artifact-bearing soil horizon caps the profile, and the sampled feature initially thought to be a pit is readily visible. Photo taken in September 1999 when a backhoe was preparing to dig a large, deep pit to expose the base of the profile.

At least three cut-and-fill episodes are visible, and each has artifacts incorporated in its fill (Fig. 13).

These excavations and profiles provided abundant information relevant to the location's geological formation, its age, and late Holocene environments. This information is presented in the following chapters on the site's geoarchaeological findings and the snails recovered from the sediments manifest in the profiles. The research reported by Green and Leith add important perspectives on the site's integrity and my study of the chipped stone artifacts.

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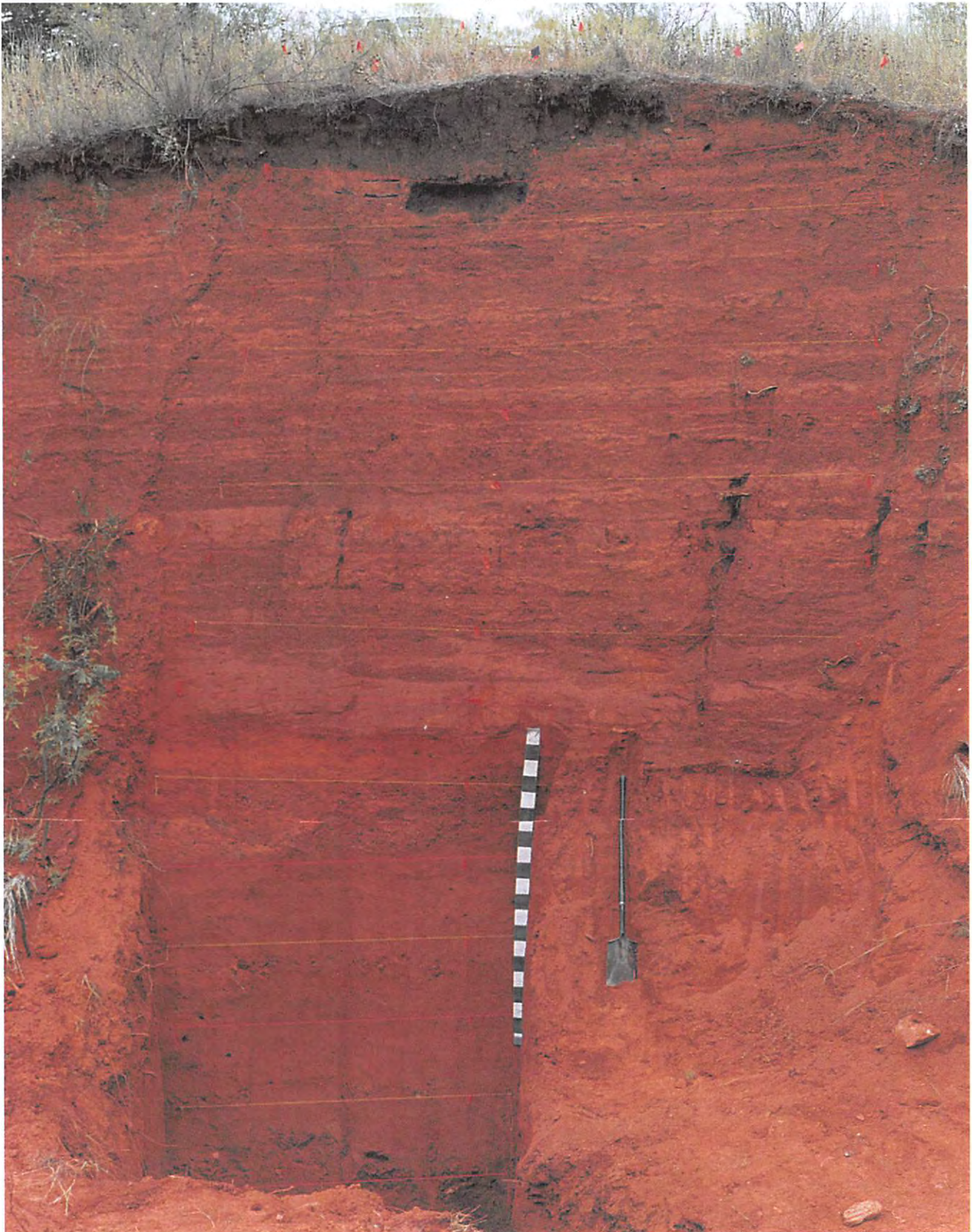


Figure 13. The deep profile, West Profile #2, after the backhoe had deepened the exposure. Interbedded silt and gravel strata are capped by the dark soil initially thought to be an intact midden. Scale is in 10 cm increments. Photo taken September 1999.

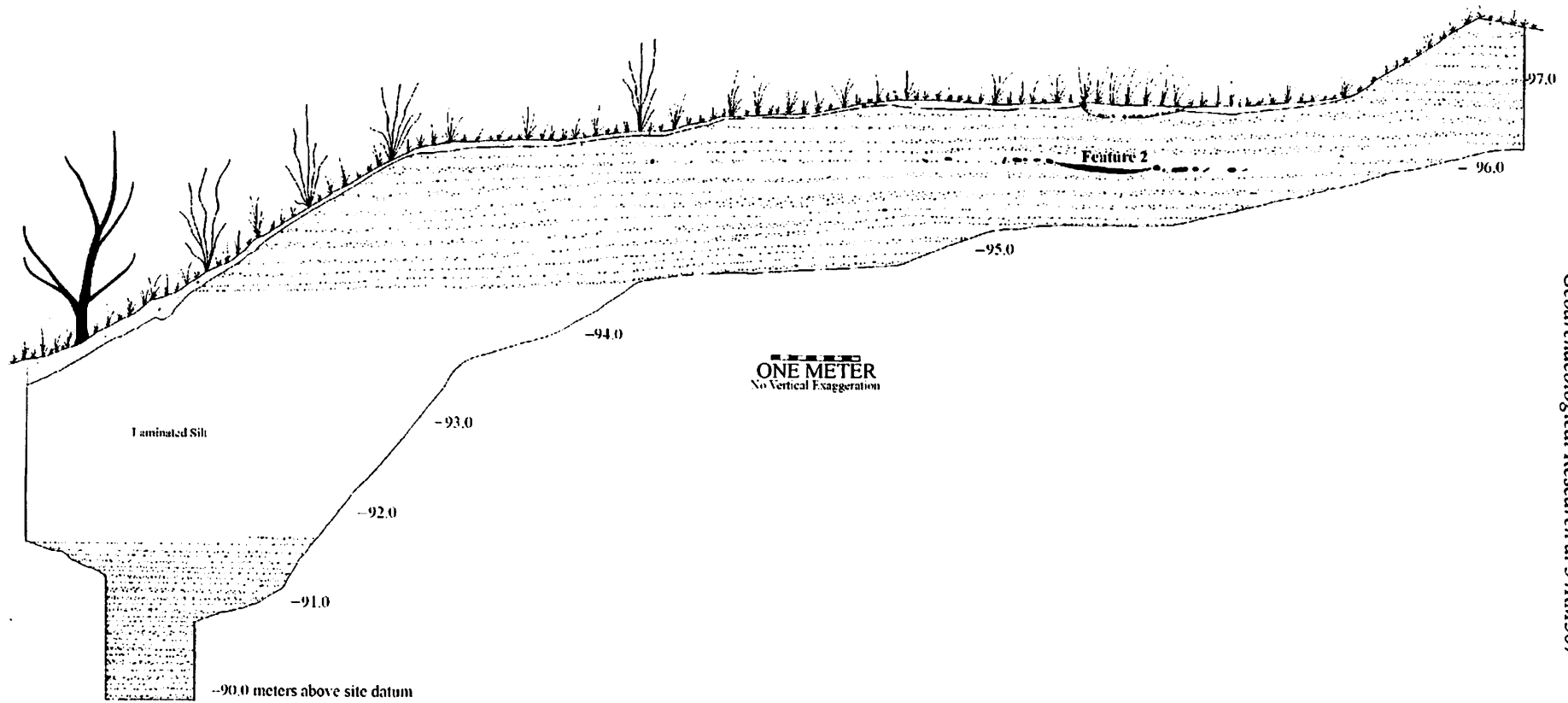


Figure 14. West Profile #1 at 34RM507. This profile bends twice but generally faces west. The unit at the top of the profile is the modern soil. The upper and lower portions of the profile consist of alternating layers of silt and tabular shale fragments, the latter averaging 10 mm in maximum dimension. Between elevations 94.5 and 92.4 m, slightly harder silt laminae (2-3 cm thick) alternate with slightly softer silt laminae (2-3 cm thick). The pattern is surprisingly even and irregular. From elevation 92.4 to 91.8 m, the laminae are thinner; the harder ones are 3-4 cm thick and the softer ones 1-3 cm thick. The shale clasts are weathered and redeposited from the Doxey Shale Formation. Feature 2, a hearth, is associated with 1 Late Archaic dart point, 4 bifaces, 6 flakes, and 10 burned rock fragments. Two radiocarbon dates on woody charcoal yielded intercepts of AD 30 and AD 45. Note the correspondence to the upper extremity of West Profile #2.

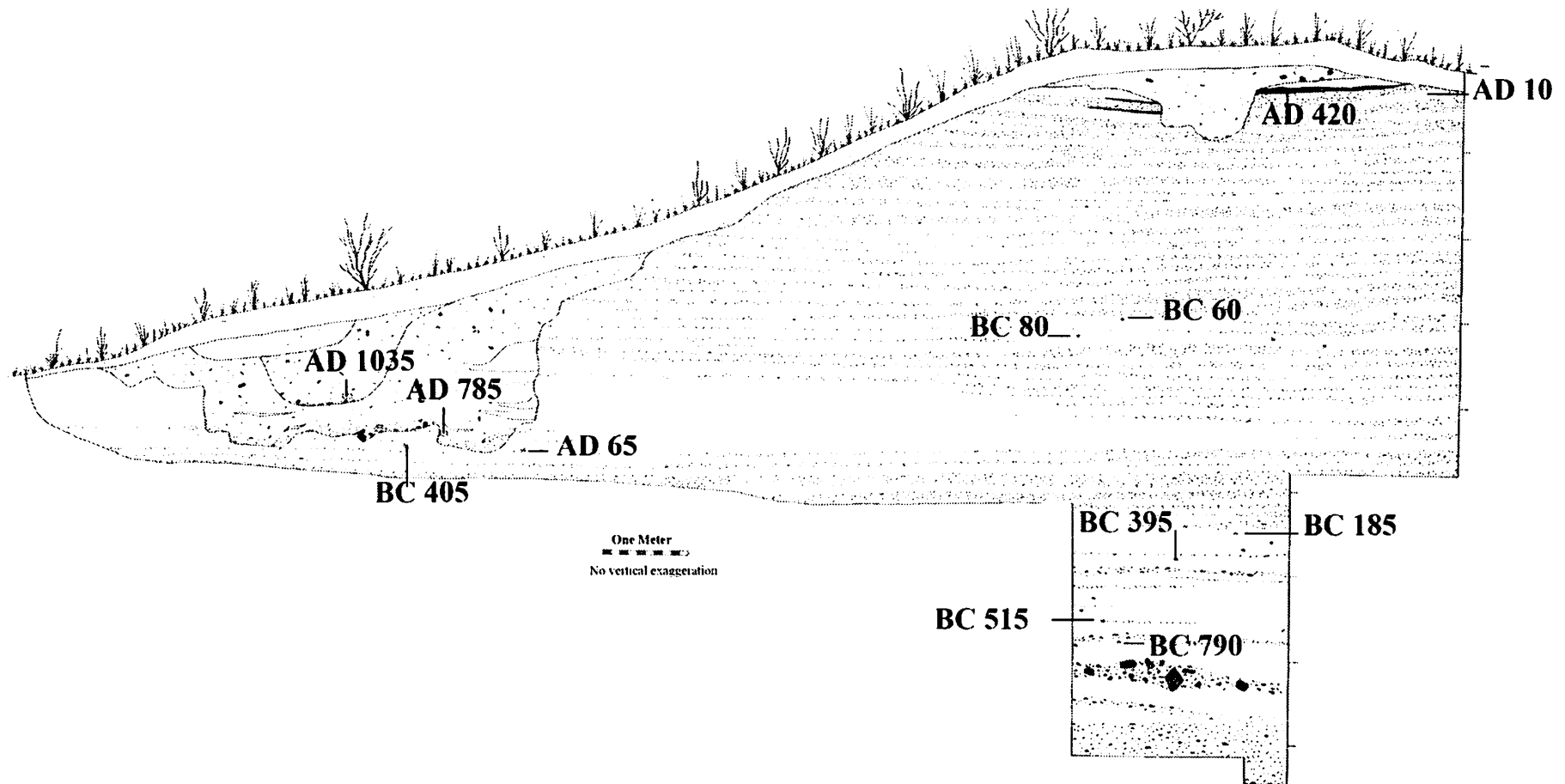


Figure 15. West Profile #2 at 34RM507. This profile bends near its center but generally faces southwestward. The unit at the top of the profile is the modern soil. The bulk of the profile is composed of alternating layers of silt and tabular shale fragments weathered and redeposited from the Doxey Shale Formation upstream between BC 1300 and AD 100. The rate of sedimentation in this sequence increased from .33 cm/year below elevation 92.0 m to .76 cm/year between elevation 92.0 and 94.0 and to 1.81 cm./year above elevation 94.0 m. The gully at the upper right incised during the Higgins Creek Interpluvial of AD 600-775, then rapidly filled with melanzed soil and artifacts eroded and redeposited, either from 34RM507 or possibly an archaeological site upstream. Higgins Creek deeply incised its canyon during the Brokenleg Canyon Interpluvial of AD 1000 to 1150. Melanzed soil and artifacts from earlier (the Higgins Creek Pluvial of AD 775 to 1000) sites were rapidly deposited in two successive channel fills. Higgins Creek did not subsequently aggrade to its AD 100 level.

Geoarchaeological Research at 34RM507

Debra Green

Site 34RM507 is exposed in a deep arroyo wall where it is atop 7 meters of stratified silt and gravelly shale deposits (Figs. 12-15). The arroyo floor is considerably wider than the depth of the arroyo's incision. The low relief of the broad floor is controlled by the fluvial dynamics of Higgins Creek, a tributary to the Washita River. A beaver dam downstream from the site has contributed to blocking sediment loads. The presence of such natural ponds in prehistoric times possibly contributed to landscape evolution at site 34RM507 and at other arroyo and canyon systems across western Oklahoma. However, no significant geoarchaeological research has been performed on the effects of beaver ponds in drainage basins. These beaver ponds and spring-fed Higgins Creek support lush vegetation along the drainage that may have attracted people and game from the Dempsey Divide uplands during prehistoric times.



Figure 16. Collecting sediment samples from West Profile #2 at site 34RM507. Photo taken in September of 1999.

Our study of the site's geology was focused on the large, deep profile at the site's west edge. A main profile (West Profile #2) was cleared using a backhoe and hand shovels, exposing the stratified, interbedded fine grain and gravel strata along with traces of three buried gullies (Figs. 12-15). This profile was carefully recorded and characterized in the field, and subsequent research was conducted at the site to collect radiocarbon and sediment samples for analysis in the lab. The charcoal samples were sent to Beta Analytic for dating. I conducted chemical and grain-size analysis on the sediment samples in the archaeology lab at the Sam Noble Oklahoma Museum of Natural History. Assisted by Pete Thurmond and Don Wyckoff, I collected sediment samples from each natural layer exposed in the face of the profile (Fig. 16). However, due to the thickness of the profile and the many samples collected, a smaller representative series of samples was randomly chosen for chemical and grain-size analysis. Next, detailed drawings were made of the profile that noted differences in lithology (rock character), color, and soil formation. We also plotted in the locations of samples collected for radiocarbon dating and particle-size analysis. Finally, to assure that the complete profile was recorded, a backhoe was used to dig a pit adjacent the profile and below the arroyo floor. This backhoe cut exposed poorly sorted silt, shale, and boulder-size rocks (Figs. 13 and 15). The presence of these boulders suggests that in its initial formation Higgins Creek was flowing extremely fast. An extensive rainfall event(s) may have produced a substantial water source for the creek, thus permitting a greater sediment load. The gravel deposits at the base of the 34RM507 profile may support Thurmond and Wyckoff's (2002) interpretations of a robust post-Altithermal pluvial event.

A small filled-in gully was noticed in the upper portion of the profile near the surface (Figs. 13 and 15). The sediment

deposited in this small gully is fairly dark and is intermixed with angular gravels and artifacts. The sediment was poorly sorted, massive, and uniform, indicating rapid deposition. The angular nature of the gravel clasts also suggests that the material was washed into the gully from nearby. The sediments most likely were deposited into the gully from upslope or from a close, upstream source. While surveying upstream along Higgins Creek, I noticed shale outcrops from the Doxey Formation. These bedrock outcrops were extensively weathered into gravel with pebble-size, sheet-like or platy structure. Weathering processes are gradually wearing away the shale bedrock, but the effects of erosion tend to be more dramatic. Of particular interest to this research is the current erosion of these shale clasts and their alluviation into the arroyo. During rainstorms, large quantities of these fragments are washed onto the arroyo floor where they are transported downstream when runoff flows down Higgins Creek.

The effects of erosion are also apparent by the presence of the two creek channels adjacent site 34RM507. These channels contain similar deposits of dark, organic enriched materials consisting of angular gravel and artifact scatters. The creek channel cuts represent erosional events during drier climatic conditions. The massive runoff from upslope during moist climatic periods deposited sediments into these channels. Radiocarbon dates indicate the smaller gully filled in sometime around AD 420, and the two channel events approximately AD 785 and AD 1035 (Fig. 15). The two larger channels are cut-and-fill events of one channel when the profile was incised and then filled in successive events. Thurmond and Wyckoff (2002:12) have configured these cut-and-fill events with their 400 year pluvial/interpluvial cycles. The small gully fill coincides with the Herring Creek Pluvial (AD 400-600), and the two channel fills correlate with the Higgins Creek Pluvial (AD 775-1000).

The extensive radiocarbon dates from the profile attest to the geomorphic history of the site. These dates indicate rapid deposition within a 1000 year period. The arroyo was incised prior to 790 - 720 BC based on radiocarbon dates obtained from charcoal from the lower portion of the profile. The upper portions of the profile yielded dates of AD 45 (laminated deposits) and AD 100 (development of the surface soil). Thurmond and Wyckoff (2002) suggest the canyon was deeply incised prior to the Altithermal Pluvial (around 1300 - 1000 BC) and most recently during the Brokenleg Canyon Interpluvial (AD 1000- 1150).

The only soil development at the site is the modern soil that yielded a date of AD 100. The lack of soil development at 34RM507 indicates continuous erosion of the site and sedimentation into the arroyo. Soil development is extremely important to any geoarchaeological investigation because soils are an indicator of landscape stability. It is important to note that soils are completely different from sediments. Soils form vertically in sediment deposits through processes of chemical weathering. In contrast, sediments are weathered particles that have been transported by processes from one location on the landscape to another location (Stein 1987). Therefore, the absence of a buried soil in the stratigraphy at 34RM507 is significant to interpretations concerning the depositional, environmental, and cultural history.



Figure 16. Physiographic location of site 34RM507 on the Dempsey Divide south of the Washita River. Adapted from Raisz 1957.

Physiographic Setting

The study area is located within a major interfluvial divide between the Washita River to the north and the North Fork of the Red River to the south (Fig. 16). These uplands, known as the Dempsey Divide (Thurmond 1991), have a distinct physiographic and biotic setting associated with the geological structural history of the region. Much of this history dates to the Late Paleozoic (350 mya) age when Oklahoma experienced significant folding and thrust-faulting events of the Amarillo-Wichita and Arbuckle uplifts (Madole et al. 1991). This period of mountain building resulted in the formation of the Anadarko Basin that extends across most of western Oklahoma and the northern portion of the Texas panhandle (Fig. 17). The Anadarko Basin is just one of a number of basins that experienced downthrusting associated with the

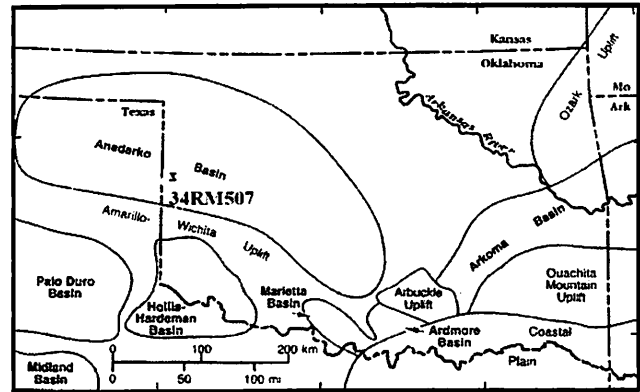


Figure 17. The location of archaeological site 34RM507 relative to the Anadarko Basin. Adapted from Morris et al. 1986:Fig. 70.

development of the Wichita and Arbuckle mountains. A succession of shallow inland seas deposited thick layers of Permian red sandstones and shales into the Anadarko Basin (Gustavson and Finley 1985). These shallow seas also deposited additional salts and gypsum during periods of climatic warming when evaporation of the marine water increased. The subsequent dissolution of these evaporates has significantly affected the region's physiographic development. Regional subsurface dissolution resulted in the collapse of overlying Permian sediments, which created sinkholes and other subsidence features across the landscape (Gustavson and Finley 1985). Drainage development was also greatly influenced by Permian salt dissolution, resulting in changes in the size, direction, and stream piracy of the Pecos and Canadian river systems and their tributaries along the Southern Plains.

Overlying the Permian sediments are Tertiary deposits of the Ogallala Formation as rivers and streams deposited outwash from the Rocky Mountains. These Tertiary deposits included coarse sediments and gravels that once blanketed western Oklahoma, creating a flat alluvial plain. However, all that remains of this plain can be found in the panhandle of Texas where it is known as the Llano Estacado or the Caprock Escarpment (Gustavson et al. 1991; Trimble 1980). Erosion has played a significant role in the westward retreat of the Ogallala Formation, but isolated remnants can be seen along the Dempsey Divide. These remnants obviously served as important sources of knappable stone (especially Ogallala quartzite) for prehistoric groups.

The eastern edge of the Ogallala outcrop produces a number of spring-fed streams along the Dempsey Divide, and this Ogallala edge acts as a major aquifer for the region. The spring-fed streams provided a reliable source of fresh water for an array of plants and animals. Along the Dempsey Divide the physiographic differences between the Ogallala outcrops and the older Permian redbeds have produced distinct floral communities (Thurmond et al. 2002).

The permeable sandy texture of the Ogallala Formation

holds considerable water and thus fosters a greater diversity of plant life than the less permeable, finer textured Permian deposits. Along the uplands where Ogallala Formation remnants occur, shinnery oak (*Quercus havardii*), sagebrush (*Artemisia tridentata*), big blue stem (*Andropogon gerardi*), little blue stem (*Andropogon scoparius*), and juniper (*Juniperus virginiana*) are common cover. The spring-fed canyons draining these uplands support dense stands of cottonwoods (*Populus deltoides*), black willow (*Salix nigra*), red mulberry (*Morus rubra*), western soapberry (*Sapindus drummondii*), and persimmon (*Diospyros virginiana*; Blair and Hubbell 1938; Thurmond 1991; Thurmond et al. 2002). In contrast, floral communities on the Permian outcrops are dominated by sumac (*Rhus trilobata*), yucca (*Yucca glauca*), prickly pear cactus (*Opuntia sp.*), buffalo grass (*Buchloe dactyloides*). Ravines cut into these redbeds support stands of hackberry (*Celtis sp.*) and American elm (*Ulmus americana*; Blair and Hubbell 1938; Thurmond 1991; Thurmond et al. 2002).

Quaternary deposits in the region consist predominantly of alluvial and eolian materials (Ferring 1990; Madole et al. 1991). Well preserved Pleistocene alluvium flanks the northern banks of the large river valleys while Holocene eolian sands form extensive dunes along the southern and northern sides of these river systems. Fluvial deposits along the uplands and interflaves are typically thin and composed of quartzites, granites, and metamorphic rocks derived from the Ogallala Formation during periods of high river discharge (Madole et al. 1991). Terrace and valley-floor alluvium are generally composed of fine-grain shale and sandstone deposits, but they may include coarse-grain deposits of sand and gravel (Madole et al. 1991; Thurmond 1991). The thickness of the alluvial deposits depends on the hydraulic characteristics of the river systems and the composition of the sediment in the channels (Leopold et al. 1992). Alluvium thickness is greater along the North Fork than along the Washita River. The broad drainage basin and braided fluvial channel of the North Fork in contrast to the narrow valley and meandering channel of the Washita resulted in the preservation of alluvial terraces along the North Fork within the study region (Thurmond 1991). In addition to alluvial deposition, eolian sand dunes and sheets are common deposits along the Dempsey Divide. The sand dunes tend to be widely scattered across the divide and the size, shape, and orientation of these dunes greatly varies (Thurmond and Wyckoff 1998). The widespread distribution of the dunes indicates the erosion and weathering of Ogallala materials. Buried soils have been recorded in a number of the dunes, and the radiocarbon dates indicate late Pleistocene ages for most of the dunes (Thurmond and Wyckoff 1998).

Landscape Evolution

The depositional history and soil formation in the canyon systems of the Dempsey Divide have been well documented in recent years (Thurmond 1990, 1991; Thurmond and Wyckoff 1998, 2001, 2002). Late Pleistocene deposits at the Brokenleg

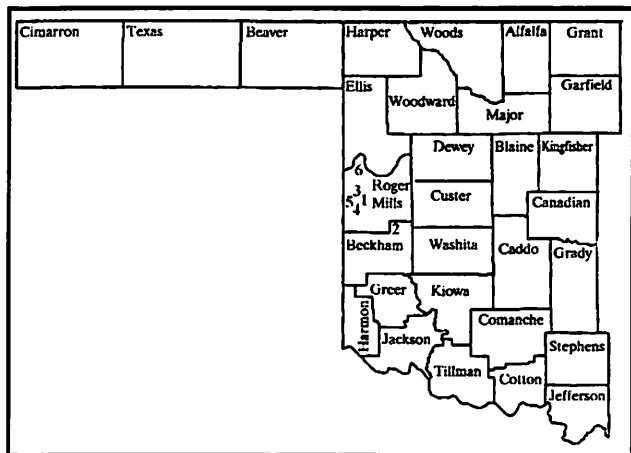


Figure 18. Western Oklahoma sites and localities near site 34RM507 where late Pleistocene and Holocene deposits have been described and dated: 1, Site 34RM507; 2, Certain site; 3, Brokenleg Bend Exposure #1; 4, Brokenleg Bend Exposure #3; 5, Finch Canyon; and 6, Antelope Hills.

Bend exposure, just a few miles west of site 34RM507 (Fig. 18), contain sequences of fine sand deposited in ponds dating from 27,800 to 22,000 years ago (Thurmond and Wyckoff 1996). The accumulation of these Pleistocene deposits terminated with erosional discontinuities and then was followed by soil formation processes that date to the recent Holocene. Land and water snails have been collected from the site and yield information on the climate and environment during and after the last ice age event. In addition, sustained research by Thurmond and Wyckoff of buried soils at Antelope Hills Exposure #1, Finch Canyon, and Brokenleg Bend Exposure #3 has provided evidence for a 400-year precipitation cycle across the region (Fig. 19). There are five pluvial (rainfall) events that are evidenced based on the radiocarbon dating of the paleosols (Thurmond and Wyckoff 2002). The first pluvial event (Finch Canyon) is documented around 50 B.C. - A.D. 100 and appears to coincide with the return of hunter-gatherers into the region (Thurmond and Wyckoff 2002:16). Significant alluviation of the Late Holocene canyon systems has been well documented along the Dempsey Divide. The inception of canyon cut-and-fill processes has been linked to these climatic intervals of pluvial and interpluvial cycles. Site 34RM507 is adjacent one of the drainages off the Dempsey Divide that has experienced canyon incision and rapid refilling during the Late Holocene.

Investigations east of the Dempsey Divide have described Holocene cut-and-fill episodes. Research at the Certain site near Elk City yielded evidence of canyon incision (Fig. 19) 2200 years ago (Bement and Buehler 1998; Green 2002). The Certain site is a large bison kill in a canyon that is currently flushed of sediments (Fig. 20). The canyon contains bone beds at the base of a sandstone cliff and in several side gullies. Radiocarbon dates from the bone deposit on the canyon floor fall around 2200 years ago, whereas dates obtained from the side gully deposits are between 1700 to 1500 years ago (Bement and Buehler 1998; Green 2002). Based on

Dempsey Divide Late Holocene Climate Sequence
A Four Century Cycle in Average Annual Effective Precipitation
As Inferred from Radiocarbon Dating of Paleosols
And the Instrumental Record Since 1893

J. Peter Thurmond & Don G. Wyckoff, Sam Noble Oklahoma Museum of Natural History

Defined Climate Intervals:

Climate Interval	Calendar Age	Subinterval Duration	Interval Duration
Bean Creek			
Pluvial	AD 1990+	10+ years	Time Will Tell...
Interpluvial	AD 1650-1990	340	
Delaware Canyon			
Pluvial	AD 1450-1650	200	
Interpluvial	AD 1300-1450	150	350 years
Brokenleg Canyon			
Pluvial	AD 1150-1300	150	
Interpluvial	AD 1000-1150	150	300
Higgins Creek			
Pluvial	AD 775-1000	225	
Interpluvial	AD 600-775	175	400
Herring Creek			
Pluvial	AD 400-600	200	
Interpluvial	AD 100-400	300	500
Finch Canyon			
Pluvial	50BC - AD 100	150	
Interpluvial	300(?) -50 BC	250	400?

Average Pluvial Duration: 185 Years
Average Interpluvial Duration: 230 Years
Average Climate Interval Duration: 415 Years

Figure 19. The late Holocene climatic sequence for the Dempsey Divide area as proposed by Thurmond and Wyckoff 2002.

geoarchaeological findings, the main stem of the canyon at the Certain site was devoid deposits and the canyon was used to trap bison. After 2200 years ago, the canyon began filling and a minor period of entrenchment correlated with the formation of lateral gullies, some of which were used as bison traps between 1800 and 1500 years ago (Green 2002). Sometime after 1500 years ago, the gullies filled, burying the bison kills beneath 3.0 m of colluvium. Historical accounts indicate that the canyon was filled with sediments 80 years ago (Bement and Buehler 1998). Recently, erosion has flushed sediments from the main canyon stem, exposing the bone deposits along the floor of the canyon and perching the gully-kill deposits above the canyon floor (Figs. 20 and 21)

Sample Descriptions and Analysis

Chemical Analysis

The percentages of organic material (OM) and calcium carbonate (CaCO_3) in the sediment samples were measured using the loss-on-ignition technique devised by Dean (1974). This technique consists of burning sediment samples in a muffle furnace at 500°C and 1000°C (Fig. 22). Burning sediment samples at high temperatures creates a chemical reaction that results in the development of gases (Stein 1984). Organic material begins to oxidize around 200°C and completely burns at 550°C . Between 800°C and 850°C , carbon dioxide begins to decompose, and it is completely oxidized by 1000°C . Both



Figure 20. Deep canyon incision at the Certain site in Beckham County.

burn events reduce the weight of the sediment sample. The amount of weight loss in the sample after each burn enables quantifying the percentage of organic material and carbonates originally present in each sediment sample.

The analysis followed standard loss on ignition procedures (Dean 1974; Stein 1984). From each sample, approximately 15 gm of sediment were removed and ground with a mortar and pestle. Three 10 ml ceramic crucibles were weighed to 0.0001 gm, and 5 gm of the powdered sediment sample were placed in each crucible. The crucibles were then placed in a drying oven for one hour at 90°C to completely dry the sediment samples. These samples were weighed once more, and the resultant weight was used for the basis of all further calculations. At each stage, crucibles were weighed twice and the average taken to insure greater accuracy of the mea-



Figure 21. View of lateral erosion exposing the Certain site some 20 miles east-southeast of 34RM507.



Figure 22. Burning sediment samples in the muffle furnace to gather data on weight loss on ignition..

surements.

The muffle furnace was preheated to 550°C. Samples were then placed in the furnace for one hour to burn the organic material. After an hour, the samples were taken out of the oven to cool at room temperature. Once cooled, the samples were placed in a desiccator for one hour to evaporate any moisture. After that, they were weighed. The difference in weight loss between the dry weight and the weight at 550°C is the amount of organic material in the sample. The furnace was preheated to 1000°C, and the samples were placed into the oven for one hour. The difference in weight loss at 1000°C compared to that at 550°C represents the percentage of decomposed carbonates in the samples. The loss of weight after the 1000°C burn was divided by 0.44. This calculation converts the carbon dioxide evolved from carbonate minerals to calcium carbonate (Stein 1984:241).

Grain-Size Analysis

Particle size analysis measures the amount of sand, silt, and clay in soils or archaeological deposits. In sedimentology, particle size analysis is the primary method for quantifying the amounts of sand, silt, and clay present. The fundamental principle is based on Stoke's Law which notes that small particles will settle at a constant rate in a fluid medium (Folk 1980). This constant velocity depends on the individual grain's shape, density, and texture as well as the density and viscosity of the fluid medium. The grain-size technique used in this analysis is based on Folk's (1980) methods discussed below.

Particle sizes smaller than 0.0625 mm in size cannot be measured using dry sieving. Therefore, in this analysis the

pipette method was used to calculate the percentage of sand, silt, and clay in each sample. Before the pipette method can begin, bulk samples must be split. This is done to allow for an accurate representation of all grain sizes in each sample. Each sample was divided into four equal parts. Of the four quarters, two were combined and then split again into smaller size quarters until a sufficiently small subsample was obtained.

The amount of sample material used for this analysis was 50 gm. This was done for two reasons. First, the amount of material used in the pipette methods depended on the textural composition of the sediments. If the sample is composed predominantly of sand-size particles and gravel, 25 gm should be used. Alternatively, for samples containing silt- and clay-sized particles, 3 gm of material is used. Samples collected from site 34RM507 predominantly consist of sand- and silt-size particles. Second, a larger sample is necessary for future microartifact analysis of the sand fraction.

Once the sample size was determined, the material was placed in a 500 ml flask containing 150 ml of deflocculant agent and then shaken for five minutes. Each sample was soaked in the solution for 24 hours (Fig. 23). The deflocculant agent is a mixture of distilled water and sodium hexametaphosphate. The purpose of the deflocculant agent is to keep the clay particles from adhering to one another. This solution was made by dissolving 1.0 gm of sodium hexametaphosphate into 1.0 liter of distilled water. Due to the

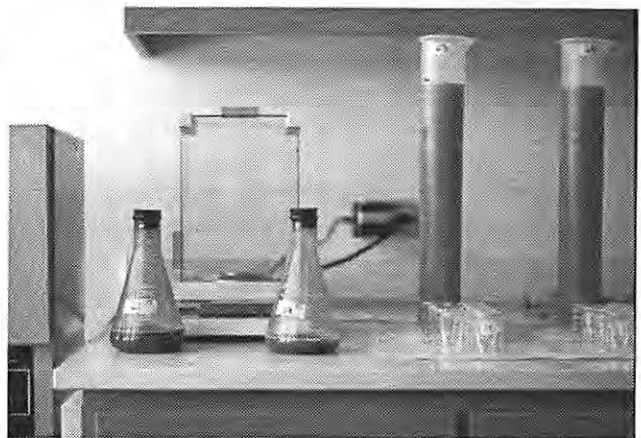


Figure 23. Soaking samples of sediment from the strata underlying 34RM507.

large sample size of this analysis, 15 liters of solution were prepared for every 12 samples. After the solution was adequately mixed, ten 20 ml aliquots of solution were drawn from the 15-liter container and placed into pre-weighed 40 ml beakers. The 10 beakers were oven dried to evaporate the distilled water, leaving only the dried sodium hexametaphosphate in the beakers. The weight of each empty beaker was subtracted from the weight of each beaker containing the dry solution. All 10 beakers were then weighed and the averages calculated. This enabled determining the



Figure 24. Wet sieving silt and clay particles from one of the samples from site 34RM507.

concentration of the peptizing agent in the solution.

The silt- and clay-size materials must be separated from the sand-size material because the smaller particles are analyzed using the pipette method, whereas the larger (sand) particles are analyzed by the dry sieving method. A 62-micron (230 mesh, 4 phi) geological sieve was used to wet sieve the silt and clay materials (Fig. 24). The sample in the 500 ml flask is washed into the screen over a large basin to catch the finer materials. The sediment was continually jet-sprayed with the peptizing agent using a 500 ml wash bottle. The silt and clay fractions were separated from the sand fraction by rocking the sediment back and forth across the screen. No more than 950 ml of solution was used because the finer material was placed into a 1000 ml cylinder for the pipette analysis.

The remaining sand fraction was washed into a 250 ml beaker and placed in the drying oven to evaporate the water. Once dry, the dry-sieving technique was used to determine the size distribution within the sand fraction. This was accomplished by pouring the dried sand into six U.S. Standard Sieve mesh screens. The sizes of the screens were: 2.00 mm (-1 phi), 1.00 mm (0 phi), 0.50 mm (1 phi), 0.25 mm (2 phi), 0.125 mm (3 phi), and 0.0625 mm (4 phi). One accepted grain-size nomenclature and classification used is the Wentworth scale system. This system divides sediment particles into gravel, sand, silt, and clay. Gravel size is greater than 2 mm; sand size particles range between 2 and 0.0625 mm; silt consists of particle sizes between 0.0625 and 0.0039 mm; and clay particles are smaller than 0.0039 mm.

The screens were nested in order from coarsest (2 mm) at the top to finest (0.0625 mm) at the bottom. Next, the nested screens were placed in a sieve shaker and shaken for 10 minutes. This process was necessary to separate the different sand fractions completely. After shaking, the contents of every screen was emptied into a pre-weighed container and

weighed to the nearest 0.0001 gm. The weight of the empty container was subtracted from the weight of the container plus the sand sample. This procedure was done for every screen size. The bottom pan nested under the finest screen accumulates the silt and clay particles that were not washed thoroughly during the wet sieving technique. These missed particles were emptied into the 1000 ml cylinder prior to the pipette analysis. This permitted more accurate measurements of the finer particles in each sample.

Before the pipette analysis of the silt and clay fractions began, eight 50 ml beakers were weighed to within 0.0001 gm. Each beaker represents the eight draws of sediment from the 1000 ml cylinder required to measure the amount of silt and clay in each sample. The precise timing of these draws was crucial to record the specific settling rate of the particles. The cylinder was agitated enough to distribute the sediment material uniformly throughout the cylinder. Immediately after stirring the sediment, the first pipette draw begins (Fig. 25). The specific time interval and depth of each draw are



Figure 25. Doing a pipette draw on a sediment sample from site 34RM507.

illustrated in Table 1. The depth was measured from the surface of the liquid, not from the 1000 ml mark on the cylinder. Each draw consisted of 20 ml of sample solution. After the draw, 20 ml of distilled water was added to the beaker, and the beaker was placed in the drying oven to evaporate the water from the sediment. Once dried and cooled, the beakers were weighed again to within 0.0001 gm. All eight samples were weighed together. This was done because the samples are able to come into equilibrium and absorb the same amount of atmospheric moisture (Folk 1980). Folk (ibid.) contends this procedure leads to less experimental error.

After all of the samples were weighed, the results were put into an Excel spreadsheet created by Carl Lipo (University of Washington) for Dr. Julie K. Stein, professor in anthropology at that university. This program calculates the percentage of sand, silt, and clay; mean grain size; standard deviation; skewness; and kurtosis for each sample (Folk 1980).

Table 1. Particle Size and Chemical Characteristics at 34RM507 West Profile #2.

Sample	Clay %	Silt %	Sand %	Gravel %	Organic Matter %	CaCO ₃ %	pH
1	11.5	64.1	19.6	4.8	0.8	10.7	7.5
2	5.1	29.6	58.0	7.3	0.6	16.7	7.6
3	13.4	36.8	46.0	3.7	0.7	10.2	7.7
4	13.2	49.3	32.7	4.8	0.8	16.4	7.6
5	3.7	25.7	61.6	9.1	0.8	12.7	7.5
6	15.7	33.5	49.1	1.6	0.8	14.0	7.7
7	14.4	54.2	30.3	1.1	0.7	17.0	7.9
8	14.1	50.1	35.2	0.6	0.6	14.8	7.8
9	19.1	59.9	16.6	4.5	0.6	13.6	7.7
10	17.7	69.8	11.3	1.2	0.7	14.6	7.9
11	15.7	42.9	38.2	3.2	0.8	12.9	7.4
12	16.5	68.0	13.0	2.6	0.5	15.6	7.5
13	9.5	38.7	43.6	8.2	0.5	11.9	7.6
14	11.0	75.2	9.4	4.5	0.5	19.9	7.7
15	18.5	20.3	46.5	14.7	0.4	15.6	7.6
16	6.7	87.1	6.2	1.0	0.6	19.1	7.5
17	10.0	72.1	7.1	10.9	0.4	19.3	7.5
18	8.2	21.5	68.6	1.7	0.4	19.4	7.4
19	8.2	43.4	30.3	20.1	0.3	19.7	7.4
20	9.1	75.7	15.3	1.2	0.3	19.4	7.6
21	17.8	40.6	30.7	10.9	0.4	20.9	7.7
22	8.6	42.6	43.7	5.2	0.5	20.7	7.7
23	5.6	49.9	44.0	0.5	0.3	19.3	7.8
24	6.6	35.8	14.3	35.7	0.3	20.3	7.8
25	9.5	55.5	35.0	1.3	0.2	18.9	7.5
26	20.4	46.4	32.7	0.5	0.2	21.9	7.6
27	10.0	25.8	17.5	53.2	0.2	21.9	7.7
28	9.7	28.7	19.2	42.4	0.2	21.4	7.7

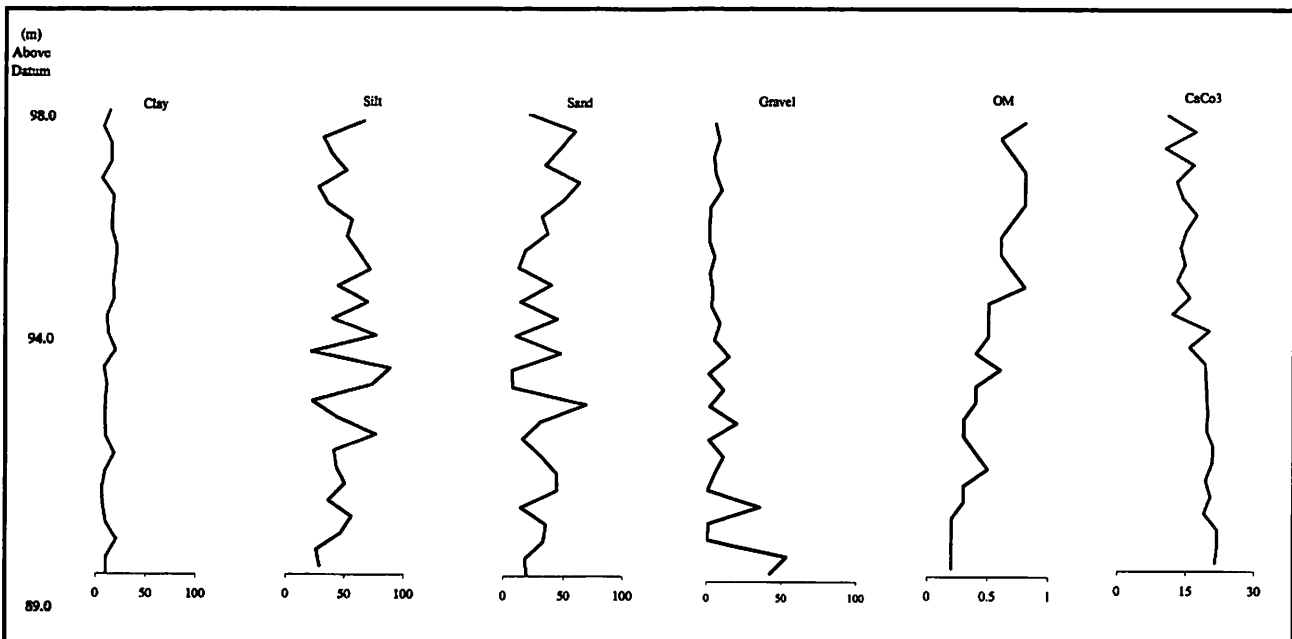


Figure 26. Chart of particle sizes, organic matter, and calcium carbonate according to elevation in West Profile #2 at site 34RM507.

Data Analysis

This section describes and examines the stratigraphic profiles for West Profile #2 and the two channel cuts in that profile. To understand the complex depositional history at site 34RM507 requires that the source, transport agent, depositional environment, and post-depositional alterations must be identified. Sediment particle-size and chemical analysis are tools that can be used to help decipher sediments that bury or incorporate archaeological materials. The nature and energy level of a transport medium (e.g., wind, water, ice, or people) is a major determinant of sediment particle size (Stein 2001; Visher 1969). Flooding streams can transport an array of particle sizes, from gravels to fine silts and clays, for example.

The textural chart (sand/silt/clay; Table 1) for the main profile reveals an interesting distribution pattern (Fig. 26). The clay content stays relatively constant upward in the profile, but three peaks occur where slightly more clay was deposited, possibly as a result of an initial increase in stream flow. These clay content peaks also coincide with increases in sand and gravel content, also suggesting increases in the amount of water flow associated with significant rainfall. To initially move clay particles, considerable stream velocity is required, which may be represented by the increase in clay. The alternating fining and coarsening upward in fine silts and sands suggests a relationship exists between the energy regime of the transport agent (stream) and climate. Surprisingly, between 93.0 and 92.0 m, the gravels decrease in the profile while the sand and silt fractions are highly variable (Fig. 25). In the lower portion of the profile, there is coarsening upward of the sand and gravel (Fig. 26), indicating the initial refilling of the setting was intense and rapid, with extreme fluctuations in stream flow velocity.

The chemical analysis reveals that the organic matter decreases with profile depth (Table 1; Fig. 26). The increase of organic matter upward may reflect the recovery of the grasslands here and on the nearby uplands of the Dempsey Divide. In addition, research on snails collected on the site also reflects climate recovery (see Leith, this volume). The recovered snails attest to increasing diversity and numbers as this profile accumulated. This evidence for increasing biologic diversity is consistent with my chemical findings. The increase in carbonates with depth is due to post-depositional processes. Pedogenic processes in semiarid areas will remove and transport carbonates downward from the upper layers (Birkeland 1999).

The stratigraphic evidence (Fig. 15) for the channel cuts reveals some interesting distinctions from the main profile. The clay content increases upward but decreases abruptly at the intersection between the two channel cuts. The silt fraction is fairly constant and homogeneous for both channels, whereas the sand fraction shows an initial decrease upward at the cross between the channels where it gradually increases again. The gravel materials increase upward until

they decrease abruptly between the intersection of the lower and upper channel fills. The results of the chemical analysis reveal a constant pattern over time. Both the organic matter and the carbonates gradually increase with depth. The increase in organic matter in the channel fills supports Thurmond's assertions that a melanized (organic enriched), sandy soil was washed down Herring Creek and redeposited into the channel cuts (Thurmond, personal communication; Thurmond and Wyckoff 2002).

Discussion and Conclusions

The picture we get at site 34RM507 is that, at the end of the Altithermal, western Oklahoma would have experienced desert-like conditions with very little rainfall. Low precipitation probably created a landscape denuded of vegetation, resulting in an increase in sheet-erosion. As the climate changed from dry to moister conditions around 3300 BP (Before Present), rainfall produced by thunderstorms resulted in mass wasting of the upland surfaces. The arroyo at 34RM507 began rapidly refilling with laminated sediments from about 3300 to 1900 BP. Rapid sedimentation along the Dempsey Divide is also documented at the Certain site (Bement and Buehler 1998; Green 2002). Radiocarbon dates (2200 BP) from the bone deposits on the floor of the Certain canyon and dates of 1750 to 1500 BP in the side gullies of this canyon attest to significant deposition at this time in western Oklahoma.

Once the landscape became stable and the canyons had filled, prehistoric hunter-gatherers reappear on the Dempsey Divide. Dates from Feature 2 at 34RM507 suggest that people returned to the area by AD 50. In addition, numerous Late Archaic and Early Woodland campsites have been documented on the Thurmond Ranch, further demonstrating the return of people after the Altithermal (Thurmond 1991). Moreover, the changes to the landscape provided an ideal strategy for hunting bison as witnessed by the numerous bison kill sites in the Texas panhandle and the multiple kill events at the Certain site in western Oklahoma.

A minor erosional event occurred during the Herring Creek Interpluvial (AD 100 to 400), creating a one-meter deep gully. The incision eroded segments of an archaeological site (34RM507), re-depositing artifacts into the gully. Along with the artifacts, shale fragments, and Ogallala gravels were also washed into the gully around A.D. 420, marking the return of moist conditions (the Herring Creek Pluvial, A.D. 400-600) in the area.

Sometime around 1300 to 1000 B.P., a sequence of cut-and-fill events occurred at the north end of the site. The erosional episodes were brief, lasting less than 200-300 years before being followed by periods of alluviation (Brokenleg Canyon Pluvial/Interpluvial). These cut-and-fill sequences coincide with Hall's (1990) evidence for channel trenching on the Southern Plains around A.D. 1000. The successive cut-

and-fill episodes appear to have been more intensive than the Herring Creek gully incision. Subsequently, these events also resulted in more erosion of the Late Archaic campsite(s). Artifacts made from the locally available Ogallala gravel are among the materials that were rapidly deposited into the channels. By A.D. 1150 to 1300, soil development at Brokenleg Bend Exposure #3 and at Antelope Hills Exposure #1 indicates this region once again experienced moist climatic conditions and landscape stability (Thurmond and Wyckoff 2002). However, geomorphic instability returned to the region, triggering another incision event that we see today at site 34RM507.

Considerably more work needs to be performed on the canyon systems in western Oklahoma before we can fully understand the dynamic interplay between climate, landscape change, and human settlement patterns. The extensive archaeological and geoarchaeological research conducted in recent years has contributed to reconstructions of what prehistoric conditions were like in western Oklahoma. Site 34RM507 provides us with a unique view of late Holocene events that influenced landform development and human occupation along the Dempsey Divide.

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Radiocarbon Dating Site 34RM507

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Assessing the age of an archaeological site is always important. Such sites result from the behavior of humans, and archaeologists always need to understand when that behavior occurred. As implicated in the previous two chapters, archaeological site 34RM507 also is the result of geological processes. Consequently it is important that we understand when these occurred. Thanks to the interest and financial assistance of landowner Pete Thurmond, a series of 17 radiocarbon dates have been obtained for this site. The submitted samples often consisted of small bits of charcoal but sometimes were organically enriched soil. These samples come from diverse locations on the site, and these locations were selected for dating because they were deemed important for understanding either the human or the geological processes that created the site. Below, these results are presented and briefly related to questions about the human or the geological factors that resulted in the way site 34RM507 looks today.

Dating the Human Occupation

Due to concerns about contexts unquestionably resulting from human actions, only three radiocarbon dates are believed relevant for assessing when hunter-gatherers occupied site 34RM507. All samples were processed by AMS dating. These samples and their uncorrected ages are:

Beta-136173 1930 \pm 50 BP Uncorrected Age
1970 \pm 50 BP Corrected Age
Intercept Age: AD 130
13C/12C Ratio: -22.8

This sample was composed of charcoal collected from Feature 2, the small, basin-like hearth exposed in West Profile #1 (Figs. 9, 14, and 27).

Beta-141601: 1990 \pm 30 BP Uncorrected Age
1980 \pm 30 BP Corrected Age
Intercept Age: AD 30
13C/12C Ratio: -25.6

This sample consisted of charcoal from the rather concentrated lens of charcoal that was exposed in level 10 (90-100 cm below surface) of Test Unit 4 dug adjacent West Profile #1 (Figs. 14 and 27). This charcoal may have originated from Feature #2, the small, ash-filled hearth exposed in West Profile #1.

Beta-141602: 1820 \pm 40 BP Uncorrected Age
1830 \pm 40 BP Corrected Age
Intercept Age: AD 215
13C/12C Ratio: -24.3

This sample was charcoal recovered from level 3 (20-30 cm below surface) of Test Unit 2 that was dug in Area B (Fig. 11). Along with this charcoal, flakes and other knapping

debris were recovered.

Discussion. Radiocarbon results are constantly undergoing improvement, especially as the technology improves and as more is learned about atmospheric carbon amounts and fluctuations through the ages. Consequently, we have elected to emphasize the uncorrected radiocarbon dates here.

Regarding the human occupation of this site, samples Beta-136173 and Beta-141601 seem especially relevant. Beta-136173 is from the only assuredly intact cultural feature (Feature #2) observed at the site (Fig. 9), and its age is determined to be 1930 \pm 50 years ago. Beta-141601 is charcoal thought to have been eroded from Feature #2, but its result overlaps very little with Beta-136173. So, it is likely that the charcoal of Beta-141601 is not from Feature #2 but is from an event shortly after the use of this hearth.

Dating Geological Processes

Fourteen charcoal samples were submitted for radiocarbon dating because the profiles at 34RM507 manifested clues to significant accumulations of sediments and notable erosion. These two processes relate to the formation of the landform on which the site occurs as well as to the integrity of the archaeological deposits. In the paragraphs below we present and discuss the dates pertaining to these two topics.

Late Holocene Sediment Accumulations. As shown in Figures 10, 12, 13, and 28, site 34RM507 is atop a dramatic sequence of interbedded silt and gravel deposits. This gravel is deep red in color, angular in appearance, and largely pebble (but sometimes small cobble) in size. The color and texture of this gravel is comparable to the Doxey Formation, the Permian shale prevalent along the north-sloping upland away from the Washita River. Interbedded with the gravel layers are "varve-like" strata of fine, red silt (Figs. 13 and 28). This silt's color and texture indicate it also is derived from the Doxey shale. The silt strata were the primary units to contain snails and charcoal fragments, and their presence led to the belief that the 34RM507 profile was important for clues about past environments (with the snails as proxy records) and the timing (with the charcoal fragments as the source) of the nearly 8.0 meters accumulation of sediments on which the site occurs. Consequently, 12 charcoal samples (out of nearly 25) were submitted for AMS dating. The results are listed below in stratigraphic order from top to bottom.

Beta-135654: 1610 \pm 40 BP Uncorrected Age
1630 \pm 40 BP Corrected Age
Intercept Age: AD 420
13C/12C Ratio: -23.8

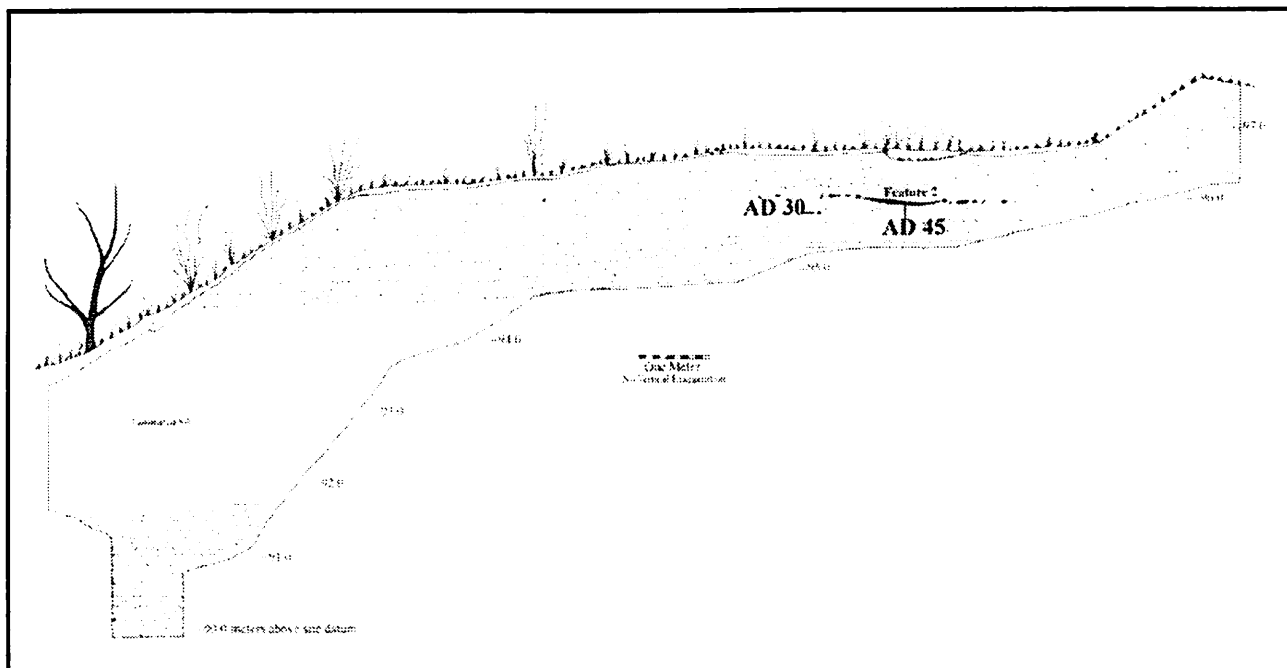


Figure 27. West Profile #1 at site 34RM507 showing the intercept dates for charcoal samples submitted for AMS dating.

This was charcoal collected from the thin ash lens nearly 0.5 m below the present ground surface about a meter south of the gully fill at the top of West Profile #2 (Fig. 28).

Beta-167554: 1980 ± 40 BP Uncorrected Age
2000 ± 40 BP Corrected Age
Intercept Age: AD 10
13C/12C Ratio: -24.0

This was Sample #20 which consisted of charcoal collected from the silt layer some 30cm below the present ground surface several meters south of the gully fill at the top of the profile (Fig. 28).

Beta-135655: 2090 ± 40 BP Uncorrected Age
2070 ± 40 BP Corrected Age
Intercept Age: BC 60
13C/12C ratio: -25.8

This was Sample #1 taken from West Profile #2. The sample came from a silt layer 3.5m below the surface and more than 2.0m below the gully fill exposed at the top of the profile (Fig. 28).

Beta-146385: 2100 ± 40 BP Uncorrected Age
2080 ± 40 BP Corrected Age
Intercept Age: BC 80
13C/12C Ratio: -26.3

This was Sample #19 collected from West Profile #2. It consisted of charcoal recovered from a silt layer some 3.75m below the surface of the ground and some 25 cm below Beta-135655 (Fig. 28).

Beta-135656: 2280 ± 40 BP Uncorrected Age

2330 ± 40 BP Corrected Age
Intercept Age: BC 395
13C/12C Ratio: -22.0

This is Sample #5 from West Profile #2. It consisted of charcoal collected from a silt layer some 5.75m below the present ground surface (Fig. 28).

Beta-139177: 30 ± 50 BP Uncorrected Age
80 ± 50 BP Corrected Age
Intercept Age: AD 1950
13C/12C Ratio: -22.0

This sample (#12 from West Profile #2) was collected from a layer of red silt 6.1m below the surface.

Beta-135657: 2170 ± 40 BP Uncorrected Age
2150 ± 40 BP Corrected Age
Intercept Age: BC 185
13C/12C Ratio: -26.0

This sample (#9 from West Profile #2) came from a silt layer 6.5m below the ground surface (Fig. 28). Note that the result is younger than Beta-135656 which was above it.

Beta-139175: 2400 ± 40 BP Uncorrected Age
2440 ± 40 BP Corrected Age
Intercept Age: BC 515
13C/12C Ratio: -22.1

Designated as Sample #10 from West Profile #2, this consisted of charcoal collected 7.0m below the ground surface (Fig. 28).

Beta-139176: 2510 ± 40 BP Uncorrected Age
2570 ± 40 BP Corrected Age

Intercept Age: BC 790

$^{13}C/^{12}C$ Ratio: -20.9

This is Sample #1 from West Profile #2. The sample consisted of charcoal collected from a thin gravel stratum at 7.1m below the present ground surface (Fig. 28)

Beta 135658: 400 ± 40 BP Uncorrected Age

370 ± 40 BP Corrected Age

Intercept Age: AD 1490

$^{13}C/^{12}C$ Ratio: -26.8

This is Sample #13 from West Profile #2. It came from red silt that was 7.2m below the surface. Note that the result is inconsistently young relative to the recorded depth and sample Beta-139176 which was slightly above it.

Beta-141605: 1930 ± 40 BP Uncorrected Age

1940 ± 40 BP Corrected Age

Intercept Age: AD 65

$^{13}C/^{12}C$ Ratio: -24.4

This is Sample #17, charcoal collected from the western extension of West Profile #2 (Fig. 28). The sample was collected from red silt 2.5m below the surface, but this sample's stratigraphic position corresponds to an undated zone lying between samples Beta-146385 and Beta-135656 in the thickest part of West Profile #2. This sample is also important because it lies adjacent and just below the cut-and-fill sequence recorded in this western extension of West Profile #2.

Beta-141606: 2420 ± 80 BP Uncorrected Age

2380 ± 80 BP Corrected Age

Intercept Age: BC 405

$^{13}C/^{12}C$ Ratio: -27.3

This is Sample #18, which also came from the western extension of West Profile #2 (Fig. 28). It consisted of charcoal that occurred in a red silt stratum underlying the cut-and-fill sequence recorded in this western part of the profile. Despite being at about the same stratigraphic position as Beta-141605, this samples's result is noticeably older.

Discussion. The 12 samples listed above were submitted for radiocarbon dating in order to assess how long it took to create the bluff-like setting on which site 34RM507 occurs. Of these samples, two (Beta-139177 and Beta-135658) yielded results inappropriate (essentially modern) to their recorded depths. These two samples clearly represent recent charcoal positioned in the profile from either geological or biological processes that were not observed as the profile was recorded.

Disregarding the two spuriously recent dates, the remaining 10 results attest to this site's high profile accumulating between roughly 2500 and 1600 years ago (Fig. 28). Multiple cycles of erosion of Doxey shale upslope (east) and upstream (south) account for the repeated silt-gravel strata manifest here. The end result of this aggrading was the creation of a high point within a small stream valley. This setting afforded vistas of the adjacent stream (Higgins Creek) valley and of some of the rolling uplands that slope north towards today's Washita River. The erosion that helped create this bluff-like vista also may have exposed the nearby, lagged out gravel deposits containing the Ogallala quartzite cobbles so favored by the location's human occupants some 1900 years ago.

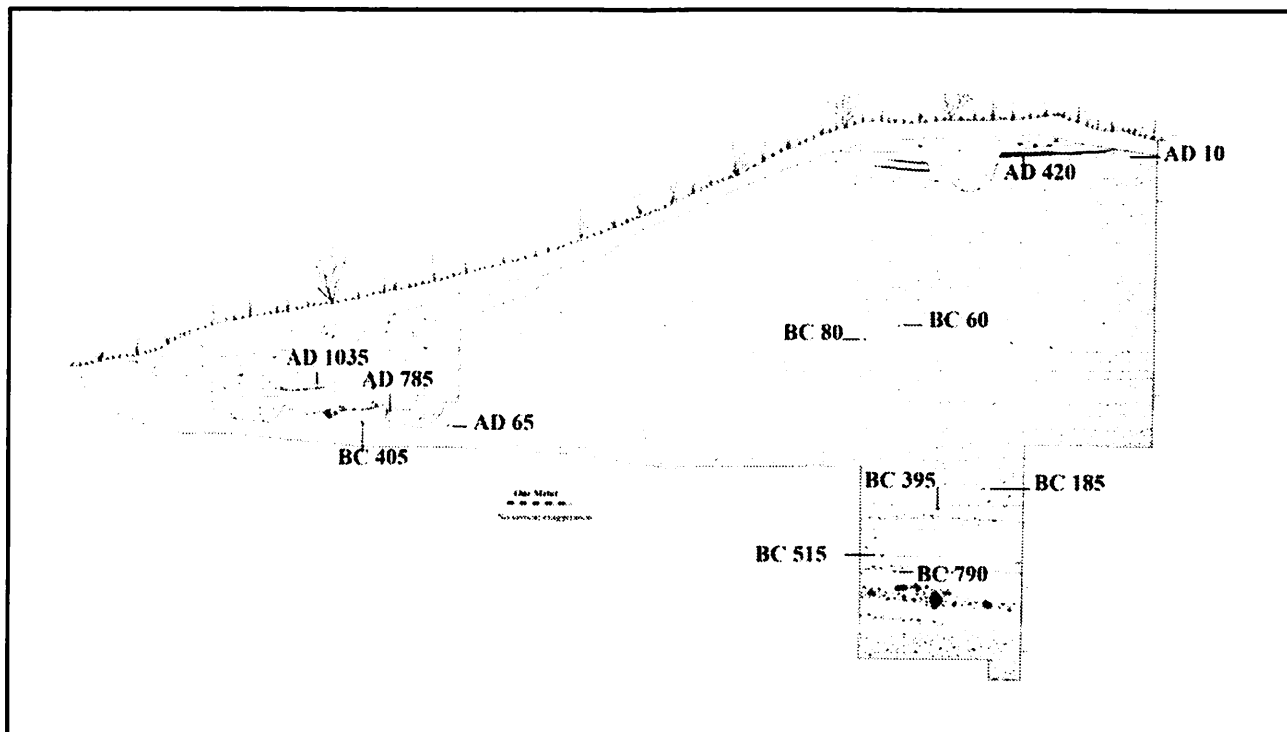


Figure 28. West Profile #2 at site 34RM507 showing the intercept dates for select charcoal samples submitted for AMS dating.

Late Holocene Erosion on the Site. While cleaning and recording the high wall comprising West Profile #2, we recognized that a gully had cut into (and been refilled) the top of the profile (Figs. 10, 12, and 13). Among the contents of this erosional feature were flakes, ash, and pieces of bone and fire-cracked rock. These implicated that the archaeological site had been eroded sometime after people had occupied the setting. Further evidence of cutting and filling was revealed as we were cleaning the northern part of West Profile #2. There, the creek bank angles westward. Initially, it did not look distinctive because rain had washed reddish sediment over it, essentially "painting" it. But upon cleaning this westward extension we discovered traces of three episodes of gully cutting and filling preserved in the profile (Fig. 28). The lower two of these cut-and-fills contained charcoal fragments, so we submitted single samples from each of the two fills. These results are:

Beta-141604: 1120 ± 40 BP Uncorrected Age
1220 ± 40 BP Corrected Age
Intercept Age: AD 785
13C/12C Ratio: -18.8

This is Sample #16 which consisted of charcoal collected from the first (lowest) gully fill exposed in the west extension of West Profile #2 (Fig. 28).

Beta-141603: 870 ± 40 BP Uncorrected Age
960 ± 40 BP Corrected Age
Intercept Age: AD 1035
13C/12C Ratio: -19.6

This is Sample #15 which included charcoal collected from the second lowest gully fill exposed in the west extension of West Profile #2 (Fig. 28).

Discussion. We assumed the charcoal submitted from these two contexts originated from fires not associated with the human occupation of site 34RM507. On that basis, the results are interpreted to roughly date the periods of erosion that filled the two lowest gullies manifest in the west extension of West Profile #2. The earliest (lowest) gully filled around 1120 years ago, whereas the second lowest one filled around 870 years ago.

The human habitation debris observed in both of these cut-and-fill contexts most likely eroded from 34RM507, although it is possible they washed downstream from occupation areas known to the south. Unfortunately, lacking any diagnostic artifacts from these aggraded gullies, we can't prove where the artifacts originated. Noting that gullies draining 34RM507 today tend to come downslope and turn to the north (or downstream), it seems parsimonious that these cross-sectioned gullies near the present creek bed originated in close proximity. Perhaps one or both were even linked to the gully evident at the top of West Profile #2?

Conclusions

Seventeen samples from various contexts at site

34RM507 were radiocarbon dated. The results help explain when the site setting was created, when people frequented the setting, and when erosion occurred subsequent to people occupying the location.

As noted on preceding pages, eight samples yielded dates that are in relative stratigraphic order and that attest to sequences of aggrading silt and gravel (Fig. 28), both derived from the locally prevalent Doxey shale. From the stratigraphic succession of these dates it is evident that over six meters of this aggrading occurred between 2500 and 1600 years ago.

Three samples were thought initially to be relevant to the actual presence of hunter-gatherers at this location. The most directly relevant date is around 1900 years ago. This result comes from a small hearth exposed in profile below the surface in West Profile #1 (Fig. 27). A slightly older date (1990 years ago) on charcoal recovered near this hearth attests to a burning episode that we can't confidently link to the presence of people. Finally, a date of roughly 1800 years ago might be related to people's activities here. If so, it would indicate the location was periodically revisited.

West Profile #2 contains cross sections of cutting and filling from erosion after the human occupation of location. Three stratified instances of cutting and filling are evident (Fig. 28). Charcoal from the lowest instance yielded a date of 1120 years ago, whereas charcoal from the second lowest yielded a date of 870 years ago. On the basis of these results we believe erosion has notably affected site 34RM507, probably to the extent that the present distribution of tools and debris have little spatial relationship to the original activity areas where they were made, used, or originally deposited.

Environmental Interpretation of Gastropods, Archaeological Site 34RM507, Roger Mills County, Oklahoma

Luther Leith

Abstract

This paper examines the past environment at archaeological site 34RM507 using snails as proxy indicators. The research includes a brief history of the use of gastropods at archaeological sites as environmental indicators, followed by a synopsis of the Dempsey Divide research area in Roger Mills County, focusing on site 34RM507. The methods for the gastropod collection, processing, and identification are also discussed. The findings cover the period from around 3200 BP to around 1900 BP. The data indicates spring activation at the start of the sequence. There are two dry episodes, after which the climate ameliorates, becoming a dry prairie environment at the uppermost portion of the profile.

Introduction

The recognition and use of snails as proxy indicators of past environmental conditions began in Europe and was later emulated in the United States. Gastropod studies then went through fluctuations of relevance and interest as procedures were being worked out to fit with the American paleontological, climatological, and archaeological analytical approaches. Geologists were interested in finding "index fossils" for the Pleistocene in order to correlate Pleistocene deposits. This was unsuccessful because some species could be used as index fossils in certain areas but were not applicable on a continental scale (Evans 1972; Miller 1975).

Archaeologists wanted to reconstruct past environments and hypothesize on how environmental shifts affected people living at that time. Morse and Wyman (1867-1875) were some of the first researchers to look at possible shifts in the environment after discovering snails species in archaeological sites that inhabited woodlands but the sites were in treeless areas (Bobrowsky 1984). By the late 19th and early 20th centuries, snail studies had regressed to being side notes in archaeological investigations. Some problems with the early research included sampling in visibly rich zones and focusing on the larger snail species. This did not allow for clues to minor fluctuations in climate over time, because these are seen in changes in the population of smaller, more sensitive species (Evans 1972). However, by the 1920s, snails as notable sources of information were again being addressed. In 1925, Baker noted that there were gastropods introduced either by natural or cultural interaction while Morse continued to stress the use of gastropods as environmental indicators (Bobrowsky 1984).

By the 1930s, a debate had begun over the possibility of

gastropods as a food source versus natural inclusions in the archaeological record. This debate continued through the 1950's until the present. The argument over natural versus cultural (food sources) prevented the advancement of theory and method in gastropod studies. By the late 1960's and 1970's researchers such as Baerreis and Morrison were giving detailed information on snails recovered from archaeological sites. Baerreis and others were interested in the reasons behind snail taphonomy, which influenced the current paradigm in malacology (Bobrowsky 1984).

Site Synopsis

Archaeological site 34RM507 is located in the Dempsey Divide study area (Fig. 29), the uplands separating the Washita River drainage from that of the North Fork of Red River in northern Beckham and southern Roger Mills counties of western Oklahoma (Thurmond and Wyckoff 2003).

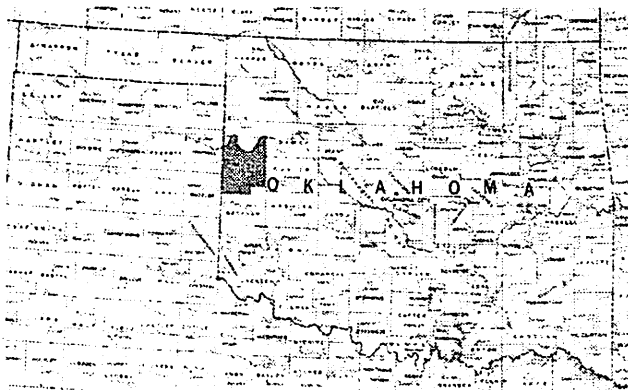


Figure 29. Location of Roger Mills County in western Oklahoma. The Dempsey Divide runs east and west about through the center of the county.

The Dempsey Divide is part of an erosional zone on the eastern edge of the Ogallala Formation which overrides the Permian redbeds there. Site 34RM507 is on the eastern edge of the Thurmond Ranch which straddles this outcrop boundary. The upland divides, in conjunction with the river systems in the area, acted as highways for prehistoric people. The boundary between the Ogallala Formation and the Permian redbeds hosts an ecotone. There are deep, sandy soils on the Ogallala that support a mix of edible and medicinal plants, whereas the Permian exposures of shale have thin soils that support short grass plains. This mix of diversity is a very favorable location for prehistoric camps because their inhabitants could gather edible and medicinal plants, take small game, and harvest bison (Thurmond and Wyckoff 2003).

Archaeological site 34RM507 is in the Higgins Creek drainage that flows north from exposed Ogallala Formation deposits through the short grasslands on Permian bedrock to the Washita River (Fig. 30). The site is adjacent a deeply incised canyon and consists of approximately 8.0 meters of laminated beds of silt and shale atop which habitation deposits occur. Higgins Creek is fed by a weak spring which is perennial today but becomes more active during periods of increased rainfall. Aquatic snails recovered from the base of the 34RM507 profile include species common to ponded water. This could have been formed by debris slowing the stream flow (J. Peter Thurmond, personal communication, 2003). This pond or pool probably supported a riparian woodland that would have been a favorable habitat for snails. However, the lower portion of the profile coincides with the end of the Alithermal and may not have been as lush as one might think. The deep profile implicates an unstable landform from 3200 to 1900 years ago (Fig. 31), thus the snails may be in secondary context. However, this being said, the snails must have been in a protected niche somewhere upstream, and they do show changes over time that indicate environmental change.

Methods

Field Methods

Field methods in gastropod research vary depending on the research goals. The overall sampling strategy is usually devised following transects with sub-sampling at a predeter-

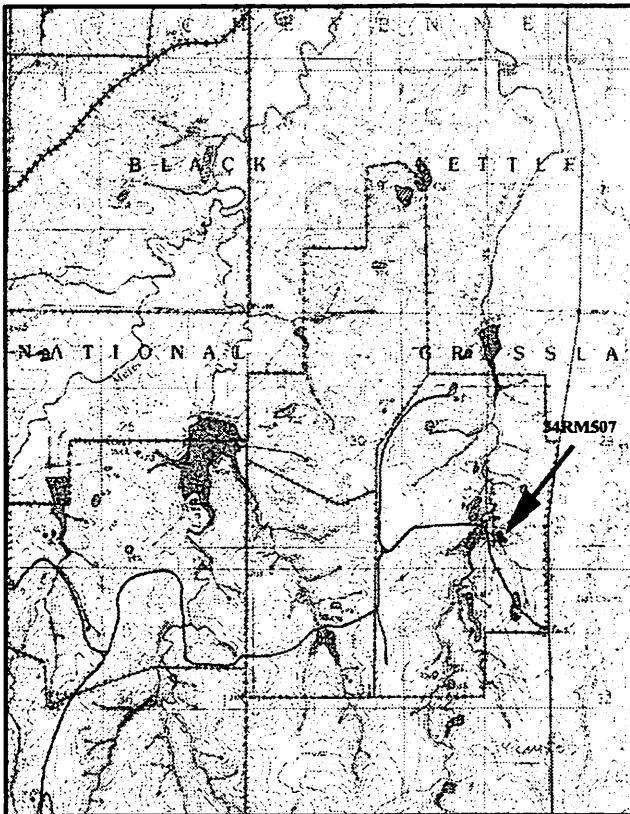


Figure 30. Location of archaeological site 34RM507 along Higgins Creek where it flows across Permian shale.

mined interval or by the extraction of a column through the profile. A sample of around 1000 individuals is needed to have a viable population representation (La Rocque 1966). The gastropod samples for site 34RM507 were taken from the exposure below the archaeological deposit. The exposure was mechanically excavated to bedrock by a backhoe with the site's datum being 89 meters above the site (Fig. 31).

Laboratory Methods

The soil samples were air-dried and water screened/floatated to separate the light and heavy fraction using a #40 sieve. The samples were then air-dried and put through a set of nested sieves (1/4", #10, #20, and #40). The gastropods larger than 2 millimeters (i.e., 1/4 and #10) were picked macroscopically from the samples. The remaining sample materials (#20 and #40) were placed in Petri dishes and, using a small artist brush, the snails were sorted and recovered under a low power binocular stereoscopic microscope.

Only complete shells and diagnostic fragments (such as aperture fragments) were saved. The samples that had specimens with clogged apertures were boiled to remove sediment from the aperture. When necessary, detergent (sodium oxalate) or a deflocculant (such as Alconox™) was used to loosen and remove the sediment from the aperture.

Identification

Only the shell of the snail remains for identification in archaeological samples. This may limit the degree of identification because certain snails can only be accurately identified to the family class with their soft tissue present (Turgeon et al. 1998). One example of this is the family *Succineidae* (Leonard 1959). Identification of terrestrial snails begins with the basic shell morphology. It is very important to have a reference collection to compare samples that have questionable shell morphology. Next, the samples are separated based on morphology; either the shell is flat (disc shaped), globose, or elongate (pupilliform). The number, shape, and direction of the whorl narrow the possibilities. The last external features of the shells are the color and texture of the shell. These indicators further narrow the range to certain families. To identify specimens down to the genus and more specific typologies, the lip reflection (if present) and teeth (lamellae) are the diagnostics. Differing positions, angles, and number of teeth permit very specific identification of snails. The samples are then sorted to genera/species and are counted and entered onto a spreadsheet program for analysis.

Results

A total of 3748 gastropods, including 15 terrestrial and 5 aquatic taxa, were represented in the samples from 34RM507. These data were entered into a Microsoft Excel spreadsheet (see Table 2). The counts were then adjusted to two-liter samples in order to perform statistical analyses (Table 3).

Gastrocopta pellucida was the most abundant, widespread species, occurring in every sample. *Gastrocopta*

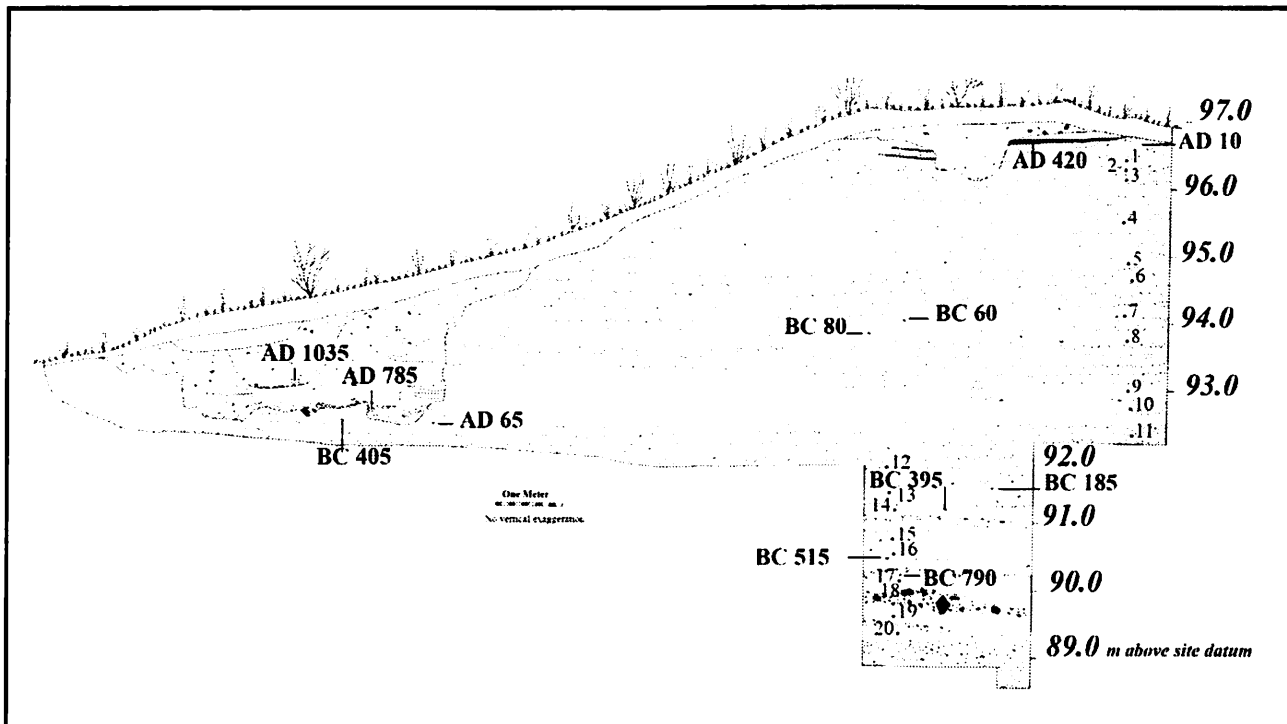


Figure 31. Profile at West Profile #2 at site 34RM507 showing stratigraphy and the provenience of the 20 samples extracted for the study of gastropods. Profile adapted from drawing by Pete Thurmond.

procera was the next most abundant species, occurring in all but Sample #1. *Carychium exiguum*, *Gastrocopta armifera*, *G. contracta*, *G. pentodon*, *Fossaria obrussa*, *Physella* sp., and *Gyraulus circumstriatus* were only found in single samples, most as only single individuals. The overall results show a fairly viable gastropod population, with changes in frequency of certain taxa reflecting changes in the environment. Figure 42 shows a comparison of the xeric species. The two large sets of peaks in this graph represent hotter periods, and the valley in the middle representing dry periods with less cover. Figure 43 shows the Woodland and Transitional snails. The two sets of larger peaks on this graph indicate the relative amount of cover and development from woodlands to riparian woodlands. A comparison of both the xeric and the woodland/transitional gastropods recovered from the site (Figs. 42 and 43) shows that there was some cover even during the hotter periods, but during the drier periods the cover became more scarce.

Systematic Discussion

Carychium exiguum (Say 1822) prefers moist, humid environments (Leonard 1952). It is found under old logs, sticks, twigs, and vegetation in marshy areas around ponds and creeks (Leonard 1952; Branson et al. 1962). Sometimes it is found submerged in water, but not in ponds and creeks in the same situation as *Physa* or *Fossaria* (Leonard 1959). It lives in the crevices of rotten logs or on dead leaves in moist to very wet places (Pilsbry 1948). It is found living among wet leaves along seeps and spring-fed brooks; it ranges from wet areas immediately adjacent to streams and springs to constantly moist areas on the banks (Hibbard and Taylor 1960).

This species was not recovered from any upland locations during the recent Southern Plains gastropod survey (Theler et al. 2004).

Carychium exiguum is present only in Sample #1 where it is represented by one shell.



Carychium exiguum
1.8 to 2.0 mm
(Burch 1962)

Gastrocopta armifera (Say 1821) occurs in a wide variety of habitats (Branson et al. 1962) and is gregarious, being usually found in large numbers (Leonard 1959). It is common on wooded slopes near streams or removed from a stream, and it is found under dead wood, limestone rocks, or light cover of leaf litter and other debris where there is constant residual moisture (Franzen and Leonard 1947; Leonard and Goble 1952; Cheatum and Fullington 1973). *G. armifera* is also found in roots of tall grass (Leonard and Goble 1952; Miller 1966), under boards and beneath dead wood in cottonwood groves (Miller 1966), and on dry sparsely wooded hillsides (Cheatum and Fullington 1973). The modern distribution across the Southern Plains finds *G. armifera* most commonly in mixed grass/tall grass near limestone rock ledges and also in mixed tall grass, forb, and cottonwoods near streams. It does occur in relict populations near perennial streams, but it was found only at the easternmost and westernmost sites in the Southern Plains gastropod survey (Theler et al. 2003).



Gastrocopta armifera
3.0-4.8mm
(Burch 1962)

Table 2. Actual Counts of Gastropods Recovered From Site 34Rm507, Roger Mills County, Oklahoma.

Terrestrial Taxa	Sample: Liters:	West Profile # 2																				Totals
		SS.1 2/3	SS.2 1	SS.3 1	SS.4 1	SS.5 1	SS.6 1	SS.7 1	SS.8 1	SS.9 1	SS.10 1	SS.11 1	SS.12 2	SS.13 2	SS.14 2	SS.15 2	SS.16 2	SS.17 2	SS.18 2	SS.19 2	SS.20 2	
<i>Carychilium exiguum</i>	(Say, 1822)	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	
<i>Gastrocopta amifera</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	
<i>Gastrocopta contracta</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	
<i>Gastrocopta cristata</i>	(Pilsbry & Vanatta, 1900)	--	10	--	4	4	8	16	--	3	2	2	--	15	32	7	5	3	11	4	2	
<i>Gastrocopta pellucida</i>	(Pfeiffer, 1841)	4	25	11	36	4	6	5	1	6	1	6	22	39	36	4	5	15	39	87	29	
<i>Gastrocopta pentodon</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	
<i>Gastrocopta procerata</i>	(Gould, 1840)	--	12	8	22	1	12	14	3	1	1	5	14	25	73	17	1	9	38	41	24	
<i>Gastrocopta sp.</i> [Unidentified]		4	3	2	2	--	--	2	--	1	--	--	--	10	9	5	2	12	7	20	9	
<i>Pupoides albilabris</i>	(C.B. Adams, 1841)	--	--	--	--	--	--	--	--	2	--	--	2	--	3	1	--	2	8	2	2	
<i>Valtonia perspectiva</i>	Sterki, 1893	17	26	4	43	3	4	5	5	--	--	--	--	--	--	--	--	1	19	13	1	
<i>Valtonia sp.</i> [Juvenile]		39	58	3	83	58	29	13	5	--	--	--	--	--	--	--	--	--	53	40	--	
<i>Helicodiscus paraifektus</i>	(Say, 1817)	1	--	1	5	--	--	1	--	--	--	--	1	3	4	16	3	18	10	10	1	
<i>Helicodiscus singleyanus</i>	(Pilsbry, 1890)	2	4	6	5	--	2	1	2	6	--	2	15	13	36	36	21	15	14	48	11	
<i>Helicodiscus tridens</i>	(Morrison, 1935)	--	--	--	--	--	3	--	--	1	--	--	--	6	15	13	8	16	23	18	4	
<i>Succineidae sp.</i>		--	1	--	1	1	1	1	--	1	1	--	6	--	2	1	2	1	1	7	6	
<i>Hawalia minuscula</i>	(A. Binney, 1840)	3	--	3	5	3	--	--	3	--	1	--	4	8	21	16	5	2	14	12	2	
<i>Deroceras laeve</i>	(Muller, 1774)	--	1	--	3	2	12	--	1	--	2	2	6	--	--	3	1	--	--	--	--	
Subtotal		71	140	38	209	76	77	58	20	21	8	19	68	121	228	121	54	93	231	309	92	2054
Terrestrial Juveniles		32	100	45	213	31	106	88	40	32	8	23	75	197	261	75	66	69	127	66	15	1669
Aquatic Taxa																						
Sphaeriidae Clams		--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	2
<i>Fossaria sp.</i> [Juvenile]		--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	--	--	2	--	4	4
<i>Fossaria obrussa</i>	(Say, 1825)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	2
<i>Physella sp.</i> [Juvenile]		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	2	2
<i>Helisoma anceps c.f.</i>	(Menke, 1830)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1
<i>Planorbella sp.</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	5	6
<i>Gyraulus sp.</i> [Juvenile]		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
<i>Gyraulus circumstriatus</i>	(Tyron, 1866)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	4	4
Ostracoda		--	--	--	--	--	--	--	--	--	--	--	2	1	--	1	--	--	--	--	4	4
Total																						3748

Taxonomic nomenclature follows Turgeon et al. 1998.

Table 3. Gastropods Recovered From Site 34Rm507, Roger Mills Co. Oklahoma (adjusted to 2 liters)

Terrestrial Taxa	Sample: Liters: Depth in cm.	West Profile #2																				Totals
		SS.1	SS.2	SS.3	SS.4	SS.5	SS.6	SS.7	SS.8	SS.9	SS.10	SS.11	SS.12	SS.13	SS.14	SS.15	SS.16	SS.17	SS.18	SS.19	SS.20	
<i>Carychium exiguum</i>	(Say, 1822)	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
<i>Gastrocopta armifera</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1
<i>Gastrocopta contracta</i>		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	1
<i>Gastrocopta cristata</i>	(Pilabry & Vanatta, 1900)	0	20	0	8	8	16	32	0	6	4	4	0	15	32	7	5	3	11	4	2	2
<i>Gastrocopta pellucida</i>	(Pfeiffer, 1841)	12	50	22	72	8	12	10	2	12	2	12	22	39	36	4	5	15	39	87	29	29
<i>Gastrocopta pentodon</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
<i>Gastrocopta procera</i>	(Gould, 1840)	0	24	16	44	2	24	28	6	2	2	10	14	25	73	17	1	9	38	41	24	24
<i>Gastrocopta</i> sp. [Unidentified]		12	6	4	4	0	4	0	4	0	2	0	0	10	9	5	2	12	7	20	9	9
<i>Pupoides albitarsis</i>	(C.B. Adams, 1841)	0	0	0	0	0	0	0	0	4	0	4	0	2	0	3	1	0	2	8	2	2
<i>Vallonia perspectiva</i>	Sterki, 1893	51	52	8	86	6	8	10	10	0	0	0	0	0	0	0	0	1	19	13	1	1
<i>Vallonia</i> sp. [Juveniles]		117	116	6	166	116	58	26	10	0	0	0	0	0	0	0	0	53	40	0	0	0
<i>Helicodiscus parvifolius</i>	(Say, 1817)	3	0	2	10	0	2	0	0	0	0	1	3	4	16	3	18	10	10	1	1	1
<i>Helicodiscus singleyanus</i>	(Pilabry, 1890)	6	0	12	10	0	4	2	4	12	0	4	15	13	36	36	21	15	14	48	11	11
<i>Helicodiscus tridens</i>	(Morrison, 1935)	0	8	0	0	0	6	0	0	2	0	0	0	6	15	13	8	16	23	18	4	4
Succineidae		0	2	0	2	2	2	2	0	2	2	0	6	0	2	1	2	1	1	7	6	6
<i>Hawaila minuscula</i>	(A. Binney, 1840)	9	0	6	10	6	0	0	6	0	2	0	4	8	21	16	5	2	14	12	2	2
<i>Deroceras laeve</i>	(Müller, 1774)	0	2	0	6	4	24	0	2	0	4	4	6	0	0	3	1	0	0	0	0	0
Subtotal		213	260	76	418	152	154	116	40	42	16	38	68	121	228	121	54	93	231	309	92	2862
Terrestrial Juveniles		96	200	90	426	62	212	176	80	64	16	46	75	197	261	75	66	69	127	66	15	2419
Aquatic Taxa																						
Sphaeriidae Clams		--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	2
<i>Fossaria</i> sp. [Juvenile]		--	--	--	--	--	--	--	--	--	2	--	--	1	--	--	--	--	2	--	--	5
<i>Fossaria obrussa</i>	(Say, 1825)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	2
<i>Physella</i> sp. [Juvenile]		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	2
<i>Helisoma anceps</i> c.f.	(Menke, 1830)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1
<i>Planorbella</i> sp.		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	5	6
<i>Gyraulus</i> sp. [Juvenile]		--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0	0
<i>Gyraulus circumstriatus</i>	(Tyron, 1866)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	4
Ostracoda		--	--	--	--	--	--	--	--	--	--	--	--	2	1	--	1	--	--	--	--	4
Totals																						5307

Taxonomic nomenclature follows Turgeon et al. 1998.

Gastrocopta armifera is present only in S.S. #19, where it is represented by one shell fragment.

Gastrocopta contracta (Say 1822) lives on wooded slopes near rivers and streams, under fallen logs, and among leaf litter and grass (Franzen and Leonard 1947). Its habitat is similar to *G. armifera* though it prefers areas of greater moisture (Leonard 1959; Cheatum and Fullington 1973). It is not abundant at any one locality and is also not found in such dry situations as *G. armifera* (Leonard 1959). It is found along river and creek floodplains where there is plenty of moisture; in forests of sycamore, oak, and elm; on hillsides in forests of oak, hickory, basswood, and pine; on bluffs of limestone; and even on dry railway embankments (though scarce there; Baker 1939). It is found in loose soil under leaves near streams and around roots of small trees, shrubs, tall grass, and weeds (Leonard and Goble 1952). The modern distribution across the Southern Plains finds it in mixed grass/tall grass near rock ledges and along riparian woodlands; eastern Oklahoma may be the western fringe of its modern distribution, and these may be relict populations (Theler et al. 2004).



Gastrocopta contracta
2.2-2.5 mm
(Burch 1962)

Gastrocopta contacta is only present in S.S. #20 where it is represented by one shell fragment.

Gastrocopta cristata (Pilsbry and Vanatta 1900) is highly adaptable to semi-arid regions (xerophilic; Cheatum and Fullington 1973). It is common to grassy meadowlands (Leonard 1943), among roots in upland grasslands, in timbered areas in uplands and along floodplains (Leonard 1959; Cheatum and Fullington 1973), under scrap wood and in dry upland meadows (Miller 1966), and near streams (DeVore 1975). It needs protection with a fairly high moisture content (Branson et al. 1962). The modern distribution across the Southern Plains finds *G. cristata* most commonly in cottonwood riparian woodlands and also in open areas with good protection near sagebrush and yucca (Theler et al. 2004).

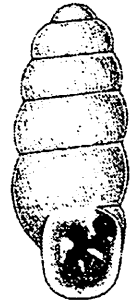


Gastrocopta cristata
2.7-3.0 mm
(Burch 1962)

Figure 32 shows the change in *G. cristata* frequency with depth at site 34RM507. The large spikes indicate more moist riparian woodlands were present. The low frequencies around 700 cm, between 500 and 300 cmn, and near the top of the profile implicate drying periods.

Gastrocopta pellucida (Pfeiffer 1841) frequently occurs in stream drifts and on exposed slopes (Miller 1966). It is abundant in open grasslands with scattered trees and shrubs

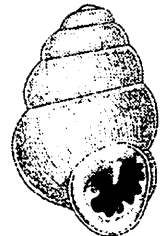
associated with grass roots (Leonard 1959; Miller 1966; Cheatum and Fullington 1973). *Gastrocopta pellucida* is essentially a southern snail (Franzen and Leonard 1947). It may live among grass roots and even on exposed areas (Hibbard and Taylor 1960). The modern distribution shows it is widespread across the plains, though nearing its northern distribution in Kay County, Oklahoma (Theler et al. 2003). *Gastrocopta pellucida* is most common in protected niches near rock ledges where it is associated with good cover that ranges from grass, yucca, cholla cactus, sagebrush, and forbs; it is also found in riparian woodlands of cottonwood, juniper, pine, and oak (Theler et al. 2004).



Gastrocopta pellucida
1.7-2.6 mm
(Burch 1962)

Figure 33 shows the change in frequency with depth for *G. pellucida*. Again, the spikes implicate more moist periods with fluctuations from moist to dry between 700 and 200 cm.

Gastrocopta pentodon (Say 1821) is found in well drained woodlands and meadows associated with sparse vegetation, with leaf litter and other objects serving as cover (Leonard 1959; Cheatum 1973). It can be found on wooded hillsides in forests of oak, cherry, ironwood, and basswood, under leaves and debris, and also in grass in open places: it is seldom found in wet places (Baker 1939). *Gastrocopta pentodon* can be found on dry wooded slopes (Leonard and Goble 1952). The modern distribution across the Southern Plains finds the western edge of its range in riparian woodlands in Kay County, Oklahoma (Theler et al. 2004).



Gastrocopta pentodon
1.5-1.8 mm
(Burch 1962)

Gastrocopta pentodon is only present in S.S. #17 where it is represented by one shell.

Gastrocopta procera (Gould 1840) occurs in open as well as wooded areas (Leonard 1959; Cheatum and Fullington 1973). It is more abundant under limestone rocks on sloping hills with sparse trees and shrubs (Cheatum and Fullington 1973). It also is found on timbered slopes near streams where it lives in leaf mold under fallen logs or loosened bark, beneath stones, and sometimes in meadows of dead grass. *Gastrocopta procera* can withstand high temperatures and drought, typically by residing on timbered hillsides; it shuns extremely moist situations (Baker 1939; Franzen and Leonard 1947; Leonard and Goble 1952;



Gastrocopta procera
Size: 2.2-3.0 mm
(Burch 1962)

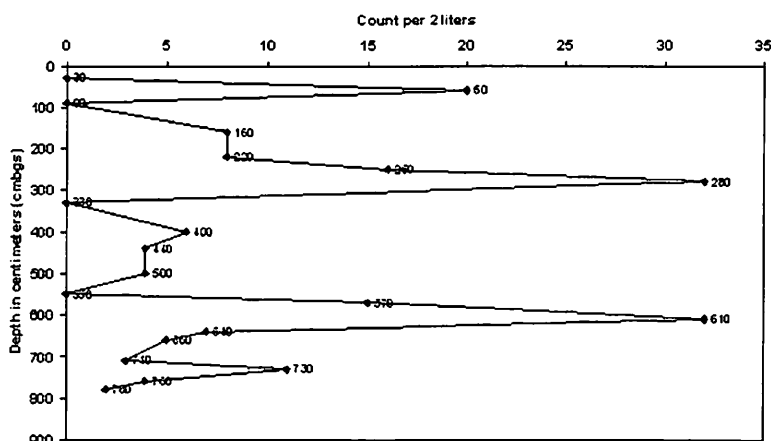


Figure 32. *Gastrocopta cristata* changes with depth in samples from site 34RM507.

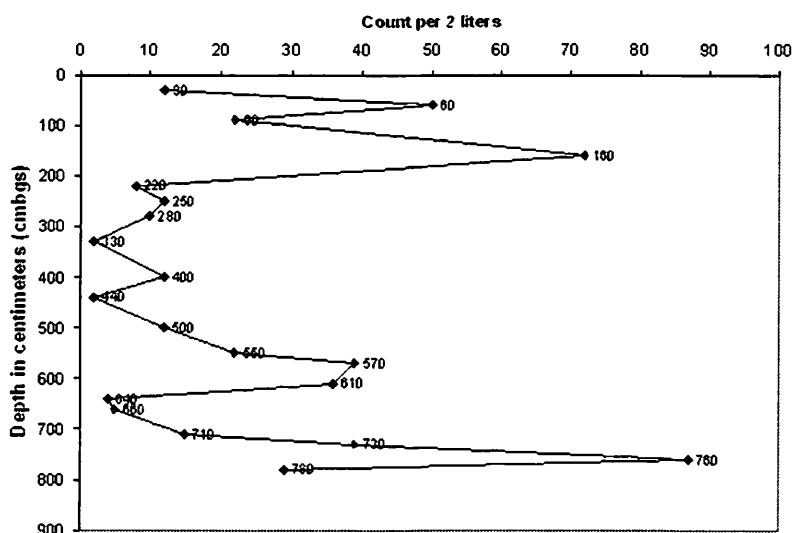


Figure 33. *Gastrocopta pellucida* changes with depth in samples from site 34RM507.

Leonard 1959). The modern distribution of *G. procera* shows it needs 160+ frost-free days; it was most common on protected rock ledges and in riparian woodlands on the Southern Plains survey (Theler et al. 2004).

Figure 34 shows the change in frequency of *G. procera* with depth at site 34RM507. Much like the trends of previous graphs, spikes occur at several depths; these probably attest to moist periods while a drying trend seems prevalent by the numbers occurring between 600 and 300 cm.

Pupoides albilabris (C.B. Adams 1841) is able to withstand arid conditions (high summer temperatures and low humidity). It is common in well drained woodlands and is reported in deep grass, even among the roots of short grass in unshaded areas far from water (Franzen and Leonard 1947; Leonard and Goble 1952). It is abundant in limestone areas and is found under rocks, in grass roots, and under leaf litter in sparse woodlands (Cheatum and Fullington 1973). It often

seeks shelter in bedrock fractures, coming out at night or after a rain, but it has been found crawling about on barren outcrops during bright sunny days after a good rain (Miller 1966). It lives under sticks, logs, and leaf litter in wooded areas as well as drier situations such as open pastures, railroad embankments, and rocky, open country (Baker 1939; Leonard 1959). This hardy snail has been collected from sagebrush flats (Leonard 1959). The modern Southern Plains distribution indicates *Pupoides albilabris* is common to all habitats, but it is one of the most xeric tolerant species and occurs in relatively low densities (Theler et al. 2004).



Pupoides albilabris
Size: 4.2-5.0 mm
(Burch 1962)

Figure 35 reveals a different trend from those of previous graphs. However, the spike between 800 and 700 cm indicates a well developed riparian woodland. The fluctuations

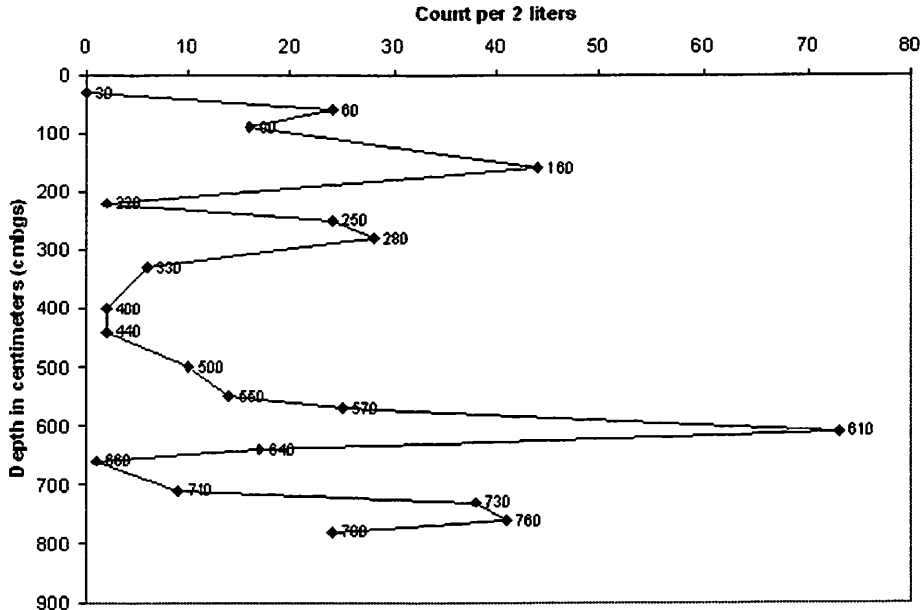


Figure 34. *Gastrocopta procera* changes with depth at site 34RM507.

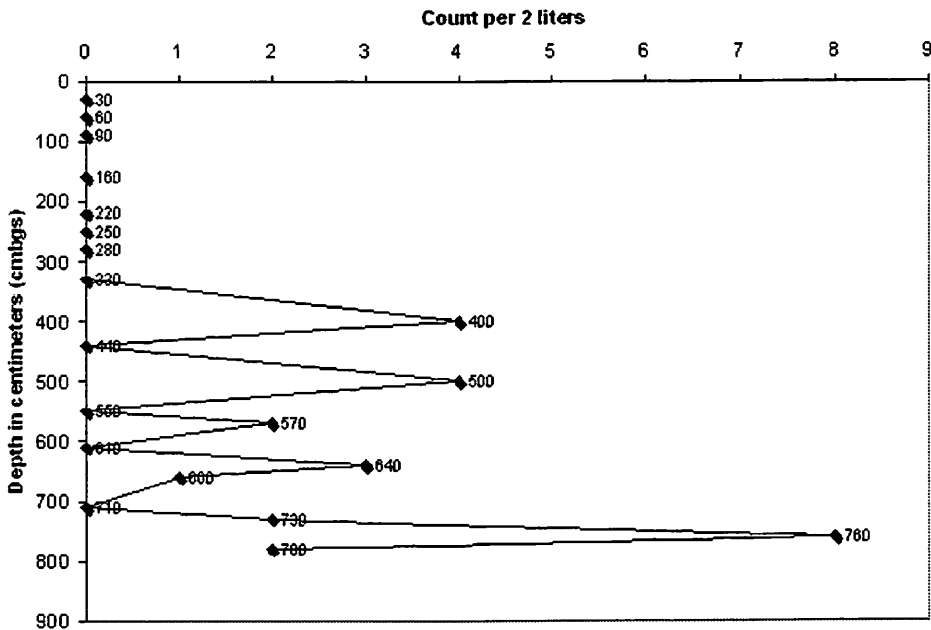


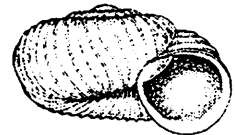
Figure 35. *Pupoides albilabris* changes with depth at site 34RM507.

between 700 and 300 probably show the changes in the amount of woodland cover during moist/dry oscillations.

Vallonia perspectiva (Sterki 1893) occurs in the Chiso Mountains where it is restricted to leaf litter in scrub oak (*Quercus intricata*) thickets and under dead *Agave scabra* on an uplifted block of Boquillas limestone (Fullington and Pratt 1974). It is missing in similar habitats on rhyolite in the rest of the range (ibid.). It also occurs in brushy thickets along limestone along Independence Creek (Fullington and Pratt 1974). This species was not recovered during the Southern Plains gastropod survey (Theler et al. 2004), although Theler (1997) has reported *V. perspectiva* in relatively “stressed” (little cover where a wide range of temperature

and moisture occurs) habitats in southwestern Wisconsin.

Figure 36 shows the changing frequencies of *Vallonia perspectiva* within the deposits at 34RM507. Although there is limited information about this species on the plains, the spikes may indicate established woodlands.



Vallonia perspectiva
Size: 2.0 mm
(Burch 1962)

Helicodiscus parallelus (Say 1817) is typically found in woodland settings; there it lives among decaying wood in shady or humid places or under damp leaves (Pilsbry 1948;

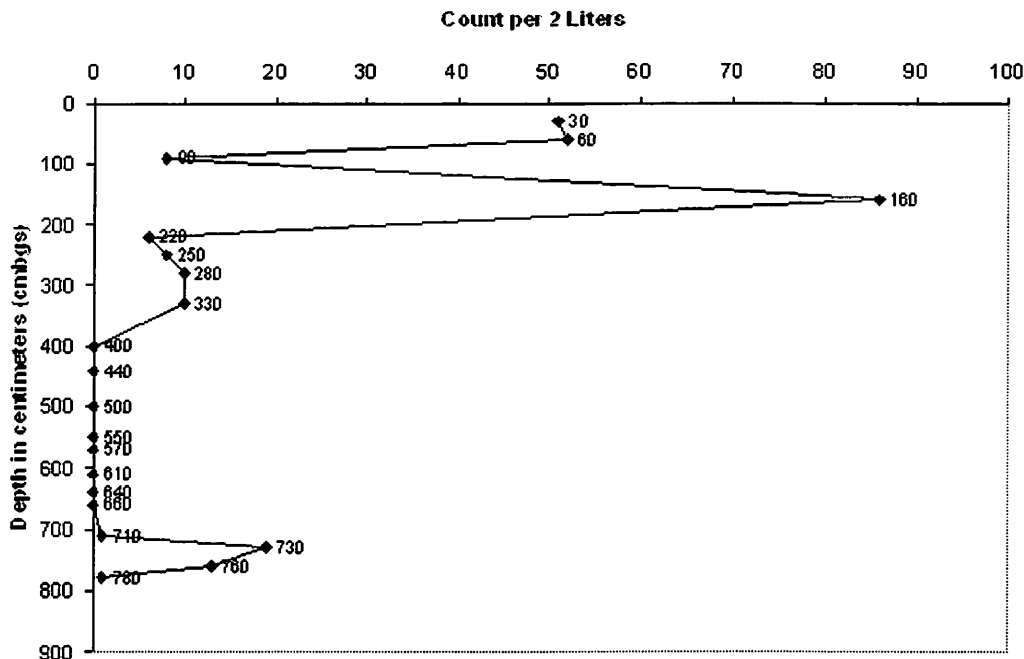


Figure 36. Vallonia perspectiva changes with depth at site 34RM507.

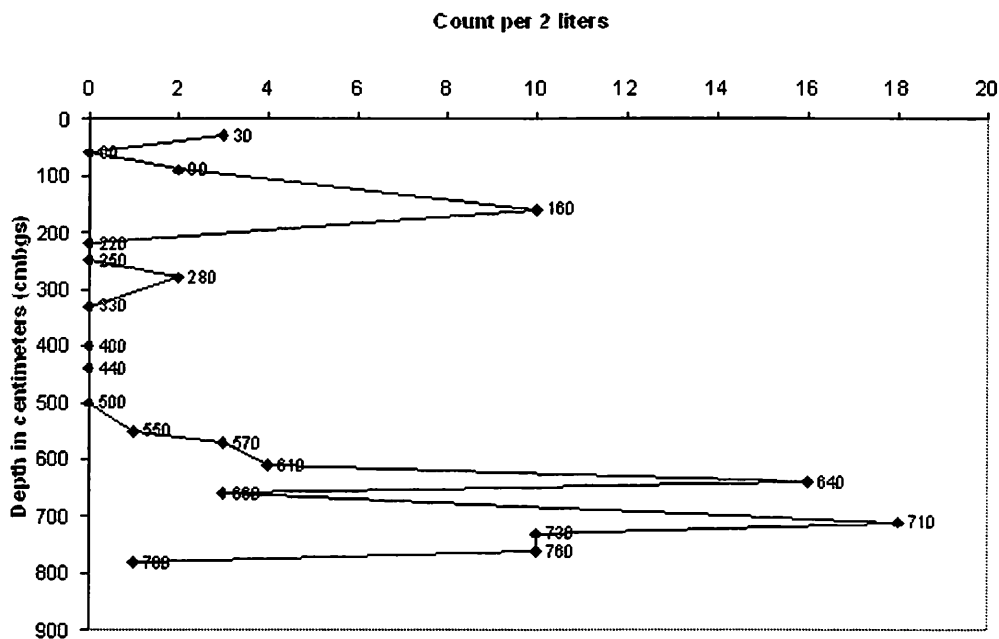


Figure 37. Helicodiscus parallelus changes with depth at site 34RM507.

Leonard 1959; Branson et al. 1962). It also is found in grassy fields, sparsely timbered slopes, and on rocky ledges as well as in more moist niches, and it is limited to woodland cover usually around decaying timber in more arid places (Leonard and Goble 1952). In Illinois, it is found in river valleys wooded in oak, walnut, elm, basswood, and sassafras or in floodplains wooded in oak, elm, and hickory (Baker 1939). It rarely is found in exposed areas although it occurs in grasslands

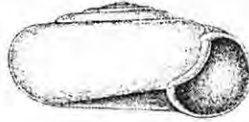


Helicodiscus parallelus
Size: 3.2-3.5 mm
(Burch 1962)

and cutover lands among trees of second growth oak, walnut, and hickory (ibid.). Across the Southern Plains its modern distribution was mainly in riparian woodlands, but it was found near rock ledges (Theler et al. 2004).

For site 34RM507, the *Helicodiscus parallelus* changes in frequency are shown in Figure 37. The spikes are interpreted to indicate deposition times of more moisture and the development of protected niches. This is the same pattern observed on the previous graphs that show moist/dry fluctuations.

Helicodiscus singleyanus (Pilsbry 1890) can survive the hot, dry summers of the High Plains and lives among grass roots and grasses, even on exposed slopes (Leonard 1959; Hibbard and Taylor 1960; Branson et al. 1962; Miller 1966) or in fractures and cracks on exposed surfaces during the hot, dry part of the day (Miller 1966). It is also found in forest debris, under leaves, and in old piles of washed material, but rarely occurs with old logs and under loose bark (Baker 1939). The modern distribution across the Southern Plains finds *Helicodiscus singleyanus* most commonly with protected rock ledges where short bunch grass, yucca, cholla cactus, junipers, and forbs comprise cover from sun and wind; it also was found with protected spots on mesa tops as well as riparian woodlands (Theler et al. 2004).

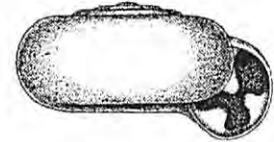


Helicodiscus singleyanus
Size: 2.0-3.0 mm
(Burch 1962)

Figure 38 shows the change in frequency with depth for *Helicodiscus singleyanus*. This species can survive as a xeric species, but it needs protected areas and cover. The spikes in Figure 35 indicate more moist periods, but the smaller spikes near the top are interpreted to indicate a lack of sufficient cover as opposed to the bottom of the profile.

Helicodiscus tridens (Morrison 1935) has only been reported from four counties in Texas and one county (Cleveland) in Oklahoma in modern times, and it should be looked for among grass roots (Hubricht 1985). It is found in the

southern Great Plains in habitats similar to *H. parallelus* (Branson et al. 1962). This species was not found in the recent gastropod survey across the Southern Plains.



Helicodiscus tridens
Size: 1.6 mm
(Burch 1962)

Figure 39 shows the vertical trends for *Helicodiscus tridens*. Little is known about this species, but it may be able to withstand high temperatures and low moisture based on its Texas distribution. The spike near the bottom of Figure 36 may indicate hotter periods with less rain, but with woodland cover. This would coincide with well developed riparian woodlands as interpreted from other species. The drop of *H. tridens* near the top of the graph may indicate a relatively cooler period, forcing this species southward.

Hawaiia minuscula (A. Binney 1840) is commonly found under decaying vegetation, among grass roots, under logs and under leaf litter (Leonard and Goble 1952; Devore 1975); under logs, sticks, stones, and in clumps of grass in both floodplains and uplands (Leonard 1959; Miller 1966). It also occurs on sticks buried in moist leaf litter in a small gully in a stand of cottonwood trees near the edge of a lake (Miller 1966). *Hawaiia minuscula* seems to be common to woodlands of oak, hickory, and sycamore in Illinois (Baker 1939). This species is widely distributed and can withstand arid conditions. It is more common in wooded places with higher moisture conditions than in treeless prairies, but it also is

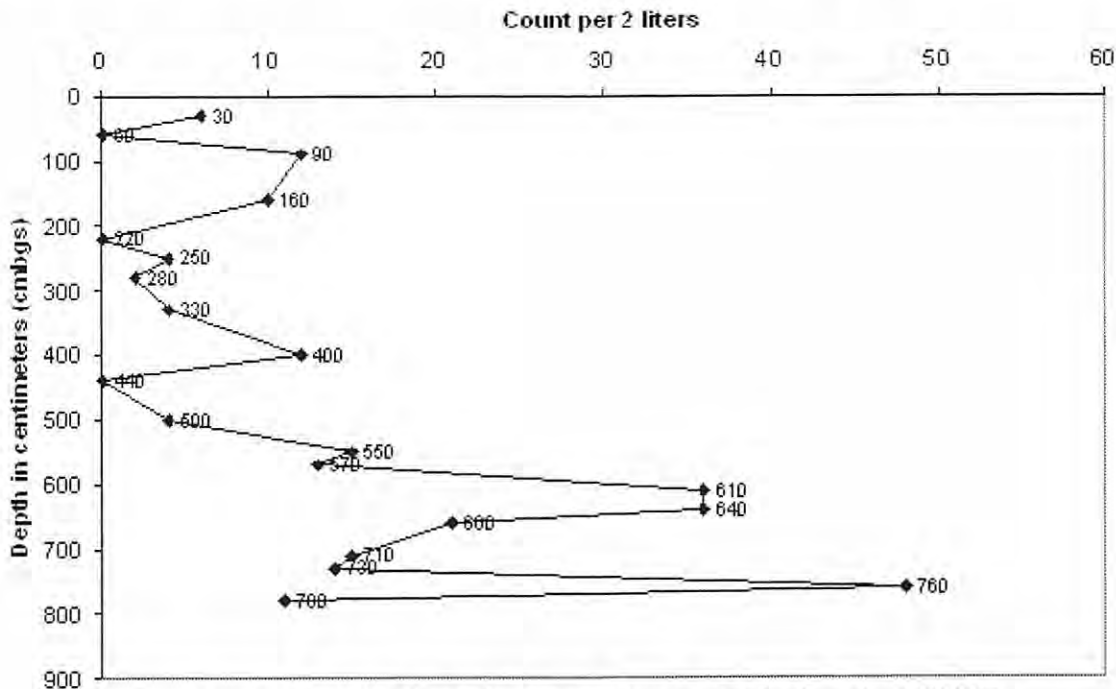


Figure 38. *Helicodiscus singleyanus* changes with depth at site 34RM507.

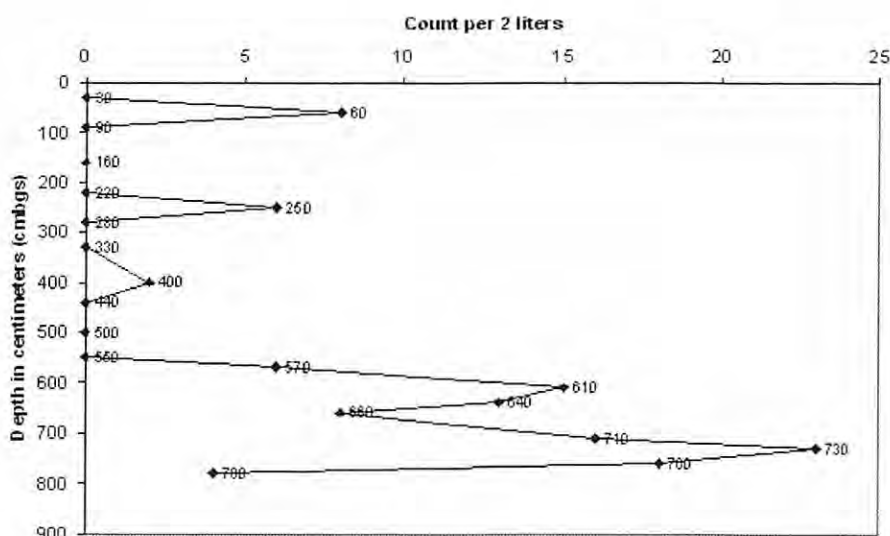


Figure 39. *Helicodiscus tridens* frequency changes with depth at site 34RM507.

common to rocky ledges in moist areas such as along floodplains and wooded slopes. It occurs in grassy upland situations, but is not abundant there (Leonard 1943, 1952). The modern Southern Plains distribution finds *H. minuscula* on rock ledges, especially protected niches, and also in riparian woodlands under cottonwood limbs and debris (Theler et al. 2004).



Hawaiiia minuscula
Size: 2.0 - 2.8 mm
(Burch 1962)

Figure 40 shows the same trends in frequency for *H. minuscula* as for the previous species. There is a warm, moist period implicated at the bottom of the graph with drying trend apparent near the middle; a return to moist conditions seems evident near the top.

Deroceras laeve (Muller 1774) is a slug which is represented in the archaeological record by a small calcium carbonate disc. This slug thrives among organic debris in moist conditions (Leonard 1952). It lives beneath sticks, stones, bark, and leaves in woodlands, and beneath boards, logs, and even sidewalks in urban communities. It requires a rather moist habitat, has been observed crawling about submerged for periods of an hour or more, and is highly active at night (Leonard 1959). It is found in marshes, woods, and on rocky slopes, active only when relative humidity is high; at other times it retreats under stones, logs, leaves, and other sources of protection from sun and wind (Leonard and Goble 1952). The modern distribution across the Southern Plains finds it most com-



Deroceras laeve
Size: 15-30 mm
(Burch 1962)

mon to riparian woodlands, but it is also found on toe slopes, rock ledges, and broad plains (Theler et al. 2004).

Figure 41 shows the frequency trends with depth for *Deroceras laeve*. It is a moisture sensitive slug, so the spikes along the graph probably represent moisture changes. The lack of this slug at the bottom of the profile may be due to this species slow introduction into the locality following the Altithermal.

Fossaria obrussa (Say 1825) is found on floating vegetation at or near water's edge and is common in small bodies of water such as creeks, ponds, and marshes along river banks (Miller 1966; DeVore 1975). It is at home on sticks, stones, and other debris that may be in water or along its edge (Miller 1966; DeVore 1975). In Kansas it is found in shallow water with a muddy bottom and on exposed mud flats on the edge of a lake, in clumps of sedges or cattails, and *Sagittaria* where it is common along the muddy shore (Leonard 1959).



Fossaria obrussa
Size: ~8 mm
(Burch and Trotterham 1980)

Fossaria obrussa is present only in S.S.#20 where it is represented by one shell.

Helisoma anceps c.f. (Menke 1830) lives in lakes, ponds, rivers, and streams among vegetation. It is not found in temporary water habitats (Clarke 1981).



Helisoma anceps c.f.
Size: 30 mm
(Burch and Trotterham 1980)

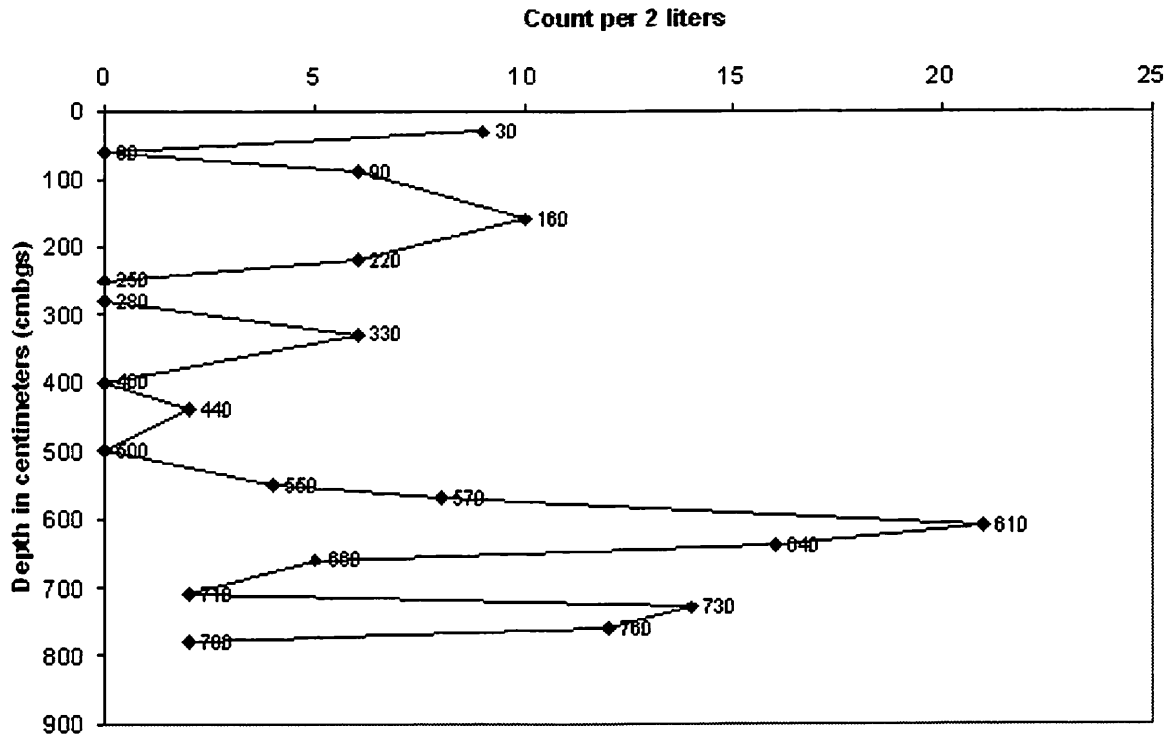


Figure 40. *Hawaiiia minuscula* frequency changes with depth at site 34RM507.

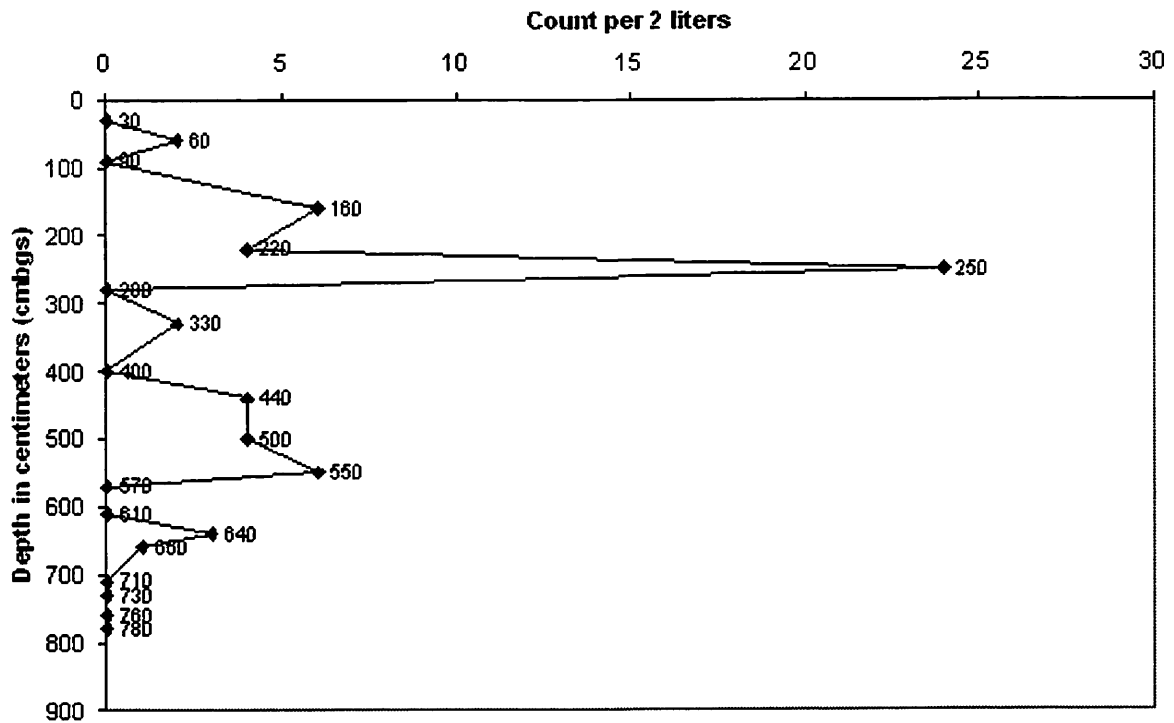


Figure 41. *Deroceras laeve* frequency changes with depth at site 34RM507.

Helisoma anceps was represented by one sub-adult that conforms favorably to this species. It was recovered from S.S. #20.

Gyraulus circumstriatus (Tyron 1866) lives in small, temporary bodies of water such as pools in woodlands, ponds on flood plains, marshes, and prairie ponds (Miller 1966; DeVore 1975). In Kansas it is found on dead and living vegetation in shallow water of natural and artificial lakes, usually in quiet nooks or inlets near tree-lined shores (Leonard 1959).



Gyraulus circumstriatus
Size: 4.0-4.5 mm
(Burch and Trotterham 1980)

Gyraulus circumstriatus is represented by four shells, all of which come from S.S.#20.

Ostracoda are small aquatic crustations, common in many aquatic situations, both temporary and permanent, such as ponds, streams, lakes, etc. (Delorme 1991).

Ostracoda were found in S.S. #13, #14, and #16, indicating at least temporary water at these levels. This conforms with the moister periods indicated by other snails recovered between 570 and 660 centimeters.

Discussion

In this section the recovered species are grouped according to habitat preference and are compared vertically to ascertain environmental shifts through time (Table 4; Figs. 42 and 43). The discussion begins at the bottom of the profile, starting with the oldest deposit and working to the most recent.

Snail samples #20 to #17, approximately 780 to 710 centimeters below ground surface (cmbgs), indicate a well developed riparian woodland was present. This dates to around 3200 to 2790 B.P. Evidence from the Group I snails (Table 4) indicates a spring-fed pond or pool, possibly representing activation of a seep or possibly created by debris restricting the flow of the stream. The fairly high number of Group IV snails in this zone (Fig. 42) indicates warm to hot conditions, whereas the Group II and III snails implicate mixed open woods and grass/forb vegetation near the pond or pool (Fig. 43)

The pool or pond seems to disappear after Snail Sample #20 (780cmbgs), possibly due to a strong, fast rain from convectional storms that moved the blocking debris or due to a drying up of the seep. There is a dramatic increase in xeric species in S.S. #19 (760cmbgs; Fig. 42). This would indicate summers with high temperatures and low annual precipitation. Snail Sample #18 (730cmbgs) also implicates a warm environment. Snail Samples #18-19 (730-760cmbgs) contain

burned snails. This may indicate convectional storms that had lightning, causing wild fires in the uplands and strong/fast rain carrying snails in the runoff. Such fires could also have been caused by humans. *Heliocodiscus tridens* occurs in its highest number (23 individuals), but the other Group IV species decrease in frequency. There is a slight increase in Group II and III species, showing that some patches of vegetation cover persisted, whereas the absence of Group I snails indicates that the pond or pool had dried. Snail Sample #17 (710cmbgs) shows there is ephemeral water, though it is probably shallow. This is evidenced by the single *Planorbella* sp. from the Group I snails. All the other groups generally decrease, possibly indicating that the sheltered niches were decreasing.

Snail Samples #15 and #16 (640 to 660cmbgs) show a dramatic decrease in all groups except Group IV. I interpret this zone to represent a drying period (Fig. 43). Again, evidence exists for ephemeral ponding at the site. This is represented by non-gastropods, i.e., one Spheariidae clam fragment and one Ostracoda. *Helicodiscus singleyanus*, *H. tridens*, as well as *Hawaiiia minuscula* hold fairly steady during the time these sediments were deposited (Figs. 42 and 43). Snail Sample #16 (660 cmbgs) probably represents a hot, dry period, one that stressed even the hardy Group IV xeric-tolerant species. There is evidence of moisture in protected niches at this time, as seen in *Deroceras laeve* recovered from samples #15 and #16 (Fig. 40).

Snail Samples #12 through #14 (550 to 610cmbgs) show a moist trend. The temporary ponding still persists, as seen in the Ostracoda (though it is possible that this specimen is redeposited). Snail Samples #12-14 also include burned specimens, which may again indicate fires caused by convectional storms. There is a general increase in Group III and IV species in samples #12 through 14. *Gastrocopta cristata* and *Hawaiiia minuscula* increase during the time of deposition and are interpreted to indicate that riparian woodland is still viable (Fig. 43).

Snail Samples #8-11 (330-500cmbgs) may indicate a drying trend and a general decrease in all of the groups (Figs. 42 and 43). The exception is *Deroceras laeve*, which is a moisture lover. The only evidence of seasonal water is two aquatic juveniles in Snail Sample #11 (500cmbgs). This sample is the last occurrence of aquatic gastropods in the sequence. By around 2060 B.P. there is evidence of a return to a moist riparian woodland habitat in Snail Samples #6 and 7 (250-280cmbgs). At this time there is a diverse and thriving snail population (Figs. 42 and 43). The environment was probably slightly more moderate than the present, with Groups II and III indicating a fairly moist, open woodland (Fig. 43). Snail Sample #6 (250cmbgs) appears to have adequate moisture with 24 examples of *Deroceras laeve* present (Fig. 43). There is a trend from the riparian woodland to a dry stable prairie between samples #7 and #5 (220-280cmbgs). Snail Samples #1 through #4 (30-160cmbgs) show a trend to the modern

Environmental Interpretation of 34RM507 Gastropods

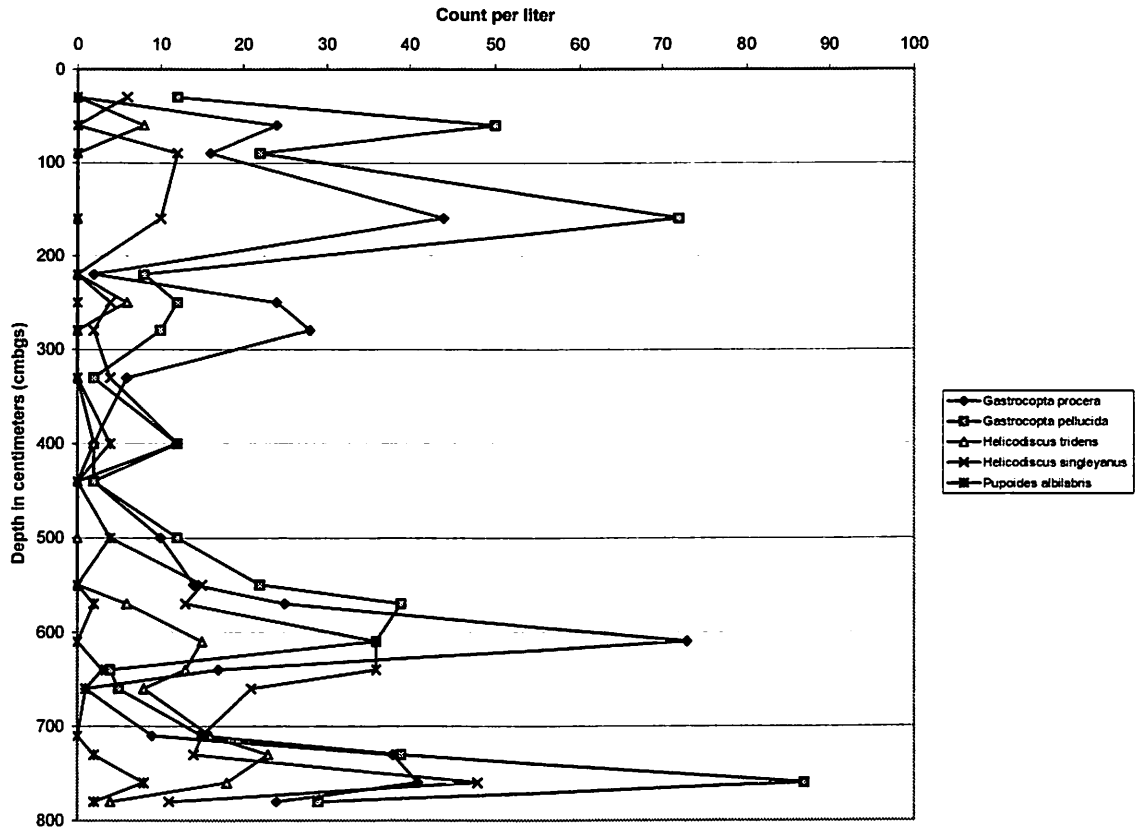


Figure 42. Xeric gastropod species frequencies plotted according to depth at site 34RM507.

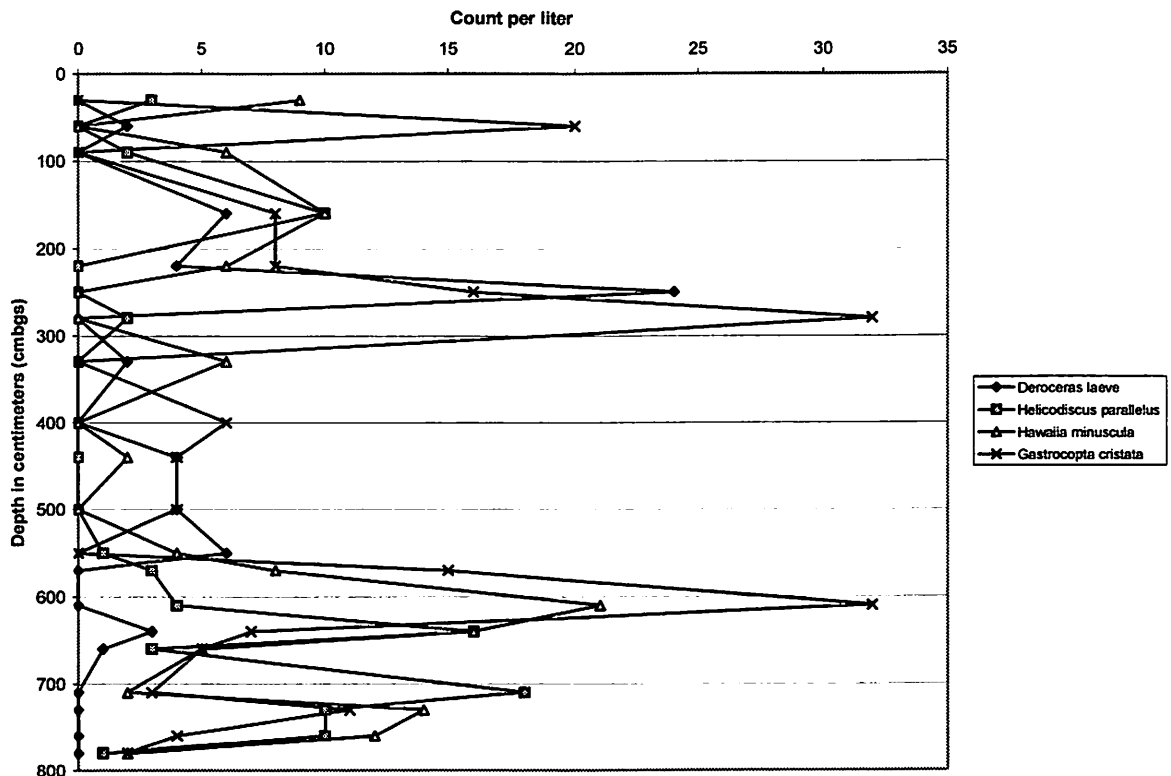


Figure 43. Woodland/transition gastropod species frequencies plotted according to depth at site 34RM507.

Table 4. Snail Species Groupings According to Habitat Preferences.

Snail Species in Respective Groups	Snail Groups and Habitat Implications
<i>Helisoma anceps</i> c.f. <i>Fossaria obrussa</i> <i>Gyraulus circumstriatus</i> <i>Carychium exiguum</i>	<i>Group I</i> - Aquatic or semi-aquatic: indicative of small bodies of water, permanent to intermittent, muddy bottoms, surrounded by trees or other vegetation.
<i>Deroceras leave</i> <i>Helicodiscus parallelus</i> <i>Gastrocopta contracta</i>	<i>Group II</i> -Moist woodland: indicative of wooded to sparsely wooded, with various vegetation detritus for cover; relatively high moisture.
<i>Gastrocopta armifera</i> <i>Gastrocopta pentodon</i> <i>Hawaiiia minuscula</i> <i>Gastrocopta cristata</i>	<i>Group III</i> -Transition setting: well drained woodland to open grassland with good cover.
<i>Gastrocopta procera</i> <i>Gastrocopta pellucida</i> <i>Helicodiscus tridens</i> <i>Helicodiscus singleyanus</i> <i>Pupoides albilabris</i>	<i>Group IV</i> - Xeric species: can withstand high temperatures and dry conditions, grassland to woodland, with cover from sun and wind.

habitat on the Southern Plains as well as an opening of the site with less cover for the snails.

Conclusion

From my analysis of gastropods recovered from the thick sediments at site 34RM507, I believe a spring-fed pond or pool existed nearby around 3300 B.P. Between 3200 and 2790 B.P. the recovered snails indicate a riparian woodland was nearby. At about 2720 B.P. it appears the climate became drier for a short time. This was followed by a shift to a slightly wetter climate and then to a longer drying period that ended around 2080 B.P. By 2060 B.P. a notable and viable snail population was established that seems to attest to a shift from a riparian woodland to a dry, stable prairie. This continued to around 1900 B.P.

Acknowledgments

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A Lithic Technological Study of Site 34RM507

Karin J. Rebnegger

After the test excavations and the discovery of the second gully, it was apparent that the artifacts from 34RM507 were in secondary context. The remaining questions were where was the original location of the site and what was the course of the gully. Cores taken between the gullies and throughout the artifact scatter during the spring of 2001 did not help determine the courses or relationships of the large and small gullies. These cores only provided information that the sediments continued to accumulate around the site due to overgrazing and drought conditions during the past 70 years. The probe and cores (70 cm deep) yielded no information on the gully that displaced and helped deflate the site.

Figures 14 and 15 provide profile views of the site that may help us understand the post-depositional processes operating there. Only a few tested cobbles were recovered from Area A, and I do not think that the site was located in this area. If it had been, the artifacts would be scattered to a

greater extent and more artifacts would be on the southern and northern, not just on the west, slopes of Area A (Fig. 41). The majority of the artifacts were discerned in Area B (Fig. 41), the east and west part of the site as noted by Moore and Thurmond in 1986. This eastern part of Area B is deflated. A cow path there may have a lot to do with this process. In just the three years that I've been working at the site I have seen a big change in the amount of erosion. Originally I had thought that the site was buried and was eroding out because of the cow path. This was one of the reasons I selected the spot for Unit 3; I hoped to find a buried part of the site there.

We conducted test excavations in the western part of Area B (Figs. 41, 42, and 43). The recovered artifacts appear to have washed to the west. The small gully seems to become shallower towards Unit 2 and may indicate the direction of water flow. At one time, artifacts may have washed north-

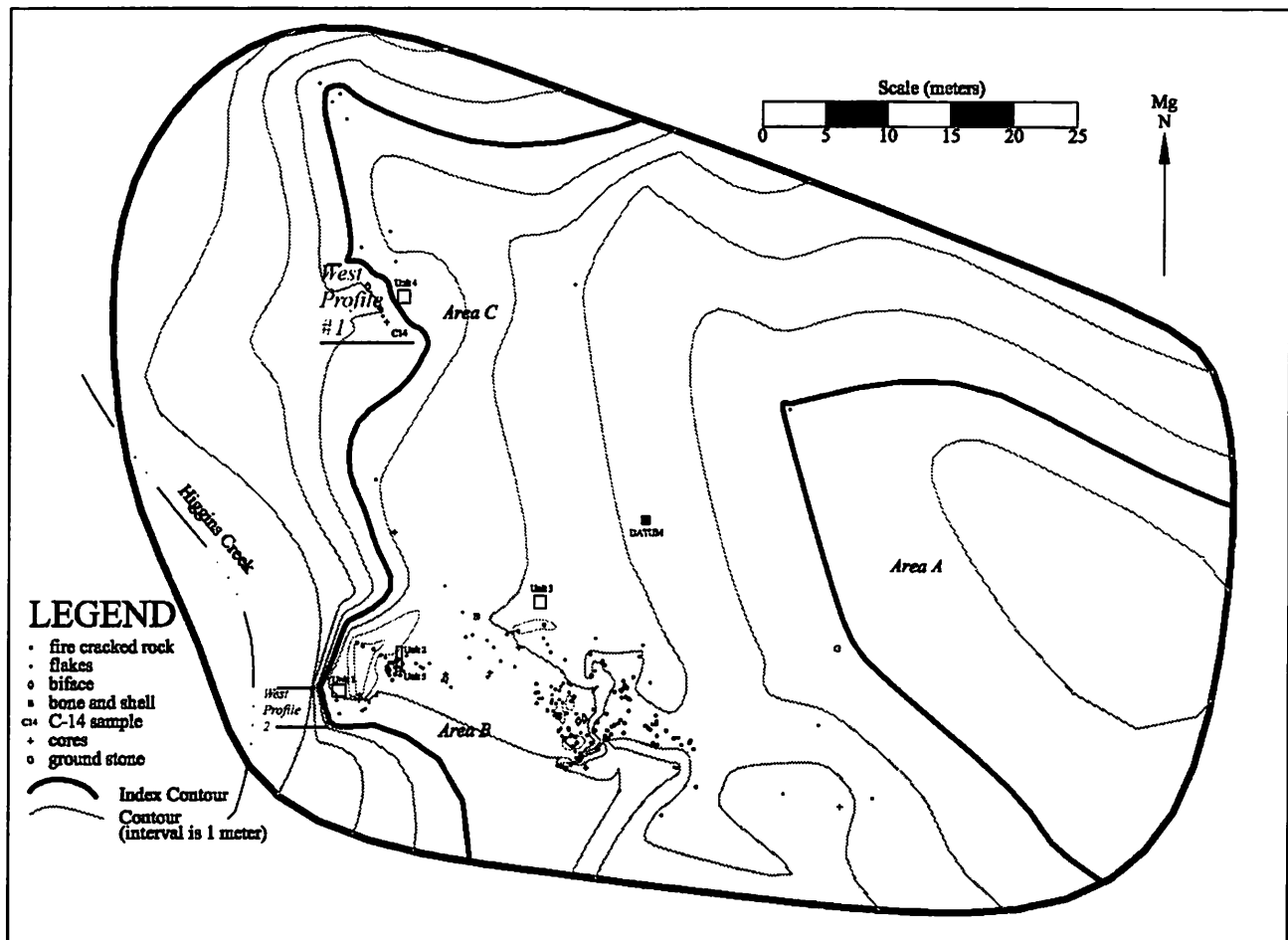


Figure 41. Site 34RM507 and the areas collected, tested, and profiled.



Figure 42. Units 2 and 5 dug in Area B of 34RM507. Artifacts were recovered from the darkened soil on top with very few being found below that soil. Photo taken in February of 2000.



Figure 43. A quartzite biface exposed in Unit 2 in the west part of Area B of site 34RM507. Scale in 10 cm increments. Photo taken in February of 2000.

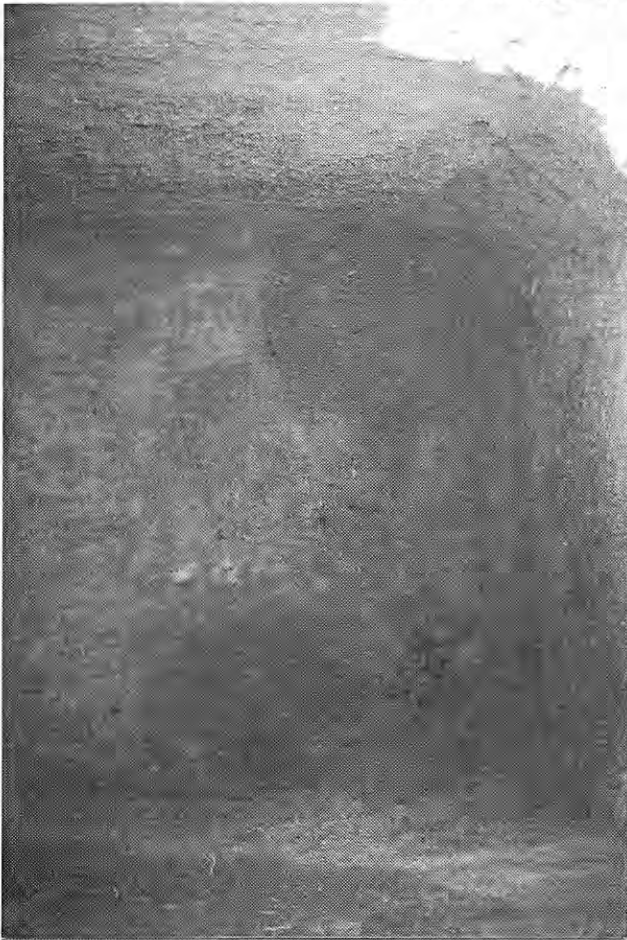


Figure 44. Charcoal and ash exposed at 90 cm below the surface in Excavation Unit 4 adjacent West Profile #1. Photo taken in February of 2000.

west and also into the large gully to the west. These events are noted and seem most likely when viewed in Figure 15. The hearth with the date of A.D. 45, along with the dates of B.C. 45 to A.D. 80 from Unit 4 could represent the dates when the site was occupied. For this reason, I do not think that the site has washed that far from its original setting, but it is still in secondary context and this makes it impossible to study artifact distributions as evidence for activity areas.

The hearth (Feature #2) exposed in West Profile #1 (Figs. 10, 13 and 15) is about a meter lower than the habitation deposits exposed in the Area B profile to the south. A date of A.D. 45 was obtained from Feature #2, whereas dates ranging from 45 B.C. to A.D. 80 came from charcoal recovered from Excavation Unit 4 (Fig. 44). In contrast, at Area B the fill in the small uppermost gully is undated but cut through a lens dating to A.D. 420 while the fill in the large gully yielded dates ranging from A.D. 785 to A.D. 1035 (Fig. 15). Because these gullies contain artifacts, charcoal, and dark brown soil, they clearly post-date the habitation of the site.

If the hearth represented by Feature #2 (Figs. 9 and 14) was part of the original surface of the site, what happened to the rest of the site? Apparently, the hearth was the lowest

point of the site because it is on sterile red sediments and not on or in a developed soil horizon. That this seems likely is born out by the few artifacts found within the hearth but almost nothing being found around it. This is important because the gully fills to the south are dark brown and full of organic matter and artifacts ranging from flakes to projectile points. Where did this organic matter come from? Did a soil form on the site after it was inhabited and then erode into both gullies, first the smaller one and later into the large one? If this is so, why are so many artifacts mixed with the gully fill? It is highly unlikely that only the artifacts and soil were washed into the gullies leaving behind only the sterile subsoil. Because of this, it is improbable that the soil accumulated after the site was occupied.

I am still left with the problem that most artifacts occur in the small gully fill that is slightly higher (1 meter) than the hearth. Did prehistoric lithic reduction take place on the higher ground away from the hearth? And why did the artifacts not wash downhill? The site's slope may have been significantly different, and most of the artifacts may have been displaced when, around AD 420, the first gully filled (as this gully had a higher density of artifacts). Still, it continues not to make sense that a soil had formed on the high area and not on the lower part of the site where the hearth occurs (Fig. 9). How does the hearth figure into the site?

Another possibility is that the hearth is actually the remains of a pit that was dug into sterile soil and not a hearth built on the surface. The ash lens and charcoal of Feature #2 did extend back into Unit 4, but there is no way to tell how large the pit may have been or if the area was reused year after year. The topsoil may have eroded into the larger gully, leaving just the bottom of the pit. This would have had to have been after much of the site eroded after A.D. 420 in order to explain why more artifacts occurred in the smaller gully. The higher area (Area B) of the site may have been out of range of the later erosion episode, leaving the artifacts that had originally been washing into the gully in their secondary context.

Because of the secondary context of the artifacts, I am forced to abandon studying artifact distributions as clues to discrete activity areas. Now I can only study the lithic reduction technology of Late Archaic bison hunters. This is still important. Campsites of this lifeway are not well known in the archaeological record. I think that this site can be a model for the many Late Archaic campsites known but not studied. Site 34RM507 shows that these Late Archaic camps were situated on landscapes susceptible to dynamic erosion. This may be why evidence for camps near bison kills are so scarce. If there was a time when erosion was filling in arroyos and covering kills, then it makes sense that ephemeral or short term processing sites were probably being eradicated too. Was site 34RM507 a long-term camp? Did these people stay in one place for an extended period? Did they winter somewhere like here? If they wintered here, could it be that site

34RM507 was not atop a knoll like it is today? Clearly, the landscape has changed, so it is possible that 34RM507 was an ideal spot to winter and retool for spring hunts.

Reorienting the Study:

From Site Structure to Lithic Processing

The extensive collection from 34RM507 looks simple and relatively straightforward. Because the collection includes broken and complete bifaces, I was sure it was a reduction workshop, and I knew that an extensive flake analysis was necessary to figure out if biface manufacture was the only activity taking place here. Because the site is near a lag deposit of Ogallala Formation gravel, I was certain that I would find the entire reduction sequence from tested cobbles and flakes to finished products, especially broken tools. Every artifact collected from the site was included in this study. As I studied these artifacts I sorted out cores, flakes, flake tools, and bifaces so that I could further investigate the processes that site 34RM507 campers used to reduce Ogallala quartzite into implements and the debris from making them.

To accomplish this study I recorded 46 pieces of information and characteristics for each artifact (Table 5). This included general information such as lot number, area collected, level, excavation unit, unit area (i.e., southeast quarter), and specimen type as well as other specific data about each artifact. Each specimen type could have had at least 36 different attributes recorded, including nominal and continuous information. This analysis included each complete flake as well as flakes with platforms, retouched flakes, cores, and bifaces. As much information as possible was gleaned from broken flakes (distal ends and midsections) and blocky debris.

Another avenue taken in this investigation was to actually knap Ogallala quartzite cobbles. This was done to gain understanding of this material's fracture mechanics and also to try to replicate types of tools recovered from the site. I set several objectives for this activity. I had no intention of just trying to make tools. The flakes and cores from such work were also important. I also hoped to break a few during manufacture and to "resharpen" the tools made to see if they resembled the possibly reworked artifacts found at the site. Don Wyckoff and I set out to find Ogallala quartzite cobbles at gravel exposures in Dewey County some 70 miles northeast of site 34RM507. We did not collect materials from the lag gravel exposed near site 34RM507 because flakes there indicated it had been frequented by prehistoric people. At three gravel deposits we collected some 60 quartzite cobbles and also a few cobbles of Alibates agatized dolomite, petrified wood, and unidentified cherts. This collection was helpful because I gained appreciation for the frequency of materials and the sizes of quartzite cobbles that occur in gravel deposits. Ogallala quartzite cobbles at these exposures ranged from small pebbles to 10cm long cobbles, and occasional very large boulders. We chose medium (5-6cm) to large (10cm) cobbles to keep because they approximated the sizes of the cores recovered at site 34RM507. A most important

characteristic of the Ogallala quartzite cobbles was the quality of the material. We tested for material quality with both a rock hammer and with hammerstones of other quartzite cobbles. Another test for material quality was the sound produced when a cobble was tapped with a hammerstone. A clear, high, bell-like ring meant there were no material flaws, but a dull thud or even a rattle indicated the cobble was flawed and probably would not fracture in ways we desired.

Alibates flint cobbles recovered from the Dewey County gravel exposures were usually much smaller, about 1/2 to 1/3 the size, than the quartzite cobbles. Chert cobbles were very rare. Most chert only occurred in pebble sizes. Petrified wood was scattered in the exposures, and most pieces weren't knappable due to their having several fracture planes.

Our selection of knappable quartzite cobbles turned out fairly well, but we discovered the pieces were not as fine-grained as we thought they would be. Many cobbles had flaws from freezing; when struck they broke apart along these frost fracture planes. Other cobbles has such high variation in grain size that large flakes were impossible to detach and bifaces impossible to make. After much experimentation we decided that hard hammers were really the only way to reduce these cobbles. A soft hammer could only be used when a thin flake or small, thin, bifacial core was being worked. We were able to detach numerous large flakes, and we made



Figure 44. Fire-cracked rock and flakes littering the south part of Area B. Photo taken in February of 2000.

Table 5. Attributes and Variables Recorded for Chipped Stone Objects from Site 34RM507.

Characteristic	Measurement	Significance	References
Lot #	Ranges from 2 to 13	Each lot number refers to the year that particular collection was made	
Area collected	Nine collection areas are recognized	Although these are not as significant as they would have been if the site was not so eroded and redeposited, there are 9 recognized collection areas: General Surface, East Surface, West Surface, Hearth, West Profile, Gully Fill, Drainage, Test Squares, and Probe.	
Level #	These range from 1 to 10	Level information is only available for those artifacts recovered from the test squares.	
FS# and extra number	Field specimen numbers or feature specimen numbers	Where bags with one Test Square or Feature number had many specimens, extra numbers were used for each artifact from that context.	
Unit	Numbered 1 through 5	Each number refers to one of the five excavation units.	
Unit subdivision	SW, NW, NE, SE	Each test square was divided into quarters according to direction	
Material	Raw material identification.	These kinds of materials were represented: Ogallala quartzite, Alibates chert, silicified wood, unidentified agate, unidentified quartzite, and unidentified chert. Identifications done with comparative specimens housed at the Oklahoma Museum of Natural History and the Oklahoma Archaeological Survey.	Banks 1984 and 1990
Inclusions	Present or absent	To help determine if the material was knappable or if it might have been rejected for further reduction.	
Grain size	Fine, fine-medium, medium, medium-coarse, coarse, very fine, very coarse	To help assess if particular variations of stone, especially quartzite, were preferred for particular kinds of tools.	
Color	Varied	Used to help sort flakes and cores that may have originated as the same cobble.	
Heat treatment	Yes, no, or questionable	To assess if and when in the sequence of knapping, particular materials were being heated.	Purdy 1975
Specimen class	Overall combination of attributes used to initially classify artifacts	The recognized artifact classes are: tested cobbles, cores, core fragments, cobble fragments, flakes, spalls, retouched flakes, bifaces, flake fragments, blocky debris, fire-cracked rock, hammerstones, and ground stone objects.	Andrefsky 1998; Inizan et al. 1999; Whittaker 1994
Core type	Multidirectional, unidirectional, bifacial, and core fragment	This information is relevant to assessing reduction strategies. Formal and expedient technologies involve different kinds of cores.	Andrefsky 1998:20-22; Parry and Kelly 1987; Patterson 1987
Flake type based on amount of cortex	Primary decortication, secondary decortication, and tertiary flakes; broken flakes were so noted	Amount of cortex on flake dorsal face is somewhat informative about the staging of reduction of cobble-based raw materials. More cortex is expected on larger flakes when raw cobbles are being worked on the site, whereas less cortex and smaller flakes are expected when cobbles have been preliminarily worked elsewhere. Primary decortication flakes are those with cortex completely covering their outside face, and secondary decortication flakes have cortex on 10 to 95% of their outside faces. Tertiary flakes have no cortex on their outside faces.	White 1963; Wyckoff 1973:71-100
Flake condition	Complete or broken	Potentially informative about reduction strategies. Thin broken flakes often occur during soft-hammer knapping of bifaces.	Whittaker 1994:14
Flake segment	Proximal end, mid-section, or distal end	Helpful for determining how many flakes are represented. Proximal ends can be studied for clues to kinds of platform preparation.	Andrefsky 1998: 81-83
Flake breakage type	Step, hinge (or bending), split, or radial shatter	Bending breaks frequently result during biface thinning with a soft hammer. Vertical breaks or splitting occur when excess force is applied or when material is flawed.	Whittaker 1994:187
Flake type-knapping category	Core preparation, core rejuvenation, biface thinning, retouch, etc.	These are flake categories that are based on certain attribute combinations that can be linked steps to achieve particular technological goals.	Whittaker:1994:16, 186, 276-280.
Retouched flake class	Graver, gouge, side or end scraper, multiple use tool, incidentally used flake	Likely tool categories for flakes incidentally used or purposefully shaped for use; kinds and numbers of categories implicates varied activities conducted at site; original flake type implicates what products selected from knapping were getting used.	Andrefsky 1998:20-22; Hughes 1955; Leonhardy 1966.
Biface type	Stages in biface manufacture and use.	Categories that help sort and identify steps in production of bifacially flaked implements.	Andrefsky 1998:180-186; Inizan et al. 1999:51; Magne and Pokotylo 1981:34-47.
Hammer type	Hard or soft	Hammerstones evident on the site and their use should be indicated by prominent bulbs along with hackling, and crushing or ring cracks on platforms. Soft hammers not preserved but their use will be implicated by the presence of slight bulbs and little platform crushing (no ring cracks). Use of hard hammer may be associated with expedient technology whereas evidence for use of soft hammer may be more associated with formal stone working.	Bordes and Crabtree 1969:243; Whittaker 1994:91-98, 185-187; Muto 1971.

Table 5 (cont). Attributes and Variables Recorded for Chipped Stone Objects from Site 34RM507.

Characteristic	Measurement	Significance	References
Presence of potlids and spalling	Yes or no	Attributes associated with heat treatment or at least accidental exposure to fire.	Purdy 1973.
Bulb: flake attribute	Present or not; prominent or diffuse.	An attribute believed directly responsive to type of force applied; prominent bulbs are part of series of attributes indicative of hard hammer percussion; diffuse bulbs or none evident more associated with soft hammer use, including the thinning of bifaces.	Andrefsky 1998:18-20; Speth 1972:41-42.
Platform: flake attribute	Present? Yes, no, or missing	Useful to identifying where force was applied.	Whittaker 1994:98.
Platform character	Cortex present, partially flaked, entirely flaked?	Bears witness to what the knapper felt was a workable surface or how much that surface had to be prepared before applying force to it.	Whittaker 1994:17, 98.
Platform preparation: flake attribute	Prepared, unprepared, crushed?	Useful to identifying amount and kind of preparatory work performed before force applied; has implications for discerning expedient from more formal knapping technologies.	Crabtree 1972:84; Whittaker 1994:98-104.
Platform-ridge relationships: flake attributes	Middle (M), Right (R), Left (L)	Flake shapes and sizes are highly influenced by where force is applied to the platform in relation to a prominent ridge on the face adjacent to the platform; while obviously providing clues to the core's shape, this relationship may also be indicative of a knapper's preferred approach to applying force.	Faulkner 1972:131; Phagan 1980; Whittaker 1994:105-106; Wyckoff 1992.
Exterior platform angle	Measured in degrees	A measurement of 45° or less may be associated with biface thinning (a more formal technology), whereas larger angles may be representative of blocky cores and the necessity of hard hammer use (possibly expedient technologies)	Pelcin 1996:102, 120; Withoft 1957:17.
Platform thickness	Measured in millimeters	Measured from the bulb to the exterior face, across the platform; the theoretical platform thickness is a key variable in determining flake mass.	Pelcin 1996:112, 120; 1997a; 1997b.
Platform width	Measured in millimeters	Another key variable relating to flake mass; ultimately relates to knapper's ability and knowledge for producing flakes of predictable shapes and sizes.	Dibble and Pelcin 1995.
Length	Measured in millimeters; complete or broken should be noted.	Flake length potentially has some correlation with the size of the object being knapped.	Andrefsky 1998; Pelcin 1996.
Width	Measured in millimeters; complete or broken to be noted.	From the center of the flake or artifact, usually the widest section. Has some correlation with size of object being knapped.	Pelcin 1996.
Thickness	Measured in millimeters.	From the middle of the flake or artifact.	Pelcin 1996.
Erillure: ventral face attribute	Present or absent.	Associated with the bulb of force, the erillure may have size and depth variables that correlate with kind (hard or soft hammer) of force applied.	Cotterell and Kamminga 1992:140-150; Faulkner 1972.
Ripples: ventral face attribute	Present or absent	These help identify the direction of force and they also correlate with pronounced changes in core topography.	Faulkner 1972:152-155.
Hackles: ventral face attribute	Present or absent	Associated with the bulb, these are more common when hard hammer percussion was the means of force application.	Faulkner 1972.
Number of dorsal scars	Actual count	Roughly correlates with amount of reduction having taken place.	Lintz 1978; Muto 1971:47-84, 1976:31-121.
Size of dorsal scars	Estimate percentage of surface area for each.	Roughly correlates with stage in reduction process: larger scars tend to associate with earlier reduction stage than many small scars.	Callahan 1979.
Orientation of dorsal scars	1-8, with platform up using a 8-polar coordinate grid.	Provides a standard means to document diverse directions from which previously removed flakes were struck.	Odell 1979.
Cortex percentage on dorsal face	5-10%, 10-50%, 50-75%, 75-95%, 95-100%	An aid to discerning where a flake might fit in the overall reduction sequence.	Wyckoff 1992.
Termination type	Feather, hinge, step, overshoot, unknown.	Each kind of termination correlates with appropriate or problematic applications of force.	Andrefsky 1998:85-88; Crabtree 1972:64; Faulkner 1972:135; Muto 1971:58; Phagan 1980; Pond 1930:54; Whittaker 1994:106-111.
Marginal retouch	Present or absent.	May be associated with both expedient and formal technologies; indicates edge preparation or resharpening.	Andrefsky 1998:77-80; Inizan et al. 1999:30-33; Whittaker 1994:19-21.
Location of marginal retouch	Use 8-polar coordinate grid to determine.	Standardized means to record where along a flake's margin it has been retouched.	Odell 1979.
Use wear	Present or absent.	Using a hand lens, to initially identify potential margins used in some manner.	Hayden and Kamminga 1979; Newcomer and Keeley 1979; Odell 1979.
Refits	Yes or no.	Can be helpful in identifying less disturbed reduction areas as well as strategies.	Wyckoff 1992.

a few bifaces. Perhaps the most notable result of our replication experiments was our gaining a great appreciation for the knapping ability of Late Archaic people who used this material to make spear points and other refined tools. I will continue to refer to our experiments and results as I discuss the reduction process discerned at 34RM507.

Lithic Reduction at 34RM507

Over a period of 16 years, 3471 artifacts were collected from site 34RM507. Of these, 39% came from surface collections and 60% were recovered during the two days of test excavations. The remaining 1% of the artifacts were found while cleaning and recording profiles at the site.

The surface collection manifests some bias. The collectors focused on large flakes, bifaces, flake tools, and culturally diagnostic objects, but they rarely collected small tertiary flakes. The artifacts from the test excavations provide a better representation of the site's material. They include many broken flakes and pieces of blocky debris as well as flake tools, bifaces, and a few diagnostics. The area was littered with fire-cracked rock, and some of this was picked up during the surface surveys, but many such objects were left in situ because they covered much of the site's surface. Concentrations of fire-cracked rock were mapped during the first survey; these are depicted in Figures 11 and 44. Many fire-cracked rocks were recovered during the test excavations but were not collected. Subsequently, they were never entered into the data base once we ascertained the site was so eroded and everything displaced.

The inhabitants of 34RM507 depended on stone like that from the nearby lag deposit of Ogallala Formation gravel (Fig. 4). Many of the clasts in this deposit are fine to coarse grain quartzites, materials others refer to as Ogallala quartzite, Ogallala chert, or Potter chert (Banks 1990; Hood 1978; Patton 1923). The quartzites range from gray, to brown, tan,

and maroon in color. Experimental knapping reveals that a single cobble can vary greatly in grain size and in color (Hurst and Rebnegger 1999). Also found in Ogallala Formation gravels are petrified wood, Alibates agatized dolomite, fossiliferous stone, sandstone, and unknown cherts in a variety of colors. I follow the advice of Holliday and Welty (1981) and name the materials by their formation (when known) and differentiate them by quartzite, chert, petrified wood, fossiliferous stone, sandstone, and Alibates agatized dolomite.

Of the 3471 artifacts, 89% are Ogallala quartzite. These include the fine grain to coarse grain materials characteristic of cobbles collected from Ogallala Formation deposits (Fig. 29; Hurst and Rebnegger 1999). The rest of the 34RM507 assemblage includes petrified wood, 2%; Alibates, 2%; very coarse Ogallala quartzite, 4%; and other materials, 4%. These latter are of uncertain origin but most probably were obtained from Ogallala Formation gravels. The site's inhabitants may have collected some material from nearby sources, such as chert from the Tecovas and Antlers formations (Holliday and Welty 1981).

Artifacts collected from the site include tested cobbles, cores, flakes, retouched flakes, bifaces, flake and blocky debris, cobble fragments, fire-cracked rock (FCR), spalls or potlids, hammerstones, and groundstone (Fig. 45). All types of artifacts were made from Ogallala quartzite cobbles (Fig. 46), but other materials were represented by a few artifacts. Alibates chert is represented by an unusually high percentage of bifaces (Fig. 47) and retouched flakes. The majority of the other lithic materials are represented by flakes (Fig. 45).

Because of the large quantity of lithic debris, site 34RM507 had already been considered as a camp site that was predominantly a lithic workshop. My preliminary analysis further indicated it was a place where bifaces were being made. The range of artifacts from the reduction process clearly implicated a workshop for the production of bifaces (Fig. 46) situated next to an Ogallala gravel deposit. The other recovered formal and informal tools implicated that other activities were carried out at this site. Because almost all of the recovered artifacts are broken, either during manufacture or to heat fracture, the following explanation of the reduction process is as complete as possible. This explanation is supplemented by the knapping replication experiments and experiences of Don Wyckoff, Stance Hurst and me.

During the analysis I initially sorted and examined all the flakes. Then, I separated by material, size, and stage (extent of knapping) all of the cores, bifaces, and retouched flakes (tools) for further scrutiny. As I studied the cores, bifaces, and retouched flake tools as a group I was able to see clear similarities in the products being manufactured at the site. Because the manufacture of tools is a reduction process my analysis and discussion begins with the core technology. It ends with the analysis of the flakes and small debris that resulted subsequent to the reduction of cores.

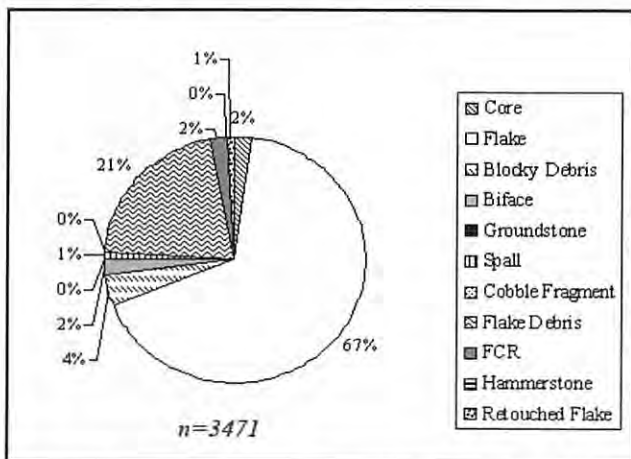


Figure 45. Percentage representations of the artifact categories established and studied for site 34RM507.



Figure 46. Examples of Ogallala quartzite artifacts from site 34RM507. The biface on the right is of coarse material, whereas the others are of fine-grain material. Scale is in centimeters.



Figure 47. Examples of site 34RM507 artifacts made from Alibates agatized dolomite. Scale is in centimeters.

Table 6. Inventory and Descriptions of Site 34RM506 Artifacts Classified as Cores.

Initial Category	Number of Specimens	Description	Artifact Class in Report
1	5	A few flakes are removed from each specimen. Cobbles of all sizes are represented in this category. Each has a possible flaw (inclusions, too coarse-grain, or step fractures) that probably caused its discard.	Tested Cobble
2a	4	Large cobbles with almost random flaking, resulting in few to many flake scars. Some have inclusions, but most seem fine-grained enough to be good material.	Large Multidirectional Cores
2b	5	Small cobbles with many flake scars removed in no particular patterns. Some may be near the end of their use life. A few may have been as large as Category 2a cobbles at the beginning of their use life.	Small Multidirectional Cores
3	3	Small and medium size cobbles with 4-5 flake scars. They appear to have a prepared platform, usually a flake removed from one face of a cobble and other flakes removed using that initial scar as a platform. If the knapper continued removing flakes from these cores they would have been reduced enough to include in Category 2b.	Unidirectional Cores
4	10	Round and flat cobbles are represented here. Flake scars are not in a particular pattern but they could be considered bifacial. Some exhibit inclusions that would have hindered removing large flakes; others have many step fractures that would have hindered further flake removal. Specimens here could have been part of the biface making sequence, so these might be considered biface failures.	Bifacial Cores
5	7	These result from working cobbles or large core sections. A few to many flake scars are visible, but all have a similar shape. One edge is worked or shows signs of use-wear.	Choppers or scrapers

Cores and the Core Technology

A total of 69 cores and core fragments are identified; these equate to only 2% of the collection from 34RM507. The categories of cores include tested cobbles, core tools, core fragments, and three types of cores (Table 6). The core types are multidirectional, unidirectional, and bifacial. The tested cobbles included both quartzite and petrified wood. Each had a few flakes removed, but they apparently were discarded due to flaws that would not permit the knapper to detach large flakes. The flaws are inclusions and step and hinge terminations that resulted during the removal of the first decoration flakes. Many of these cobbles are coarse-grained and therefore would not have been very appropriate for controlled manufacture of bifaces. While knapping various quartzite cobbles Don, Stance and I continually had this same problem. The first flake removed from the cobble suggested that it was a fine-grain, workable material, but after 3 or 4 flakes were removed the cobble had to be discarded due to grain inconsistency and the step terminations we created. Acute angles were rare on many cobbles and detaching more than two flakes was sometimes impossible.

Five of the seven recovered core tools resembled the tested cobbles and may have been originally intended for use as cores, but due to their coarse-grain nature or knapping flaws they were rejected and recycled as chopping or heavy scrap-

ing tools. Two are made from tabular cobbles, and three of the core tools may be core fragments or exhausted cores. The shape of these core tools is similar (Fig. 48). They may have been made for the same task. The other two core tools may have been choppers, although they share little in form.

The large multidirectional (large amorphous) cores were initially large rounded cobbles but subsequently had flakes removed from any possible angle (Fig. 48). As noted above, it is difficult to find an acute angle for a platform on many of the natural cobbles. We tried to detach large flakes and had little success. Many of the detached flakes were large, but only remnants of their ventral faces are visible. The large primary and secondary flakes selected for making tools appear to have been detached from these large multidirectional cores. The small multidirectional cores are similar to the large ones in that flake scars originate from very diverse directions and angles (Fig. 48). The amount of cortex remaining on specimens is a good indicator of whether the small cores were initially small cobbles or the result of reducing large multidirectional cores. Unfortunately, only two of the small multidirectional cores still have cortex, and the amount is so small that it is impossible to ascertain the original size of the cobble.

The bifacial cores appear to have been reduced from ei-

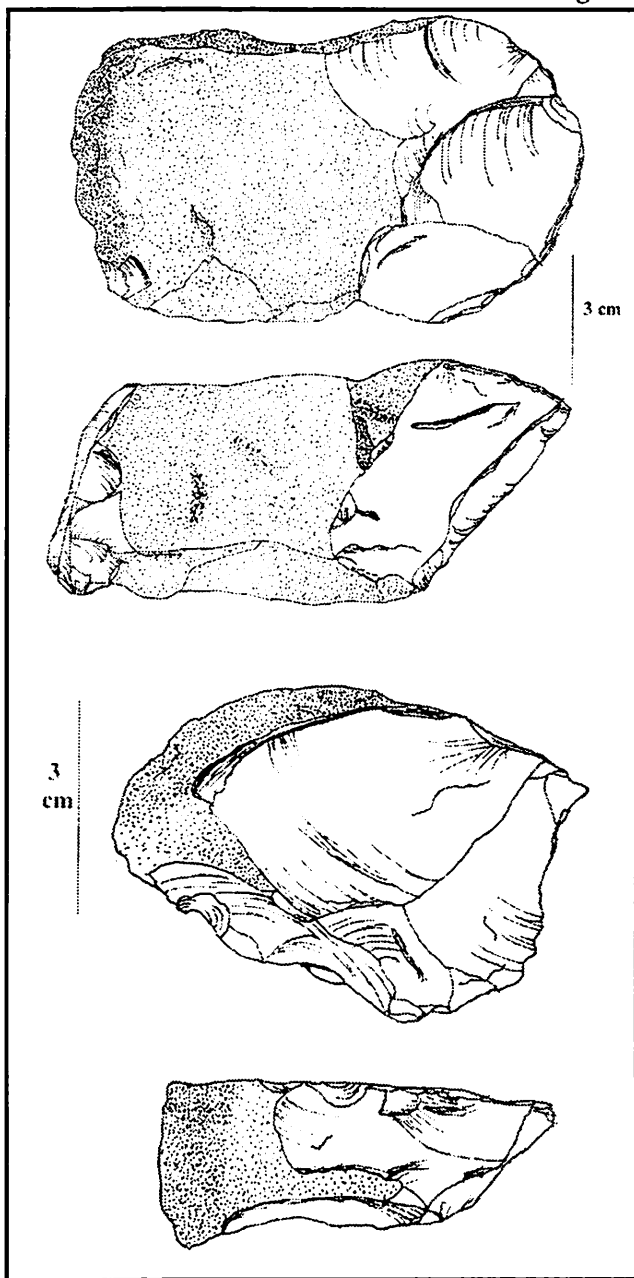


Figure 48. Top and side views of a large (top) and small (bottom) multidirectional cores from site 34RM507. Both are of Ogallala quartzite. Lateral views have platforms up.

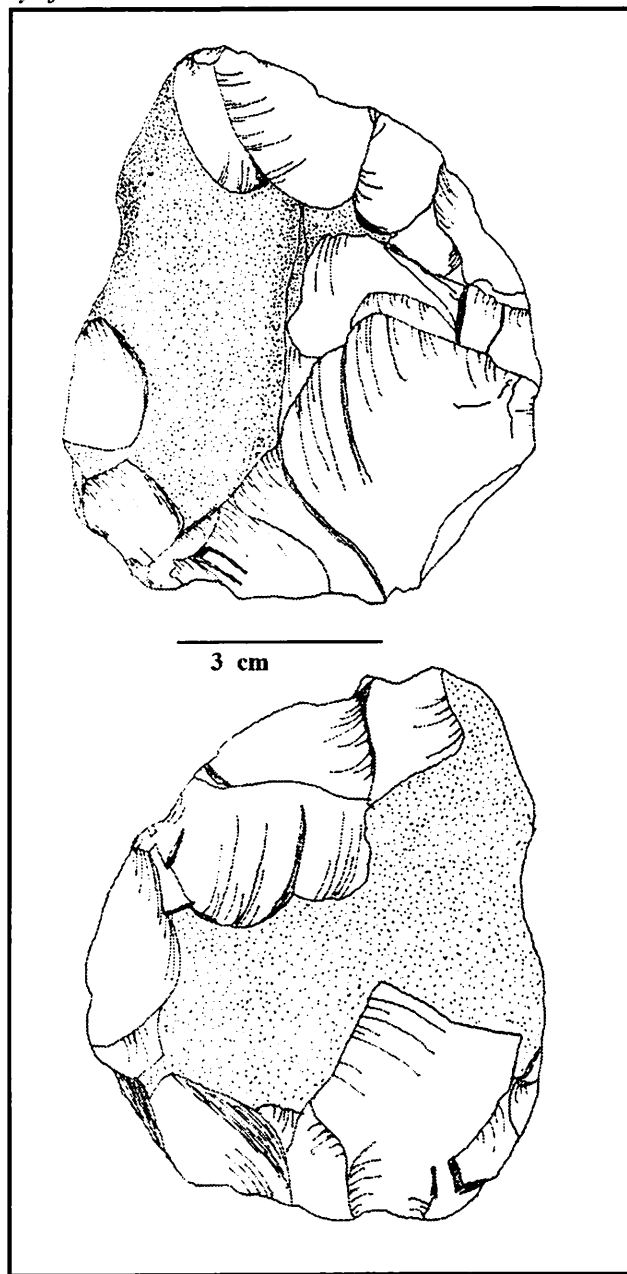


Figure 49. Both faces of an Ogallala quartzite biface core from site 34RM507.

ther small round cobbles or tabular cobbles (Fig. 49). Reduction of these seems more deliberate because recurring shapes are evident. Flakes were removed each face, and the cores may have been set up to produce large or small flakes for tools, or the knapper may have been setting up the core to produce a biface tool and thus didn't care about whether the resulting flakes were useful for tools. We tried several techniques and had some success in making bifaces. We did determine that a hard hammer was almost always necessary to detach flakes of any size from the cobbles we were working. The only soft hammer that we found would flake Ogallala quartzite consistently the biface cores was a moose antler; such a percussor would not have been available to the late

Archaic bison hunters camping at 34RM507.

Based on our two episodes of replication knapping, I expect the prehistoric knappers were both more accomplished at working Ogallala quartzite and they were more experienced at selecting quality material cobbles than we were. As noted above, many of the cobbles we brought back from Dewey County gravel exposures turned out to be of poor knapping quality. At site 34RM507 the cores of good quality material were worked to near the end of their use life. I believe that any cobble of knappable material was worked until it was either reduced to a biface or was too small to yield useful flakes. Sixty-eight percent of the recovered core

Table 7. Inventory and Descriptions of Site 34RM507 Artifacts Classified as Bifaces.

Initial Category	Number of Specimens	Description	Artifact Class or Reduction Stage	Possible Function
1	5 complete 3 broken	These are thick bifaces with step and /or hinge fractures. These knapping mistakes created bifaces that could not be further reduced. Other examples had natural inclusions that inhibited further thinning. Edge angles range from 60 to 75 degrees.	Biface Failures	Unknown
2a	3 complete 12 broken	Examples in this category are still thick enough to be reduced more. They exhibit a few small flaws such as step and hinge fractures, but these could have been fixed and the biface thinned further. Many of the broken examples appear to have fractured when taken out of a heated environment too quickly. These examples could indicate that bifaces at this stage were being heated before they were reduced further. Edge angles vary between 50 and 65 degrees.	Bifaces	Unknown
2b	4 complete 2 broken	One side is very flat whereas the other is convex, implicating these were made from large flakes. Examples may be finished products or they could be reduced more. Edge angles range from 45 to 55 degrees.	Flake Bifaces	Uncertain, possibly as knives
3	4 broken	Thinner than items in the 2a and 2b categories, specimens here are smaller in length, thickness, and width. Flaws are not evident, but all four were broken when cooled too quickly. These specimens may implicate that heat treating was undertaken at least two times during the knapping process. Edge angles range from 40 to 50 degrees.	Blanks	A stage in making finished bifaces
4	2 broken	Almost as thin as finished products, the examples sorted here are much wider. This is important because projectile points recovered from the site are narrower from having been resharpened and reworked. No flaws evident. One was broken after being removed from a heat source too quickly, whereas another exhibits end shock fracture (breakage during manufacture). Edge angles vary from 45 to 50 degrees.	Preforms	Near final stage in making finished bifaces
5	2 complete 10 broken	These are small, reworked hafted bifaces, in essence the finished products of biface making. They are very thin and usually display signs of resharpening. Some are clearly made from flakes, possibly from Category 2b specimens (above). Some broken examples exhibit crenation fractures, and some were broken in use or manufacture. Their edge angles vary from 35 to 45 degrees.	Points/ Hafted Bifaces	Dart Points
6	2 complete 2 broken	These are very narrow bifaces that display some step fracture flaws. Although narrow, they are about the same length as items in Categories 2a and 2b. Both broken examples are crenation fractures, having been removed from a heat source too quickly. They all may result from continuous reworking of Category 2a bifaces, if those were used as knives and not just part of the knapping continuum for projectile points.	Knives	Knives

fragments are fine- to medium-grain cobbles that would have provided flakes usable for making bifaces. The larger cores from the site may have been discarded due to material or knapping flaws. Compared to the cores from 34RM507, those we made look more like tested cobbles and large multidirectional cores. Out of the 30 we knapped, only 4 or 5 ended up as bifaces or yielded large flakes suitable for tools.

Bifaces

The site's assemblage includes 51 complete and broken

bifaces and 18 small fragments from bifaces; this constitutes about 2% of the entire collection. While analyzing the collection I first divided the bifaces into categories based on visible characteristics, including size, thickness, and overall shape. Later, I assembled all the bifaces and reviewed them as a group, recording other characteristics important to biface classification (see Andrefsky 1998:180-186; Inizan et al. 1999:51; Magne and Pokotylo 1981:34-47). These characteristics included the length/thickness ratio, edge angles, flake scar descriptions, cortex area, origin, and type of break (if

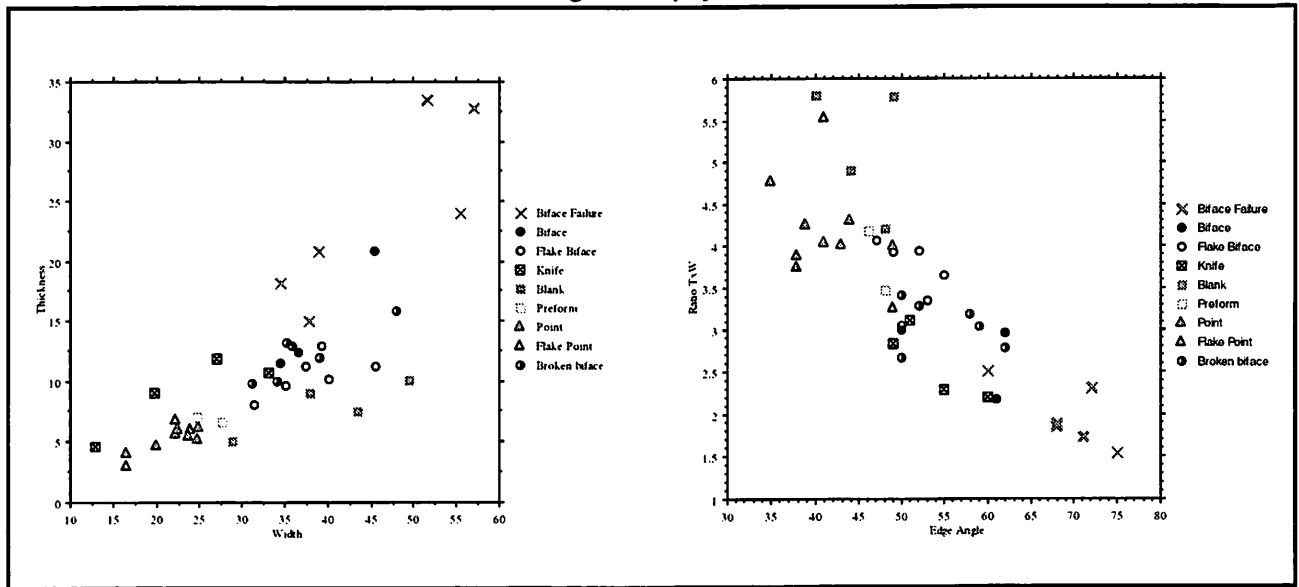


Figure 50. Charts showing thickness:width ratios (left) and thickness x width:edge angle ratios (right) for the biface categories recognized for site 34RM507.

broken; see Table 5). These measurements allowed me to refine my classification of the bifaces into six categories: biface failures, bifaces, blanks, preforms, points or hafted knives, and knives (Table 7). The ratios between width, thickness, and edge angle measurements further emphasize the differences between these categories. A higher ratio between width and thickness signifies that artifacts are thin. The larger the edge angles the thicker is the artifact (Fig. 50; Andrefsky 1998:154-155, 180-186). A few of the bifaces had noticeable edge preparation, but some also may have been crushed as the knapper attempted to remove thinning flakes. I was unable to distinguish between these two possibilities.

Biface Failures. The biface failures are very thick and display such knapping flaws as step and hinge fractures that prevented the knapper from thinning them further. The biface failures are of both Ogallala quartzite and Alibates flint (Fig. 51). Three Alibates and one quartzite examples are fine grained. Other quartzite cobbles attributed to this class were medium and coarse grained. It is possible that the knapper thought the coarse grained bifaces were a better, more easily knapped material. We found during our experimental knapping that some cobbles first appeared feasible for making bifaces, but, as we continued to reduce these cobbles, they had coarse inclusions. This may be why some of the 34RM507 biface failures are of coarse material. Biface failures may also be considered exhausted cores, but without finding flake tools that conjoin there is no way to know if they were the result of making usable flakes or one of the steps in making thinned bifaces such as knives or projectile points. It should be noted that these prehistoric knappers could correct their errors. Figure 52 shows a flake covered with step and hinge termination scars; this flake may have saved a biface from being tossed away because of knapping errors.

Stage 2 Bifaces. If knapping and material difficulty did not hinder the knapper, bifaces were thinned to what I consider Stage 2 or to a biface blanks (Stage 3; Table 7). The Stage 2 specimens here display few knapping errors or material flaws (Fig. 53). As they became thin enough to be manageable with soft hammer percussors they may have been heat-treated. I believe that heat treatment occurred at this juncture because specimens show crenation fractures (Fig. 54). Crenation is the process of the material fracturing when removed too quickly from a heating source, causing rapid cooling and distinctive fracture patterns (Purdy 1975) similar to those evident on some 34RM507 bifaces. Two quartzite bifaces made by Hurst and Wyckoff broke during knapping (due to end shock of lateral snapping), and neither resemble the fractures evident on the bifaces from site 34RM507.

The variation in 34RM507 bifaces is particularly seen in length, width, and thickness measurements. They are all still within the biface category, but some are smaller than others, perhaps because they were made from smaller flakes or smaller cobbles. It is possible that different size bifaces were to be used for different tasks. The larger ones may have been knives. However, the site yielded examples similar to them but more reduced in width (not thickness or length); these I have classified as bifacial knives. Given the poor, obviously mixed contexts I have no way to tell if the large Stage 2 bifaces were the beginning product or stage and my category of knives are the end product or stage. Smaller Stage 2 bifaces may have been prepared for making dart points, but most dart points recovered here are reworked and would have been larger than what I have considered small Stage 3 bifaces. All of the examples in this category were made from fine-grain or medium-grain quartzite cobbles.

Stage 2b Bifaces (Flake Bifaces). Other bifaces recov-

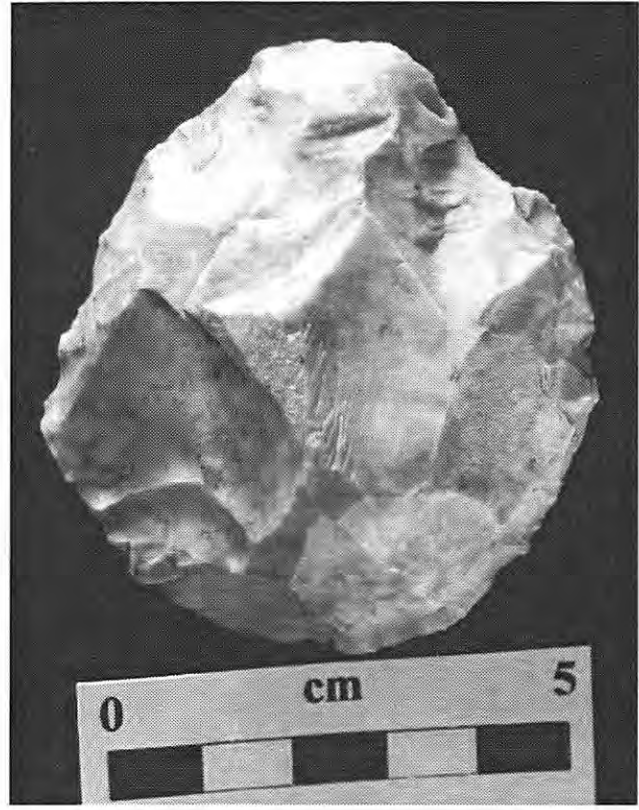


Figure 51. Examples of Biface Failure specimens recovered at site 34RM507. The example on the left is of Ogallala quartzite, whereas that on the right is of Alibates flint.

ered from the site include 5 specimens obviously made from large primary or secondary decortication flakes of quartzite (Fig. 55). These specimens have one face that is very flat like a flake's ventral face while the other face is very convex like a flake's dorsal face. Several examples display portions of cortex on the convex face. I have called these flake bifaces (Table 7). They are the same category (Stage 2) as the bifaces discussed above, but they are clearly made from flakes rather than tabular cobbles. Their edges show some retouching as if they were further reduced for use as a tool. These flake bifaces would require a great deal of thinning to be as thin as the finished projectiles found there, but their lengths resemble the larger projectiles recovered from such sites as Twilla and Certain. Blanks or preforms made from Category 2b bifaces are not represented in the assemblage from 34RM507, but two dart point fragments from the site exhibit the distinctive flat-convex cross sections of this category.

The flake bifaces may be end products, or they may be rejects before having been made into blanks and preforms. They do show a few step terminations that might have hindered further thinning. We were able to make one of these bifaces from a large, thin, decortication flake, but it is thicker than those from the site and would require a lot of thinning if it was to be made into a projectile.

Another flake biface (Fig. 56) is of unidentified chert and is a lot smaller than the quartzite bifaces in this category. It

is retouched and worn around all edges. It is much too small and thick to be destined to be a projectile point. It has cortex on one face and retains a lot of the original flake's ventral face on the opposite. This small example may have been a tool and may be evidence that flake bifaces of quartzite may have been finished products.

Biface Stages 3 and 4 (Blanks and Preforms). The next recognized stages (Table 7) in biface reduction involve what

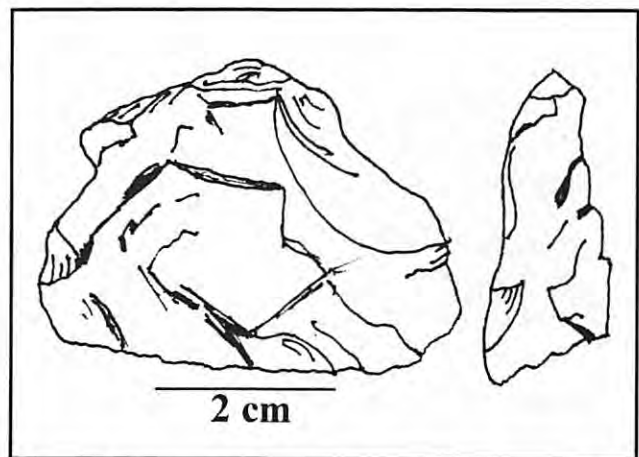


Figure 52. Ogallala quartzite flake showing successful removal of stacked step and hinge fractures. Platform is at top.

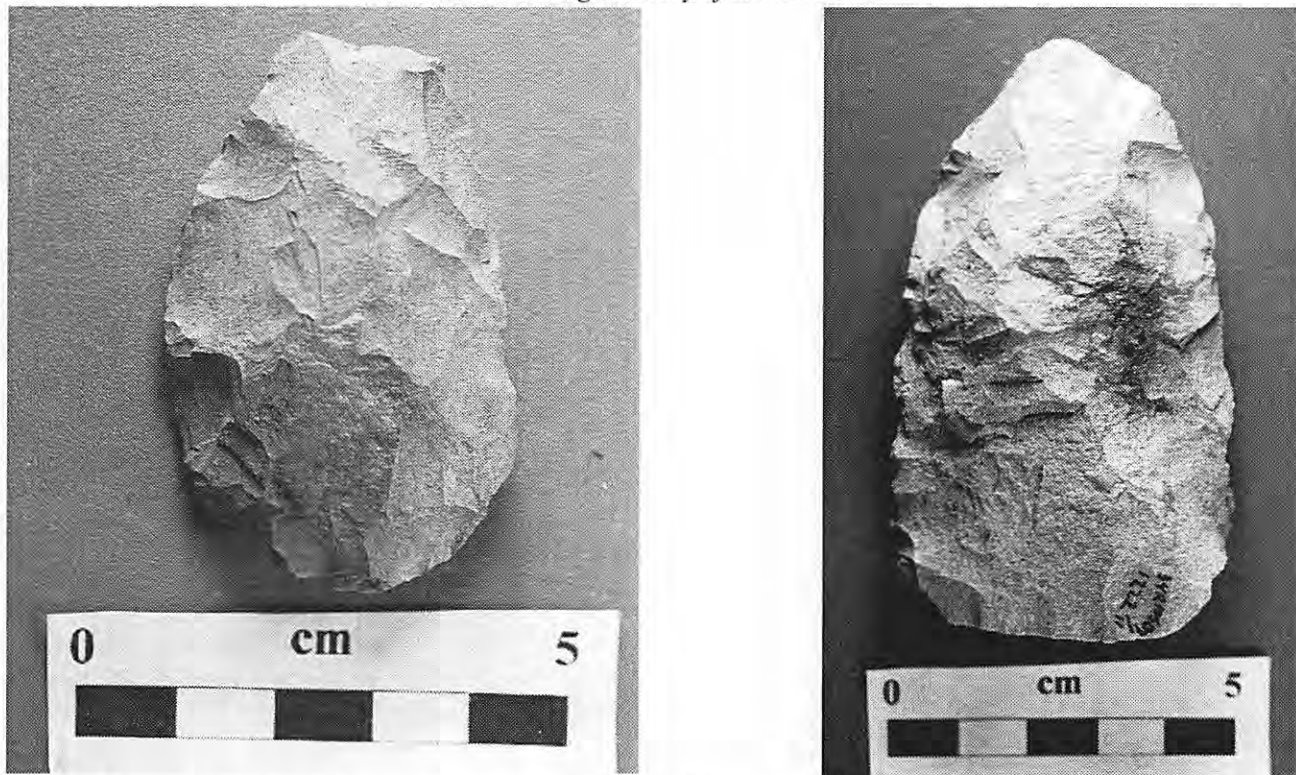


Figure 53. Examples of Ogallala quartzite bifaces (Biface Stage 2a) recognized in this study. The example on the left is fine grain material with an end-shock break on its tip. The one on the right is more coarse grained and displays a large lump resulting from stacked hinge and step terminations.



Figure 54. Two examples of Ogallala quartzite bifaces (Stage 2a) with crenation fractures resulting from cooling too rapidly after having been heat treated.

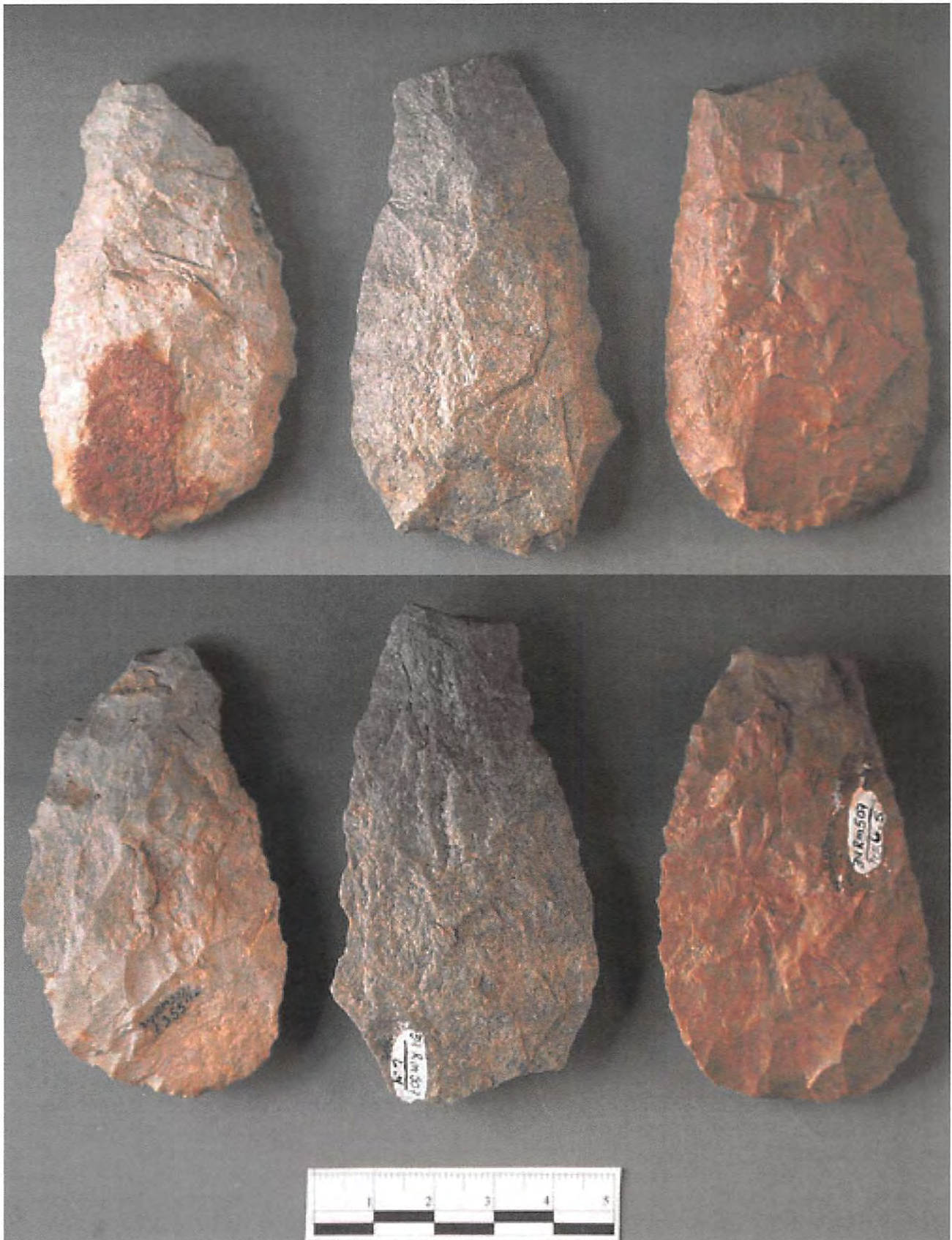


Figure 55. Three examples of Ogallala quartzite bifaces believed to be made from large flakes. The top row shows the flaked dorsal (note areas retaining cortex) faces; these have a very convex cross section. The bottom row exhibits what are believed the ventral faces of the original flake blanks; they are well flaked but very flat in cross section. The left and right examples are fine grain material, whereas the center one is more coarse in texture.



Figure 56. Small example of a flake biface made from unidentified chert. The bottom figure shows portions of the ventral face of the original flake blank.

I consider blanks and preforms. Blanks (Fig. 57) are thicker and generally larger than preforms (Table 7; Fig. 58). Both have all cortex completely removed and have slightly convex cross sections. None of the site's examples are complete. All are made from Ogallala quartzite with four being of fine grain material and two being medium grain in texture. They could be made from thick flakes or they could originate from bifaces made from rounded or tabular cobbles. None have the flat-convex cross sections like bifaces made from flakes. They were broken by either heat treatment or end shock while improperly supported during direct percussion. The preforms are those closest in thickness to the finished dart points and broken before the hafting area was created.

Biface Stage 5 (Dart Points/Hafted Bifaces). One end

product of the biface reduction sequence is the finished projectiles or knives with obvious haft areas. Two complete and 10 broken examples are represented in the site's assemblage. The broken specimens include tips, midsections, large basal fragments, and the haft areas (Fig. 59). Eight are of quartzite, 3 of Alibates flint, and 1 of unidentified chert. Except for two of medium grain texture, all are of fine grain material. Some may have been broken from heat, but most look as though the breakage came from impact fractures, retouching, or even manufacture. The fracture patterns are not as obvious as on the larger bifaces.

Blades on these objects manifest a variety of retouching events. Two tip sections (Fig. 59) are from large points, whereas the complete specimens are much smaller and show a great deal of retouching (see Fig. 59). The actual retouching on these specimens is different from other bifaces. Some flake scars are narrow enough to result from pressure flaking in an orderly or patterned way, but other scars end in small step terminations like those produced by soft hammer percussion. These small step terminations are visible on the bifaces, blanks, and preforms for the site and those created by Hurst and Wyckoff.

Most of the points appear to be of the Ellis type (Bell 1960:32-33) but one is side-notched and assignable to the Ensor type (Bell 1960:34-35). Two base fragments (both of Ogallala quartzite) compare to the more complete examples of both types found at the site. These basal fragments and several of the points broken across their blades most probably are items removed from foreshafts when the specimens were broken during hunting or butchering. These items implicate that site 34RM507 was the location where these people retooled and refitted their hunting equipment.

Figure 60 illustrates how my proposed biface reduction sequence, along with resharpening episodes, are evident when five bifaces are placed together. The large hafted point or knife is from the Certain site, a Beckham County bison kill some 15 miles east-southeast of 34RM507. All other items outlined in Figure 60 are from 34RM507. These help demonstrate that this site was not only a spot to resharpen and retool but also to produce the blanks and preforms for needed finished bifaces.

Raw Material Use and Variation among 34RM507 Bifaces. A few differences exist in the kinds of raw materials used in making the various biface categories (Fig. 61). The Alibates biface failures have a higher thickness-to-width ratio, but the Alibates dart points have a lower ratio than those of Ogallala quartzite. Unknown chert bifaces have a similar ratio to the quartzite bifaces, and the unknown chert dart point is also similar. The lone (broken) biface made from petrified wood also has the same ratio as the broken quartzite bifaces.

Flake Tools

Only 141 retouched flakes, or flake tools, were recovered



Figure 57. Examples of Biface Category 3 (Blanks) of Ogallala quartzite from site 34RM507.



Figure 58. Two sections of Biface Category 4 (Preforms) of Ogallala quartzite from site 34RM507.

from the site. I divided them into seven categories (Table 8). I applied specific names to those categories that were similar to tools already described for Late Archaic assemblages (Hofman 1977; Hughes 1955; Leonhardy 1966; Tainter 1979). Other flake tool categories are described by the retouch or use-wear patterns. Varieties within the categories are largely based on size and the diversity of specific kinds of tools. As with the bifaces and cores, I kept retouched flakes separate from the rest of the flake assemblage so that I could thoroughly analyze all of them when the initial sorting and study were done. I recorded specific information, such as edge angle, number of edges worked, area of retouch, retouch type, retouch distribution, shape of retouch, and face of retouch (Table 8). I attempted to look for polish or other use-wear traces on the tools, but because most are quartzite, and because use-wear is difficult to see on this material, I was unable to ascertain specific kinds of use. Therefore, I was very conservative in noting use-wear.

The materials used to make flake tools were overwhelmingly quartzite, mostly fine or medium textured. Of the 141 flakes, the majority (88%) were quartzite. The other utilized materials were unknown cherts (10%) and Alibates flint (2%). Many tools were fine grain quartzite and were made from either secondary decortication flakes or tertiary (non-cortex) flakes. The sizes of flakes selected for use ranged from small to large. Many of the implements made from large flakes were tools that have been classified previously for other Late

Archaic sites in the region (Hofman 1977; Hughes 1955; Leonhardy 1966; Tainter 1979). Implements made from small flakes were usually retouched along only one side and the retouching was very minimal. None of the edge angles were below 30 degrees. Some 56% were between 30 and 60 degrees, and 44% were above 60 degrees. The flake scars on the retouched areas exhibit feather, step, and smooth terminations and all three together. The distribution of retouch was both continuous and clustered. The shapes of the areas retouched were pointed, straight, concave, and convex. Many of the specimens were retouched only on the dorsal face, but a few were worked on the ventral face, and even fewer on both faces. Below, each category is briefly discussed.

Flake Tool Category 1, Gravers. Two kinds of gravers are represented at the site, and they were segregated on the basis of flake size (Fig. 62). Six specimens are in the collection: 3 large quartzite flakes (Category 1a) and 3 small flakes (Category 1b). All but one of the six were made on secondary decortication flakes; the exception is a small tertiary flake. Four of the six are of fine grain textured quartzite; one is medium grain and one is coarse. All have sharp pointed projections. Hughes (1955:63) describes gravers as having “beak like projections” and that is what is represented on the specimens from 34RM507. The edge angles recorded for these tools range between 30 and 60 degrees; one is greater than 60 degrees. The flake scars on the gravers are both stepped and feathered; there does not seem to be any consistency.



Figure 59. Both faces of Biface Category 5 (Finished Points/Hafted Knives) from site 34RM507. Typologically, these might be assigned to the Ellis and Ensor (middle specimen on bottom row) style projectile points. In terms of raw material, the top specimen is of unidentified chert; the second row specimens are of Alibates agatized dolomite; and the specimens on the bottom row are Ogallala quartzite. Scales are in centimeters.

Retouching is in one or two places on the dorsal face of the flakes. One specimen has visible polish on the graver, but the others display only small flake scars that may result from use.

Flake Tool Category 2, Gouges. Two gouges were recovered from the site (Fig. 63). Both were made on secondary decortication flakes, one of coarse textured quartzite, the other of microcrystalline chert. Both are similar in size (4.3 and 5.4 cm in length and 3.9 and 4.2 cm in width) and are retouched at the proximal end of the dorsal faces. This is the thickest part of the flake. A few small flake scars occur on the ventral face of both specimens. The retouched area is slightly concave; step flake scars occur here. Both specimens compare well with what has been called Clear Fork gouges (Hofman 1977). Neither of the 34RM507 specimens fit Hofman's recognized varieties. In fact, they are complete opposites of his Variety 1, because they have the bit end at the proximal (not the distal) end of what would have been the original flake blanks. Their working edge angles exceed 60 degrees. A slight polish is visible on the quartzite ex-

ample, but no polish is evident on the chert specimen.

Flake Tool Category 3, Unifaces. Four unifaces are identified: 1 large (Category 3a) and 3 small (Category 3b). The large example may have originally been a secondary decoration flake, but its dorsal face (Fig. 64) has been entirely flaked by scars that carry across the face and that have diffuse bulbs (implicating they were done by soft hammer). The original flake blank for this largest specimen must have been thin; the resulting uniface could be classified as a knife because its edge angle stays close to 30 degrees. It is 6.6 cm long and 3.4 cm width with a thickness of 1 cm. I find it interesting that the entire dorsal face was flaked, because the object would have been functional if only the edges had been retouched. From the amount of flaking I suspect that the knapper was trying to thin the flake blank in order to create a more acute edge angle. Its role as a tool may have been similar to the flake bifaces. Its thickness:width ratio is larger than the flake bifaces and closer to the blanks, preforms, and points in the biface reduction series.

The three small unifaces (Flake Tool Category 3b; Table

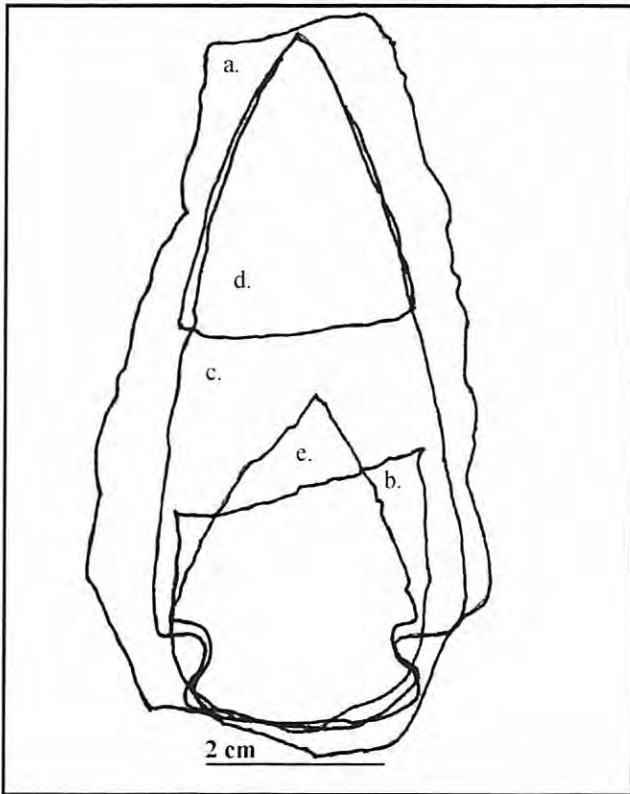


Figure 60. Overlaid outlines showing the sequence for making finished bifaces as proposed from findings at 34RM507 and 34BK50 (Certain site). Item a is a flake biface; item b, a preform section; item c, a complete slightly used projectile point/knife; item d, a finished biface tip; and item e, a resharpened point. Item c is from site 34BK50, whereas all others are from 34RM507. Note that figure is larger than actual size.

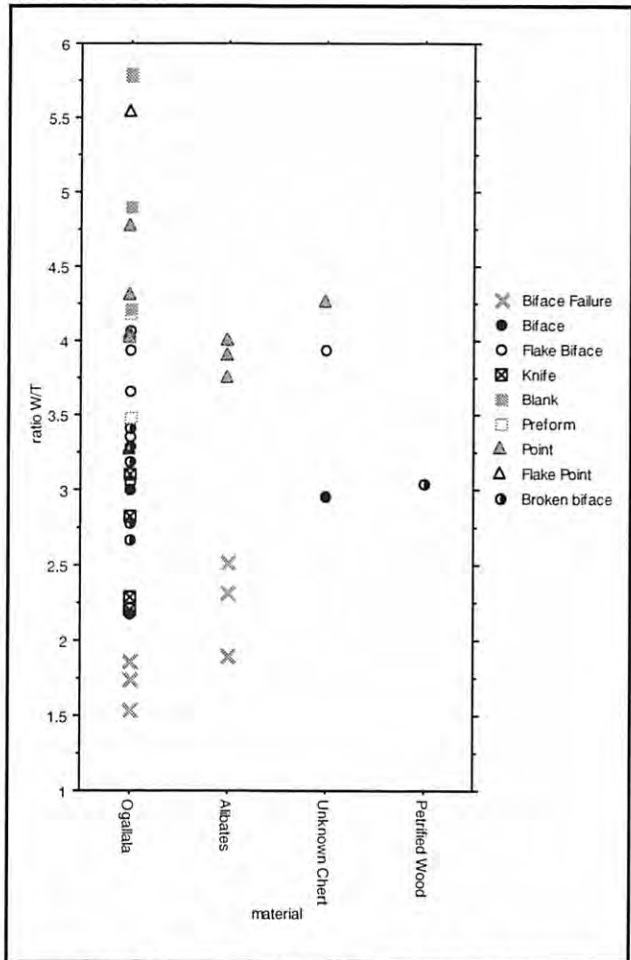


Figure 61. Raw materials represented by the various categories in the biface reduction sequence discerned for site 34RM507.

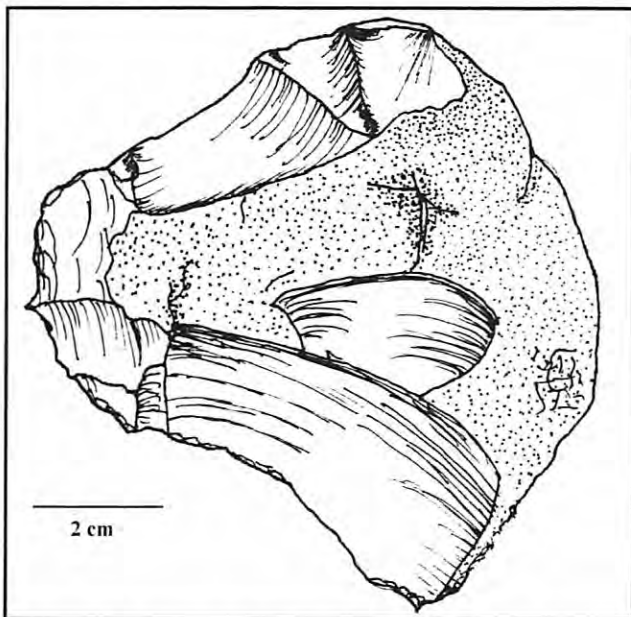


Figure 62. Graver made on a large secondary decortication flake of Ogallala quartzite. Example of Flake Tool Category 1a.



Figure 63. Examples of Flake Tool Category 2, Gouges. The one on the left is of Ogallala quartzite; that on the right is of unidentified chert.

8) are actually thicker than the large example (Fig. 64); they have most or all of their dorsal faces retouched (Fig. 65). One small uniface has a few flake scars on its ventral face that look as though the knapper was trying to remove or thin the large bulb of force, thus creating a flat ventral face that was better suited for a particular function (or hafting?). The small uniface is all about the same size, ranging from 4.0 to 5.5 cm in length, 1.9 to 2.2 cm in width, and 1.2 to 1.7 cm in maximum thickness. Each is retouched around the edge on the dorsal face. The resulting flake scars include step and feather terminations. Their edge angles are greater than 60 degrees. Some edge areas display a noticeable polish.

sidered side scrapers were also divided into large (4a) and small (4b) variations (Fig. 66). The large examples are somewhat different, one being a primary decortication flake (Fig. 66 left) of coarse textured quartzite whereas the other is a secondary decortication flake of fine textured quartzite (Fig. 66, center). Both are about the same size and are retouched only along one edge of the dorsal face. The flake scars on the coarse quartzite example are large and rather continuous. The many tiny flake scars on the finer grain example may be the result of use, and not edge shaping or resharpening. Their edge angles range between 30 and 60 degrees. Polish was clearly visible on the specimen of fine textured quartzite.

Flake Tool Category 4, Side Scrapers. What can be con-

Two of the small side scrapers are of fine grain quartzite

Table 8. Categories of Flake Tools Recognized for Site 34RM507.

Flake Tool Category	Number of Specimens	Description	Report Classification	Possible Functions
1a	2 complete 1 broken	Large flake with sharp projections, mostly created by small flakes removed from the dorsal face. The worked edge angle is 60 degrees or more. The broken example is a primary decortication flake, while the other two are secondary decortication flakes.	Large Graver	Incising or engraving
1b	2 complete 1 broken	Small flakes with at least one sharp projection. Worked on their dorsal faces, these have edge angles varying from 30 to 60 degrees.	Small Graver	Incising or engraving
2	2 complete	Large flakes with dorsal face edge worked to angles more than 60 degrees. The thickest part of the flake is retouched to a straight or slightly convex edge. Reworking and use has created many step terminations. Both are secondary decortication flakes.	Gouge (Clear Fork gouge)	Gouge
3a	1 complete	Large flake that is completely flaked on its dorsal face. This flake is very thin and its edge angle varies between 30 and 60 degrees.	Large Uniface	Cutting?
3b	3 complete	Small flakes completely flaked on their dorsal faces: all thin edges have been removed, resulting in edge angles exceeding 60 degrees.	Small Uniface	Unknown, scraping ?
4a	1 complete 1 broken	Large flakes with one edge on dorsal face retouched by small flake scars. Edge angles vary between 30 and 60 degrees. May be either primary or secondary decortication flakes.	Large Side Scraper	Scraping
4b	3 broken	Small flakes with one edge along dorsal face retouched by small flake scars. Edge angles vary from 30 to 60 degrees (although these are broken and may have been retouched along missing edges, too).	Small Side Scraper	Scraping
5a	1 complete	A large flake retouched along one thick edge of its dorsal face. The retouching is by small flake scars, and the resulting edge angle is >60 degrees.	Large End Scraper	Scraping
5b	4 complete 9 broken	Small flakes retouched along edges of dorsal faces; flake scars sometimes extend well over the surface. Most retouching is along the distal end of the flake. They have distinctive pear-shaped forms.	Small End Scraper	Scraping
6a	1 complete 3 broken	Flakes with multiple edges of dorsal faces retouched by small, sometimes continuous scars. Some are prominent projections. Their edge angles exceed 30 degrees.	Multiple Use Tool	Uncertain, possibly engraving
6b	4 complete	Multiple edges retouched on both dorsal and ventral faces with large and small flake scars. Dorsal face retouching created prominent projections that are worn. Ventral face retouching is continuous scars, often along a straight edge. Both large and small secondary decortication flakes are represented.	Multiple Use Tool	Uncertain, possibly engraving and/or cutting
7a	16 complete 52 broken	Flakes retouched along one long, straight edge, usually on the dorsal face. Retouching manifest by small flake scars.	Retouched Flake	Unknown
7b	3 complete 5 broken	Flakes with retouched convex edge on dorsal face. This rounded area is an isolated retouched area. All flake scars are small.	Retouched Flake-convex projection	Unknown
7c	5 complete 10 broken	Flakes with retouched concave edge on dorsal face. This notch is an retouched area in most cases. Only small flakes were removed. Some flake scars in the notch are obliterated due to use of the spot. The notches may have been created through use rather than having been purposefully flaked.	Notched Flakes	Unknown
7d	7 complete 4 broken	Flakes with retouched edges on both dorsal and ventral faces. The retouched areas are straight, concave, and points, with two or more such spots on a flake. All flake scars are small.	Multiple Use Retouched Flake	Unknown



Figure 64. Both faces of an example of Flake Tool Category 3a, a large uniface. The material is a fine textured Ogallala quartzite.

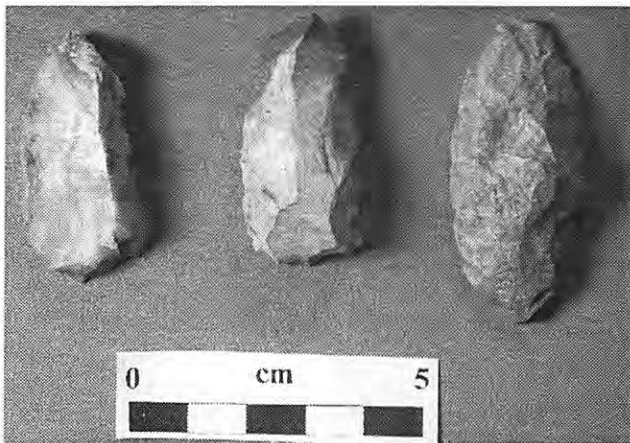


Figure 65. Examples of Flake Tool Category 3b, small unifaces.

while the third is of an unknown chert. None are complete, so they were a problem to categorize. But they are much smaller than the large examples in Category 4a. The small specimens are similar in that they are retouched on their dorsal face and they have edge angles between 30 and 60 degrees. The chert example is broken lengthwise, so it is possible that both lateral edges originally were retouched; the existing flake scars are continuous. One of the fine textured quartzite examples is missing its distal end; this could have been an end scraper, but it is impossible to tell. Its retouch flake scars are small and along the side, and they terminate in step fractures. This may be use-wear; there is evidence of some polish. The final small example is broken at mid-section:

we recovered both parts (Fig. 67), one in 1986 and the other in 1999. Edges on the dorsal face are retouched, and polish is pronounced (I am uncertain whether this resulted from use or from movement during site erosion.).

Flake Tool Category 5a, Large Scraper. One very large scraper was recovered from the site. It is retouched along a side and at one end. The flake blank was a secondary decortication flake of fine textured Ogallala quartzite. The retouched edge angle is more than 60 degrees, and the retouching is continuous, being represented by small and medium size flake scars. A polish is visible along some sections of the retouching.

Flake Tool Category 5b, Small End Scrapers. Examples of small end scrapers were recovered, including 4 complete and 9 broken ones. Ten are of quartzite (7 fine texture, 3 medium texture) and 2 are of Alibates flint while 1 is of an unknown chert. The complete examples resemble each other in shape (Fig. 68). They are also very similar in size, ranging from 3.8 to 5.2 cm in length, 2.4 to 2.8 cm in width, and 0.8 to 1.1 cm in maximum thickness. They are made from secondary decortication and non-cortex tertiary flakes. Many are not only retouched along one end but also along at least one side. Retouch flake scars are continuous and terminate in feather and step fractures. Polish is evident on some. Polish is especially visible on the one of Alibates flint (Fig. 68, bottom); this specimen was heavily used and extensively retouched. The broken sections are mostly distal ends of such scrapers. Two pieces (proximal and distal fragments) can be



Figure 66. Examples of Flake Tool Category 4, side scrapers. All are made from flakes of Ogallala quartzite.



Figure 67. Two refitted sections of a small side scraper. Material is Ogallala quartzite.

refitted to provide the scraper's length, but a heat spall is missing from the dorsal face. The working edge angles vary from 30 to more than 60 degrees.

Flake Tool Category 6a, Multipurpose Tools. Eight tools are considered to have multipurpose uses, and they were put in Category 6a. Four have one to three sides retouched somewhat like the graters described above as well as along edges retouched like scrapers. Some of the retouched sides are concave. One is a coarse quartzite; one is of Alibates, and 2 are of unknown cherts. Two have worked edge angles of 30 to 60 degrees; the other two have edge angles exceeding 60 degrees. The only complete example is of unknown chert; all others are broken.

Flake Tool Category 6b, Miscellaneous Multipurpose Tools. The four specimens included here don't fit any other proposed categories. Two are made from large secondary decortication flakes; the other two from small examples of such flakes. These may have been graters that were worn

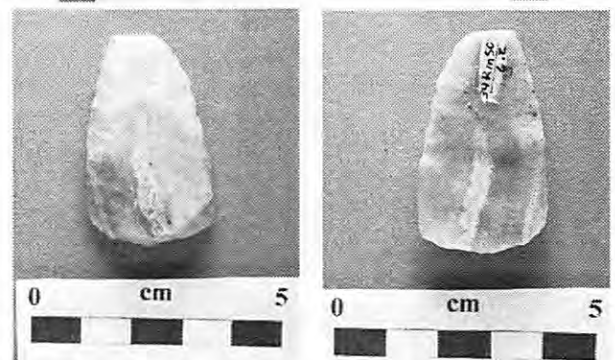


Figure 68. Examples of small end scrapers (Flake Tool Category 5b). The two on top are dorsal faces of Ogallala quartzite specimens. On the bottom are both faces of one made from Alibates flint.

down or not completed, but the pointed areas on their edges are not like the "beak like points" manifest on the graters described above. These projections are much larger and prominently extend from the flakes' lateral edges, having been created by medium size flake scars. Little, if any, retouch is apparent adjacent these projections. All of the edge angles are between 30 and 60 degrees. One large flake is a very

coarse quartzite while the other is a medium texture quartzite. This latter has retouching evident at several spots along its left lateral edge. The two smaller multipurpose tools are retouched more than the larger tools. These small examples are secondary decortication flakes of fine textured quartzite. Both are worked along one lateral edge and have a projection that is not sharp (Fig. 69). One has flake scars all along one side of the ventral face opposite the dorsal retouched edge and projection (Fig. 69). The retouching on the ventral face is heavily used and polished.

It is possible these multipurpose tools were for reaming. It is also possible the flake scars result from livestock trampling or even trowels of archaeologists (George Odell, personal communication). This might explain the lack of retouching and odd flake angles from which the flakes were removed from the possible tools. It is important to note that the smaller tools in this category are definitely reworked in other area, so I believe this site's inhabitants manipulated them.

Flake Tool Category 7, Retouched Flakes. The rest of the flake tools display minimal retouching (Andrefsky 1998:77-80; Inizan et al. 1999:30-33). Originally I had recorded 168 flakes with such retouching, but upon further study I culled it to 102 specimens. Flakes taken out of this category were removed because the marginal flaking looked like it could have resulted from natural causes (water movement, livestock, etc.). A cow path runs directly through the site and trampling was very likely to have created edges resembling retouch or use-wear. I may have been too conservative in my selection because 102 flakes equals 2.8% of the entire artifact collection and 4% of all the flakes.

The 102 flakes were further sorted. I discerned four kinds of edge areas where minimal retouching occurred: straight edges, convex or rounded edges, concave areas, and those with a combination of these.

Sixty-eight flakes had slightly retouched, relatively straight edges and comprise my Flake Tool Category 7a. Sixteen were complete, and 52 were broken (Fig. 70). Of these, 62 are quartzite (41 fine, 18 medium, and 3 coarse textured) and 6 are of unknown chert. Most are small: 59 between 3 and 5 cm in maximum length. Only five are larger than 5 cm, and seven fragments are so small that it is impossible to estimate their original size. Their edge angles are similar to other flake tools: 62% are between 30 and 60 degrees while 38% are over 60 degrees. Retouch flake scars vary but are feathered to step to smoothed. These scars are both continuous and clustered along one dorsal edge 82% of the time. Most retouched areas are straight, and most of the retouching is near the distal end of the flake or on the right lateral edge.

Flakes with retouched rounded (convex) areas are rather distinctive. Eight are in the collection with 3 being complete and 5 broken (Fig. 70). Six are of fine textured quartzite

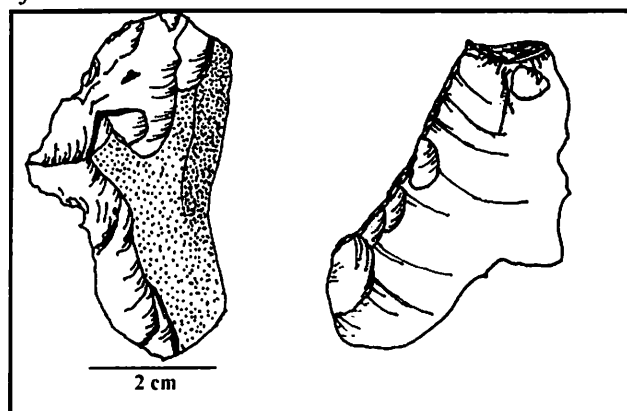


Figure 69. Both faces of a multipurpose tool (Flake Tool Category 6b) of fine grain Ogallala quartzite.

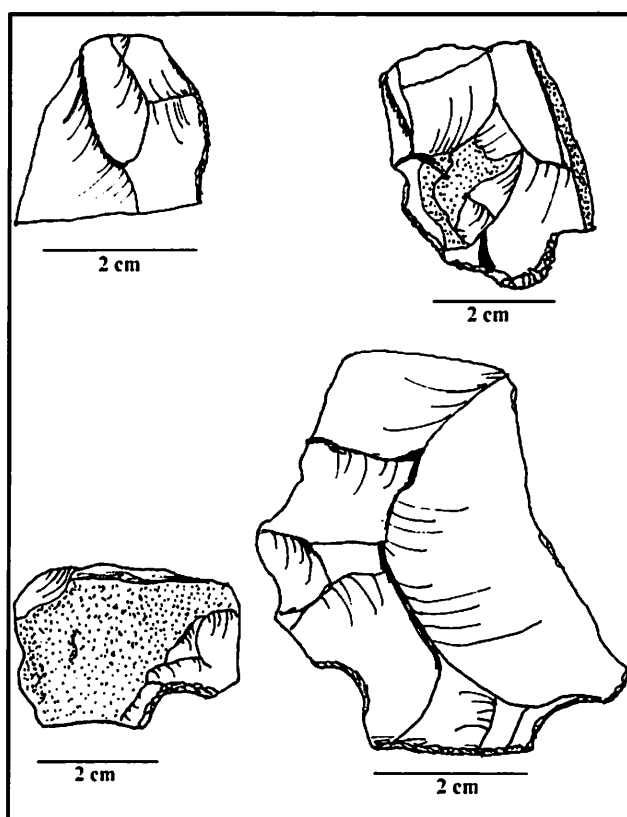


Figure 70. Examples of the various minimally retouched flakes included in Flake Category 7. Top left, Category 7a; top right, Category 7b; bottom left, Category 7c; and bottom right, Category 7d.

while 1 is medium textured, and 1 is of unknown chert. Five of the eight retouched areas exhibit step terminations on the flake scars, whereas the other three have feather terminations. Six are retouched along only one segment, but one is retouched in two areas and one in three areas. Four have edge angles between 30 and 60 degrees; four have edge angles exceeding 60 degrees. I am not sure that these objects were used in a specific way, but their distinctive form suggests to me that they were not just randomly retouched.

Category 7c includes flakes retouched in ways to create a notch or large concave are (Fig. 70). Fifteen specimens are in this category; 5 are complete, 10 broken. All are made from quartzite flakes, and 13 are fine grain while 2 are medium grain. Almost all (13) are small flakes; one is large and one broken. Nine have worked edge angles between 30 and 60 degrees, whereas six have edge angles exceeding 60 degrees. Flake scar terminations are rather evenly divided among feather (5), smooth (6), and step (4). The smoothed retouch areas are important; all flake scars are basically obliterated and barely visible with a 120x power microscope. I was unable to detect polish because the flakes that are smoothed are very fine textured and the entire surface looked polished. In some instances the notch may have been created solely by use because it is so smooth. Out of 15 specimens, 14 are retouched only on one face; the other is retouched on both faces. Ten have continuous flake scars, and five are clustered. Almost all are retouched on the dorsal face (13), but 2 are retouched on the flake's ventral face.

The last formal group (Category 7d) of flake tools consists of retouched flakes with likely multiple uses. These are flakes manifesting a combination of notches, straight, and pointed areas formed by retouching (Fig. 70). Seven are complete, whereas four are broken. All are of quartzite: 9 fine grain and 2 medium. Nine are small flakes, one large, and one broken. Four have edge angles between 30 and 60 degrees while seven have edge angles greater than 60 degrees. The terminations of the flake scars are predominantly step (7 examples), but 3 are feather and 1 is a mixture of all terminations. Most (7) are retouched on their dorsal face, but 3 are worked on their ventral face and 1 is worked on both faces. All have two areas along their edges that are retouched: 3 with continuous flake scars and 8 with clustered flake scars.

A residual category consists of four small fragments of retouched flakes. All are of quartzite. They are too small for further classification.

Debitage and Raw Material

To further understand the reduction processes undertaken at 34RM507 it is necessary to discuss the flakes recovered there. A total of 2278 flakes are in the collection, representing about 66% of the artifacts. This includes the retouched flakes in the above discussed Categories 7a-d and 8, but the total does not include flake fragments. Some 20% of the entire assemblage was considered to be flake fragments that could not be identified regarding their origin in the reduction sequence. These fragments are not included in the following discussion.

I begin by discussing the raw material represented by the flakes. This will demonstrate the kinds of materials chosen for tool making by the site's occupants. By considering the amount of cortex and dorsal scars on the flakes we will gain some perspective of the reduction stages undertaken here.

Flakes are the byproducts of knapping, and their terminations implicate the successful and unsuccessful application of force during knapping (Andrefsky 1998:85-88). Terminations are therefore important and will merit discussion. Complete flakes will be evaluated because their lengths and widths provide some implication of the sizes of the cobbles, cores, and bifaces being worked. Finally, platforms attest to preparation before knapping and to the kinds of force applied, so I look at such attributes as bulb size, lip character, platform preparation, exterior platform angle, and platform thickness.

Quartzite is represented by 92.4% of the flakes. Petrified wood is represented by only 2%, and unidentified chert comprises another 2%. Other materials such as unknown quartzite, Antler gravels, Alibates flint, Tecovas flint, agate, and unknown material comprise 1% or less of the flakes (Fig. 71).

Within each lithic material I divided the flakes into the traditional categories of primary decortication, secondary decortication, and tertiary (non-cortex). Because the definitions of these categories vary among archaeologists I base my discussion on cortex amount (% of surface) on the dorsal face of each flake (White 1963; Wyckoff 1973:71-100). For general purposes it should be noted that only 5% of the flakes are primary decortication, 27% secondary decortication, and 68% tertiary (Table 9). I have subdivided the secondary decortication flakes into three subgroups based on increasing amounts of cortex present (Table 9). I believe that the amounts of cortex present on the site's flakes are notable clues to the kinds of cobble reduction occurring there.

Alibates flint is not represented by primary decortication flakes at the site, and the occasional secondary decortication flakes of Alibates manifest only 10 to 50% cortex. On this basis it seems clear that unmodified cobbles of this high quality flint were not brought here and worked. It does appear that a partially shaped piece was further knapped at the site.

Interestingly, agate that sometimes occurs in the Ogallala gravels is minimally represented by flakes. The few present have less than 50% of their dorsal surfaces covered by cortex. So the occasional cobbles worked were brought here already prepared as cores or partially worked bifaces.

The few (3) Tecovas flint flakes are all broken but represent primary decortication, secondary decortication, and tertiary examples. This seems unusual as Tecovas cobbles wouldn't be expected in the Ogallala gravels nearby. Perhaps clasts of this distinctive chert are in gravels along the Washita River a few miles to the north. I expected to find tertiary flakes of Tecovas, but not decortication flakes from the initial stages of reduction. I thought we might find broken or expended finished tools and thus might also find tertiary flakes from resharpening or recycling such tools. Given the character of the few Tecovas flakes, perhaps they came

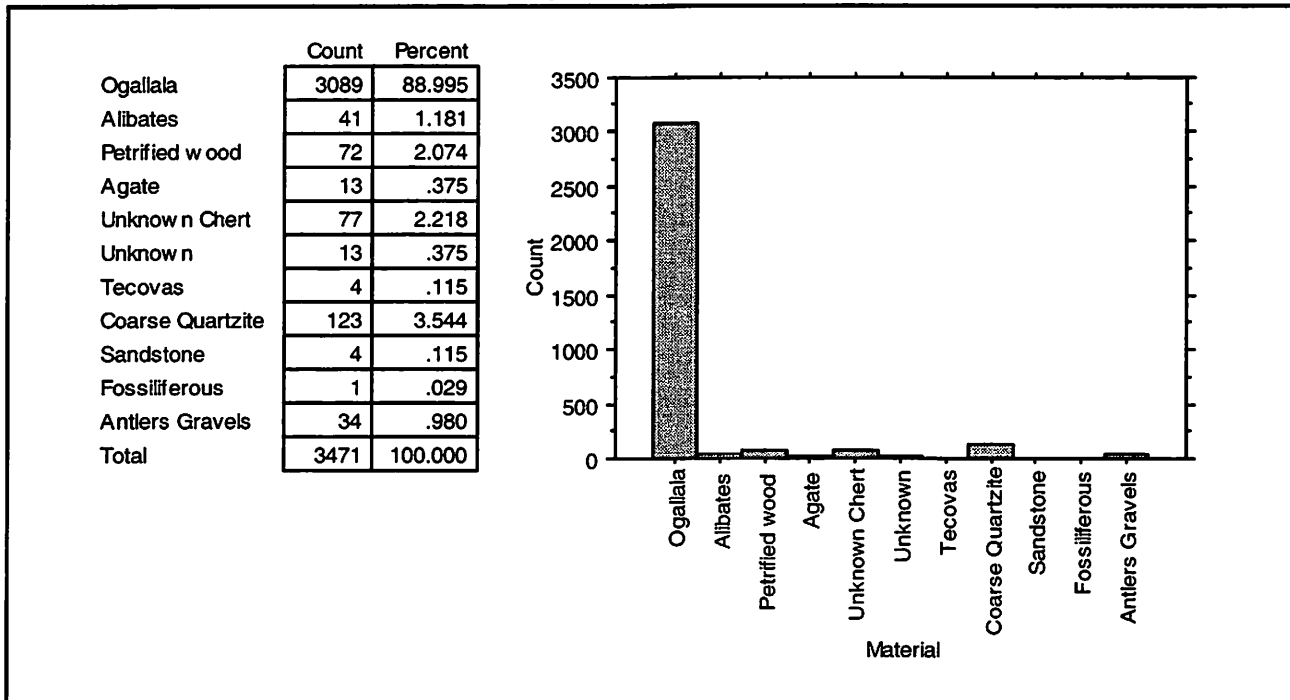


Figure 71. Quantities of flakes of the different raw materials recognized among the debitage recovered at site 34RM507.

Table 9. Cortex Criteria for Classifying Flakes at Site 34RM507.

Flake Category	% of Flake Collection	Amount of Cortex Dorsal Face	% Within that Category
Primary Decortication	5	95 to 100%	5
Secondary Decortication	27	0 to 95%	27
S.D. A	3	75 to 95%	3
S.D. B	5	50 to 75%	5
S.D. C	19	10 to 50%	19
Tertiary	68	0 to 10%	68

from a scraper or flake knife made from a large secondary decortication flake. It is unlikely an entire cobble of Tecovas flint was brought here and processed, because such reduction would produce a lot more debris than we recovered.

Many of the flakes recovered here were broken either during knapping or subsequently by erosion and trampling. Only 18% of the flakes are complete. Many of the broken flakes are tertiary flakes. Broken flakes were recorded as proximal, distal, or midsection parts, and I also noted whether they were longitudinally broken or just unidentifiable fragments. The longitudinally broken examples potentially attest to uneven platforms, too much percussion force (most likely hard hammer), or inclusions in the material (Whittaker 1994:14).

While studying the broken flakes I also recorded the kinds of breaks because these bear witness to the different kinds of force applied at different stages in reduction. Some flakes had two kinds of breakage. Bending breaks often occur dur-

ing soft hammer percussion and the making of bifaces (Whittaker 1994:187). Eighty-six percent of the flakes with a bending break are tertiary flakes, and only 12% have 10 to 50% cortex on their dorsal faces. This leaves only 2% of the flakes with bending breaks having 50 to 95% cortex on them. A total of 188 flakes were broken longitudinally as well as horizontally. These follow the same pattern as the other broken flakes: 65% are tertiary flakes while 23% were secondary decortication (20 to 50% cortex) flakes. Because most biface manufacture involves thinning pieces largely lacking cortex, I believe the broken flakes discussed here are evidence of biface knapping at 34RM507.

Further clues to what reduction processes were undertaken came from examining the numerous tertiary flakes represented in the collection. They, too, bear clues to what was being reduced. One place to start is the number and direction of flake scars evident on their dorsal faces (Lintz 1978; Muto

1971:47-84, 1976:31-121). I documented the number of flake scars on each complete or nearly complete flake while also recording the direction the flake scars relative to the longitudinal axis of the flake. I used a circle divided into eight sections (Fig. 72) to consistently determine each flake scar's direction (Odell 1979). This was done with the platform up (looking at the dorsal face) and between sections 8 and 1 (Fig. 72). Through this recording technique I gathered information about knappers' orientations of cores or bifaces as they worked them. The information gathered could then be assessed to see if recurring patterns of knapping were practiced at the site. I started with flakes that have cortex on their platform because such flakes were removed near the beginning of sequences in core reduction (Whittaker 1994:17, 98). Flakes without cortex on their platforms were potentially removed later in sequences of reduction. However, the possibility exists that platforms were created by purposefully removing cortex, so we might find primary and secondary decortication flakes without cortex on their platforms. The following analysis is therefore concerned mainly with primary and secondary decortication flakes and whether or not they manifest platforms with cortex. Table 10 shows the distribution of flakes based on the amount of cortex on their dorsal face and whether or not they have platforms with cortex.

Primary Decortication Flakes (Fig. 73). Ordinarily, primary decortication flakes would not be expected to have flaked dorsal faces, but a few from 34RM507 do have very small flake scars on them. I believe that most occurred when the knapper tried to remove the flake, most likely the first flake, from a cobble. We found in our experiments that it

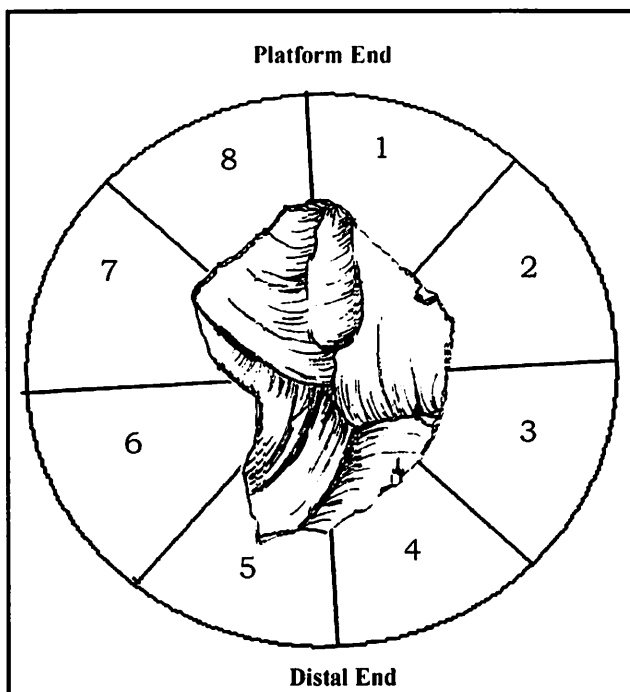


Figure 72. Illustrating how tertiary flakes were studied to document directions of previously removed flake scars.

usually took several blows to remove a large flake, and each blow often removed a small flake, usually terminating in a step or hinge fracture adjacent the platform. Our experimentally produced examples are similar to the primary decortication flakes with small dorsal flake scars I observed in the collection. Only 10 of the 111 primary decortication flakes had a flake scar; one had 2 such scars, both in the same location and attesting to repeated blows on the same platform before successfully removing a large flake. Primary decortication flakes comprise only 19% of the flake collection. Of the 10 examples with flake scars, seven had the scars adjacent the platform and on the right side; the other 3 had the scars on the left dorsal face near the platform. I think these flake scars indicate the knapper first tried to remove flakes from a platform, was unsuccessful, and then rotated the cobble and found another, more suitable platform. Some 13% of the primary decortication flakes have platforms covered with cortex (Table 10), indicating these flakes were the first to be removed from cobbles.

As noted earlier, there are only 111 primary decortication flakes. Some 43% of these lack their platforms and these are not included in the following discussion. Thirty-one percent have platforms with some cortex; 69% with platforms lack cortex on the platform. With so few complete primary decortication flakes, it is hard to ascertain much of a pattern for how 34RM507 knappers began to manipulate cobbles they were working. My first conclusion is that they were removing some cortex at or near the outcrop of Ogallala gravel. This would be the obvious place to be testing cobbles. The removal of one flake may not be sufficient to test cobbles, however. We found during our replication efforts that many cobbles seemed to be of high quality, but once we started removing more flakes the more the internal variation of each cobble became visible. The removal of a few primary flakes at the source may not have only been to test the cobbles but also to set up platforms. We discovered it was very useful to remove a large flake and then use that flake scar as a platform to remove other flakes. Such a process would explain the 69% of the primary decortication flakes lacking cortex on their platforms. In fact, two of the unidirectional cores look as if this may have been the method by which they were reduced. One flake was removed from the pristine cobble

Table 10. Correlation of Platform Character with Primary and Secondary Decortication Flakes from 34RM507.

Flake Type	Cortex Covered Platform	Partial Cortex Platform	Entirely Flaked Platform
Primary Decortication	13.2%	11.1%	3.5%
Secondary Decortication 75-95%	3.5%	22.2%	3.1%
Secondary Decortication 50-75%	6.9%	0.0%	6.5%
Secondary Decortication 10-50%	29.2%	55.5%	18.9%
Tertiary	47.2%	11.1%	68.0%



Figure 73. Examples of primary decortication flakes. All are of Ogallala quartzite. Their platforms are at the top.

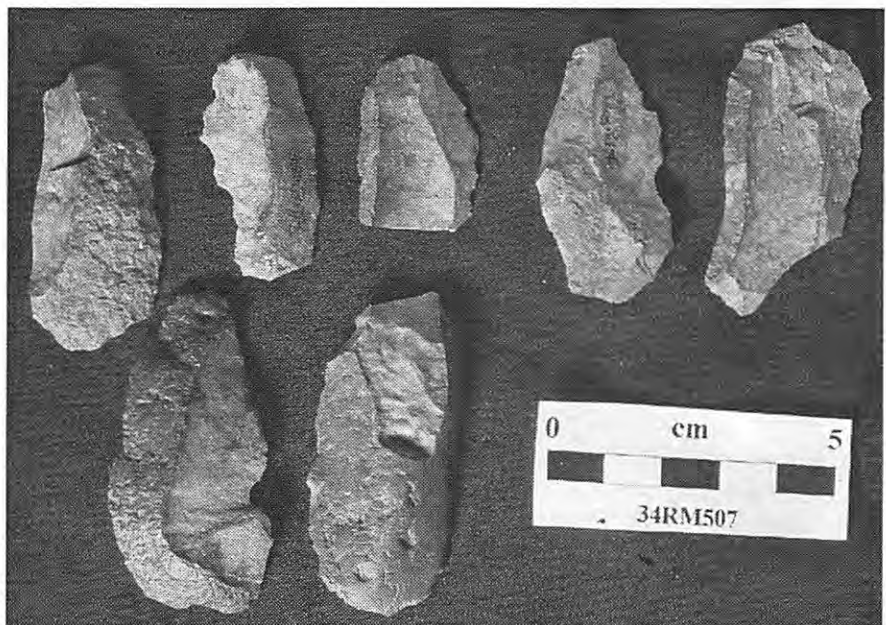


Figure 74. Examples of secondary decortication flakes. All are of Ogallala quartzite. Their platforms are at the top.

and then two or more flakes detached from the platform created by that flake scar. This may have been how many of the cores started out, but as other platforms were created the knappers utilized those too and therefore made multidirectional cores.

I hesitate to believe these people were removing all or most of the cortex from each cobble before transporting it back to the site. Many of the cobbles are not that large. Although I'll discuss the lengths of flakes and cores later, I think some of the primary decortication flakes are among the largest objects removed from the cobbles. These large flakes were important for tool making if one believes, as I do, that many flake and biface tools were made from flakes and not solely from bifacially flaked cobbles. Therefore, removing cortex to investigate the quality of the material, especially such variable material as quartzite, is only one reason so few primary decortication flakes were recovered. Many large primary flakes undoubtedly were made into bifaces and other

tools.

So few flake scars are evident on the primary decortication flakes and they are so small that I could not follow through with determining if the knappers were rotating the cobbles or cores one way or another. Most of the flake scars on the primary flakes appear to be failed attempts at removing first flakes from a cobble or from that particular chosen platform. However, the flake scars on the secondary decortication flakes may be helpful for this purpose, especially if the flake scars on the secondary flakes with more cortex show evidence they were removed earlier in the reduction process.

Secondary Decortication Flakes (Fig. 74). Of these, 64% have platforms, but only 9% of these have cortex on the platforms. These flakes have flake scars from the 2nd to the 6th sectors (Figure 72). I interpret these findings to indicate that the 34RM507 knappers were rotating their cores to the right (clockwise) while working them. Flakes with less cortex have

flake scars originating from more directions, but the majority are still between the 2nd and 6th sections. This makes sense because as the core is reduced there are fewer and fewer platforms available for producing functional flakes. Therefore, the knapper had to continually rotate the objective piece in more than one direction. It may also indicate that as reduction continued the cores were not rotated as much but flakes were continually removed from the same platform area (a majority of the flakes with less cortex have flake scars in the 1st and 8th sections).

Tertiary Flakes. The flakes considered as tertiary have from 0 to 10% cortex showing on their dorsal faces. Only 4% of these flakes have cortex on their platforms. Such a low percentage is expected given that tertiary flakes are removed during later stages of reduction. Some tertiary flakes with cortex on their platforms could result during early stage knapping. As primary and secondary decortication flakes are detached there are always a few small flakes removed as well. These would look like any tertiary flake resulting during late stage knapping except that they might have cortex on their platforms.

The majority of the flake scars manifest on the dorsal faces of the complete tertiary flakes originate from the 2nd to the 6th sectors, just like the secondary decortication flakes. Not only do 87% of the flake scars originate in this area but 68% also are detached from the platform (sectors 1 and 8). This may also be evidence that the knapper continued to rotate cores to the right, but there are still many flake scars that originate from the other sectors. Some tertiary flakes exhibit biface thinning flake characteristics. When these complete biface thinning flakes are taken into consideration, they follow the same pattern: 87% detached from the 2nd to 6th sectors and 62% from the platform (sectors 1 and 8).

Ridge Placement (Table 11). The occurrence of ridges on each flake's dorsal face is another clue to reduction strat-

egy. The studied ridges start at or near the flake's platform and continue down the length of the dorsal face. Ridges are excellent guidelines for knapping because they protrude slightly from the platform, creating a target area. Flake shapes are greatly influenced by these prominent ridges, and good knappers apply force at platform points near ridges in order to determine the size and shape of flakes they are removing (Faulkner 1972; Phagan 1980; Whittaker 1994:105-106). A ridge near the middle of a flake typically helps guide the fracture front during flake removal. Of the 2278 flakes, only 1329 were complete enough to determine where force was applied relative to a prominent ridge. I categorized the ridges according to their being at the middle, left, or right of the platform as I held the flake with the ventral face toward me. Some ridges were part of the natural surface of the cobble (see Fig. 73) and are considered natural. Some ridges were not strictly vertical, turning from one side to another; these were classified as middle-right or middle-left (M-R or M-L), right to left or left to right (R-L or L-R), or as right or left to middle (R-M or L-M; see Table 11).

When the flakes are divided by percentage of cortex amounts there are interesting results. Some 54% of the primary decortication flakes do not have ridges, and 25% of these have natural ridges in their middle, 12% natural left, and 2% natural right ridges. The remaining 7% of the primary decortication flakes have ridges on the left and middle, formed by small flake scars originating at the platform (as if from unsuccessful attempts to detach large flakes). These flakes followed natural ridges and then created new ridges that did not necessarily extend to the bottom of the core.

On the secondary decortication flakes the ridges fell into different categories relative to the amount of cortex on the dorsal face. Most ridges were in the middle, but some were on the left or right. Many flakes did not have prominent ridges, or I was unable to determine where they were relative to the platform. Overall, by the time they were detaching

Table 11. Prominent Ridge Placement Relevant to the Platform on All Flakes.

Ridge Orientation	Number	Percent of Total
Right	181	7.9
Left	217	9.5
Middle	419	18.4
Left-Right (L-R)	12	<1.0
Right-Left (R-L)	21	<1.0
Middle-Right (M-R)	16	<1.0
Middle-Left (M-L)	18	<1.0
Left-Middle (L-M)	11	<1.0
Right-Middle (r-M)	7	<1.0
Natural Right	4	<1.0
Natural Left	11	<1.0
Natural Middle	31	1.4
No ridge	298	13.1
Unknown	83	3.6
Not applicable	949	41.7

secondary decortication flakes the 34RM507 knappers were trying to create the largest flakes possible from the cobbles or cores. These would then be useful for making either bifaces or flake tools. Unfortunately, because much of the cortex is removed, the flake tools don't show a preference for ridge placement.

Complete tertiary flakes (those with 0 to 10% cortex) do not follow any of the above discussed patterns. Because these are tertiary flakes none have natural ridges. Moreover, 18% do not have a prominent ridge, but 40% have a ridge in the middle while 16% have ridges on the left and 17% on the right.

Overall, the ridges on all flakes tend to indicate the knappers focused on a centralized ridge when producing flakes throughout the reduction process. Central ridges may have been important for making the largest flakes possible, but that is not quite clear because flakes with natural ridges in their middle are often the largest flakes and they are primary decortication flakes.

A review of the lengths of flakes and ridge placement did not show a strong correlation about why knappers may have chosen to focus on ridges near the middle. Perhaps while the knappers tried to focus on a centralized ridge they struck the core at the wrong angle. Given the hardness of Ogallala quartzite, of which most of these flakes are, it is likely the platforms were not hit exactly where the knappers intended. I have done this many times.

Flake Terminations. The terminations on flakes are important clues to the knapper's ability to remove flakes (Andrefsky 1998:85-88; Crabtree 1972:64; Faulkner 1972:135; Muto 1971:58; Phagan 1980; Pond 1930:54). Feather terminations result when proper force has been applied at that contact spot on the platform and a flake is detached. Hinge and step terminations are the result of insufficient force or not enough force contact time. Overshot ter-

minations result from sufficient to excessive force applied too far back from the platform edge (Faulkner 1972; Whittaker 1994:106-111). Force application is not the only factor affecting terminations. Flaws in the material adversely affect the fracture path, often contributing to hinge and step terminations. As noted several times, the quartzite found in the Ogallala gravels has noticeable texture changes and coarse inclusions, and these inconsistencies help promote step and hinge fractures.

With the above information one would expect that many of the flakes, and especially the larger ones produced early in the reduction process, would have step and hinge fractures. I should note I had difficulty distinguishing step fractures from post-knapping breakage (i.e., from trampling), so many step fractured flakes eventually were classified as unknown. After recording terminations I discerned that 28% of the flakes had feather terminations, 7% hinge, 2% step, 2% overshoot, and 61% were unknown (Fig. 75).

The largest categories are, respectively, unknown and feather terminations. The tertiary flakes especially have a very high percentage of unknown terminations, again some due to step fractures as well as likely trampling breakage. Also, the tertiary flakes tend to be the thinnest, since they are removed later in the reduction sequence and many are probably bifacial thinning flakes. When thinning bifaces with soft hammer the flakes detach so fast that they break in the slight bending of the almost non-elastic stone.

Another interesting finding is that flakes with 75-95% and 95-100% of cortex on their dorsal surfaces have a higher percentage of hinge terminations than the other flake categories. This could result from hitting the platform too far in and without enough force while trying to produce large flakes. As noted, detaching large flakes from Ogallala quartzite cobbles and cores is not easy, but when you do get them they make excellent blanks for thin bifaces and flake tools.

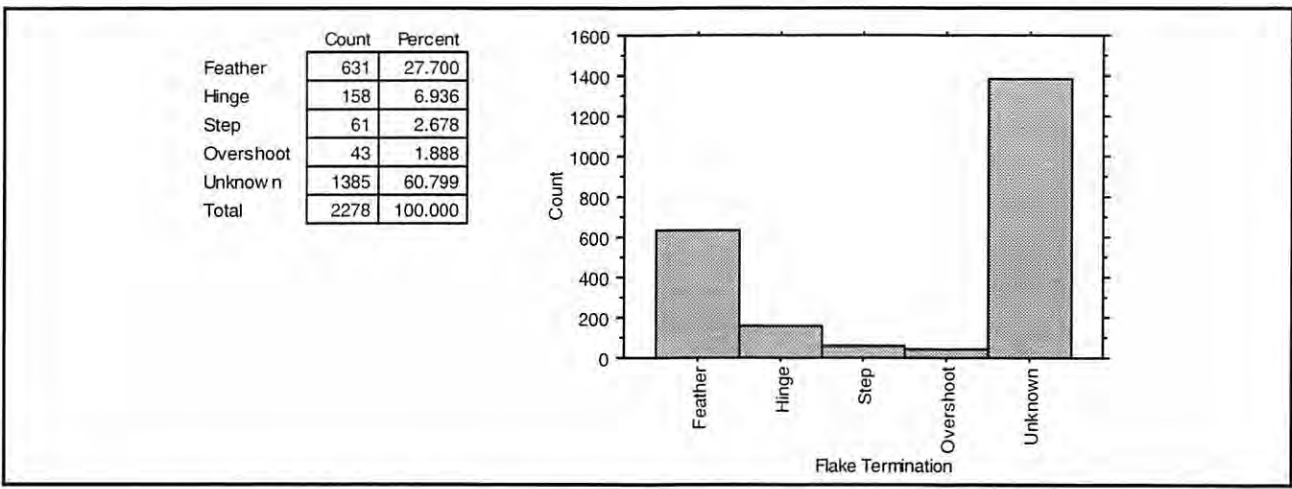


Figure 75. Kinds and quantities of terminations manifest on flakes from site 34RM507.

Overview Thoughts and Final Studies

I have now determined that the knappers at 34RM507 tended to rotate cobbles and cores to the right (clockwise) and that prominent ridges only sometimes were important landmarks as they knapped adjacent platforms. Knappers that did look for prominent ridges preferred them close to the striking point on the platform, resulting in flakes with ridges running down their center. Also I have found that they were not preparing flaked platforms through all the reduction sequence. Cortex on the platforms occurs on primary and secondary decortication flakes as well as a notable number of tertiary flakes. When platforms were prepared it was typically done by removing a large flake and using that flake's concave scar as the platform surface. This was commonly done early, as manifest by the large flakes with non-cortex (flaked) platforms. Many of the flakes are broken, but among the complete examples most have feather terminations. Such indications of proper application of force only reinforce my appreciation of the ability of this site's knappers. Finally, I do need to assess what the sizes of flakes tell us about the parameters of the cobbles and cores being worked.

Flake Sizes and Objective Pieces. To assess the size of cobbles being worked, the primary decortication flakes and my secondary decortication subclass A flakes (those with 75-95% cortex on their dorsal surfaces) are the obvious materials to study since they came off cobbles earliest in the reduction sequence. These flakes are, respectively, 0.9 to 11.5cm and 0.6 to 8.7cm in length. Surprisingly, these secondary decortication flakes are larger than some of the primary decortication flakes. But I think this is because many of the primary flakes were removed to set up platforms for the detaching of large flakes, many of which were secondary decortica-

tion flakes. To confirm this I assessed the number of flake scars found on the secondary decortication subclass A flakes (Fig. 76). Most of these secondary decortication flakes exhibit one to two flake scars on their dorsal faces, showing they were removed during early stages of unidirectional or multidirectional cores.

With the length of the complete flakes recorded it is appropriate to look at the length of the cores. I would expect the cores to be longer than the flakes, yet not too much longer since they have been reduced enough to display little cortex. Clearly, they have already had their longest flakes removed. When I recorded the cores I looked at the maximum linear dimension (MLD; Fig. 77), but a flake is not necessarily going to carry across the core's entire surface so I also took the measurement of the longest complete flake scar (Andrefsky 1998:139, 144). My compilations of these two sets of measurements are illustrated in Figure 78. When compared, it is clear the lengths of the complete flakes approximate those manifest by the longest scars on the cores. This could mean one of two things: that the larger flakes removed from cores were detached at the cobble source or that the larger flakes were made into implements. To see if this latter was the case, I examined the lengths of the retouched flake tools and bifaces. Figure 78 shows comparisons of these lengths. Many are closer to the length of the longest scar on the core faces. Because much of the mass of the original flake or cobble has been removed from bifaces, it is possible that some of these may have been large primary flakes. But many of these large flakes may have been removed at the cobble source locations. A problem with this idea is apparent in the archaeological record. A cobble source (Fig. 4) is near Area A of the site, but very few flakes and tested cobbles (that were obvi-

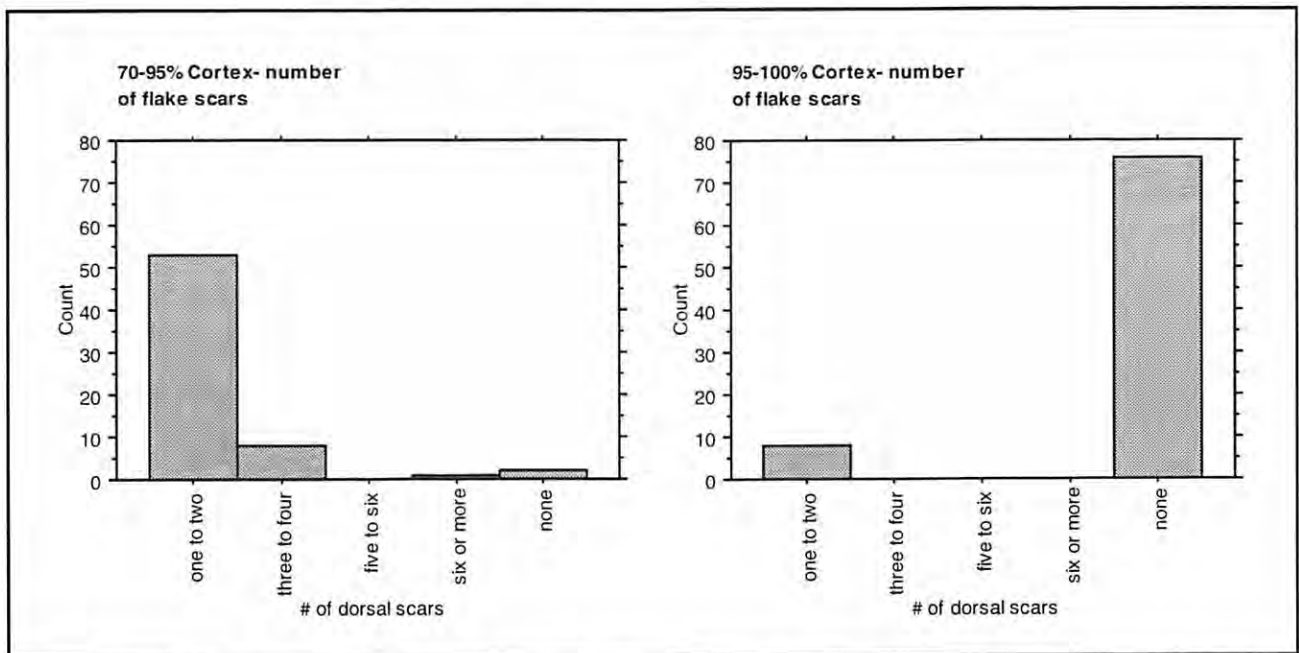


Figure 76. Comparison of numbers of flake scars on the dorsal faces of secondary decortication flakes subclass A (left) with those on primary decortication flakes (right).

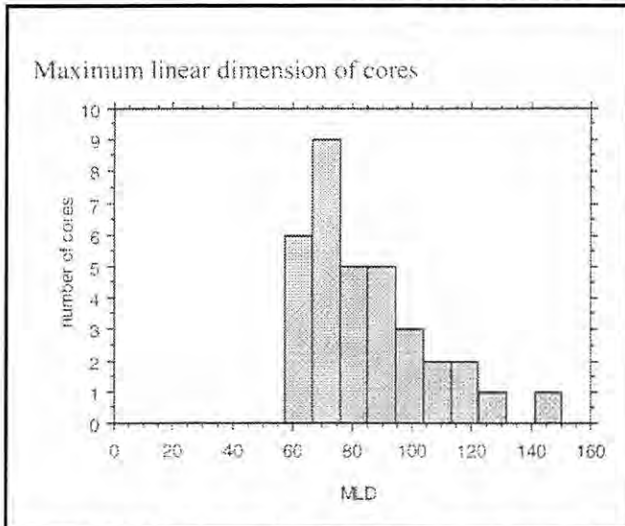


Figure 77. Maximum linear dimensions of cores from 34RM507.

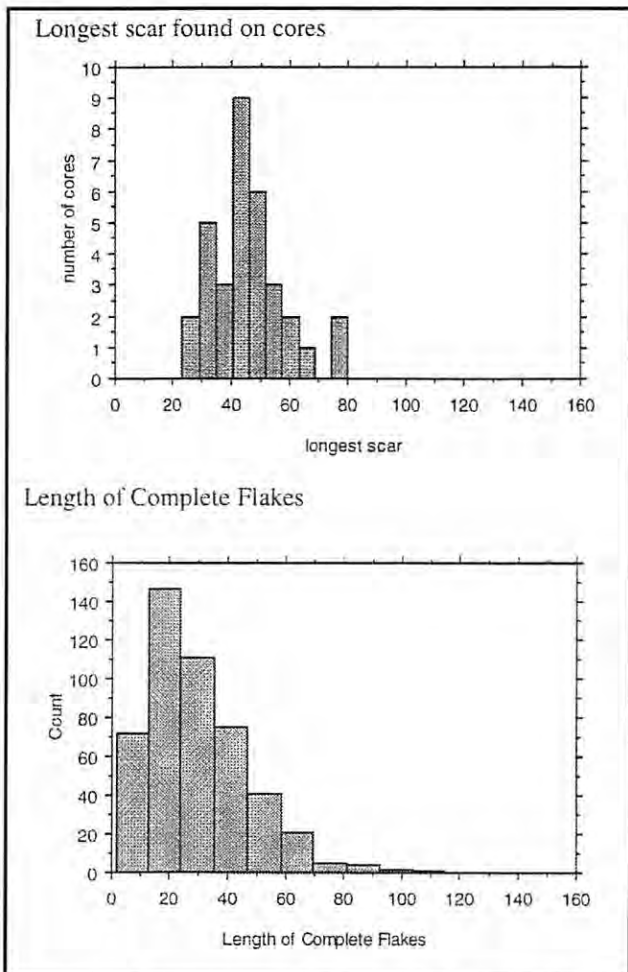


Figure 78. Comparison of lengths of flake scars on cores with lengths of complete flakes from 34RM507.

ously rejects due to their poor material quality) were observed at this gravel exposure. Possibly the site's inhabitants exploited another gravel outcrop, but they more than likely used the deposit nearest their camp if it was exposed when they

were here. Therefore, I contend that many of the large primary decortication flakes missing from the collection were made into bifaces. Some of these bifaces were broken during production, whether during heat treatment or actual knapping (end shock?) while others were completed and removed from the site when these Late Archaic hunters moved to a new camp. The lengths of the three complete flake bifaces range from 7.12 to 8.16 cm which is near the lengths of the larger primary and secondary decortication flakes that can be documented here.

The complete and broken bifaces from 34RM507 indicate that this site was not just a habitation camp but was also a tool-making location. Many of the bifaces in the collection seem to be rejected unfinished products or expended finished tools that were left behind. To gain some better understanding of the biface preparation that was taking place here I looked at biface thinning flakes from the site. Only 49 complete and 80 broken biface thinning flakes are identified. Six other flakes are possible biface thinning flakes. The complete biface thinning flakes comprise only 2% of the collected flakes, and the broken flakes represent only 3.5%. Bifacial thinning flake attributes include thin or diffuse bulbs of force, lipped platforms, signs of platform preparation, and a very acute exterior platform angle (Callahan 1979; Wyckoff 1992:90-91). Soft hammers are necessary in biface thinning, and the resulting flakes are thinner and wider than those produced with hard hammer (Andrefsky 1998:114-119; Bordes and Crabtree 1969:243; Cotterell and Kamminga 1987; Crabtree 1972:74; Wyckoff 1972). All of these attributes were recorded and are discussed below.

Flakes that I believe were produced with soft hammer comprise 33% of the collection, hard hammer flakes 25%. Unfortunately, 42% of the flakes lacked their platforms and could not be assigned to either category. As I recorded attributes for each flake, at least two attributes indicative of soft hammer had to be manifest before I would assigned to that class. Among those considered as soft hammer flakes, 78% were tertiary; that is, they had from 0 to 10% cortex on their dorsal faces. Notably, only 47% of the hard hammer flakes were tertiary. These percentages correlate with biface thinning being part of later stages of lithic reduction.

Identification of soft hammer flakes depended on the slight prominence or absence of bulbs of force, usually in combination with signs of platform preparation and overhanging lips on the ventral face (Andrefsky 1998:18-20; Frison 1970; Speth 1972:41-42; Whittaker 1994). I also examined exterior platform angles, platform thicknesses, platform widths, and maximum thickness, width, and length of flakes. These attributes and variables were compared with how I categorized flakes as products of either hard or soft hammer. Only 10% of the flake collection had lips; 48% lacked evidence of lips. Those without bulbs or with very diffuse bulbs may be considered as possible soft hammer flakes, even if they did not have lipping on their platforms (Fig. 79).

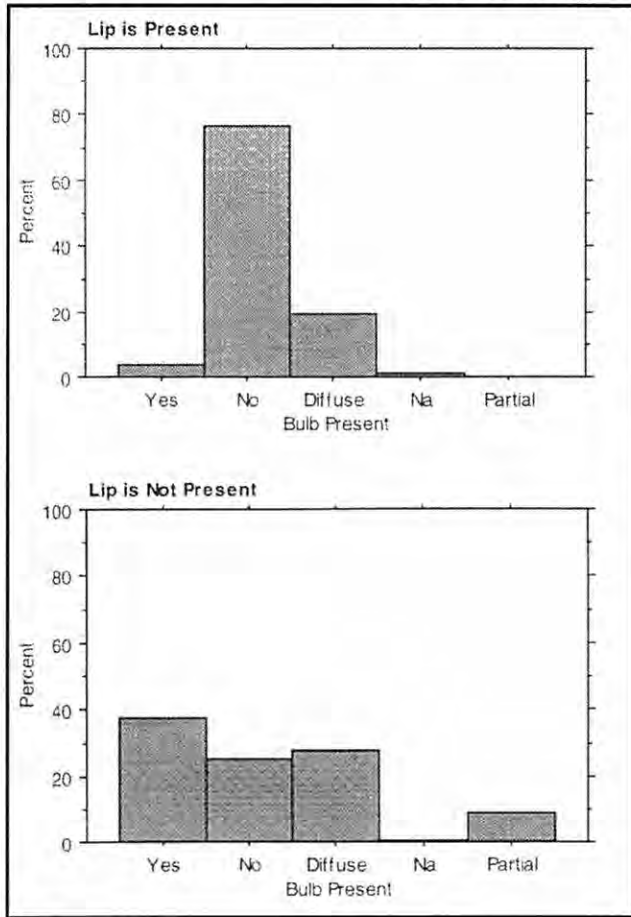


Figure 79. Flakes with lips that either lack or have very diffuse bulbs of force.

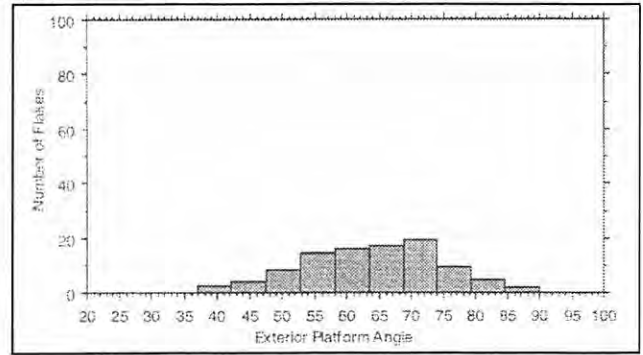


Figure 81. Exterior platform angles and their quantities as determined from measurable flakes.

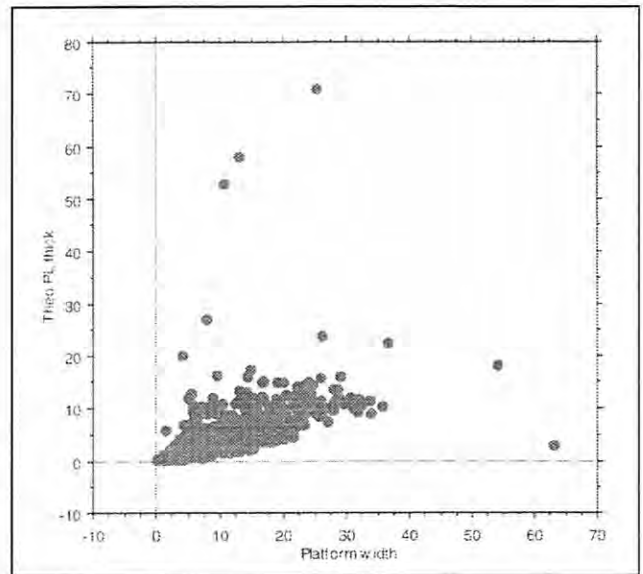


Figure 82. Correlation of platform widths with Theoretical Platform Thicknesses on measurable flakes from site 34RM507.

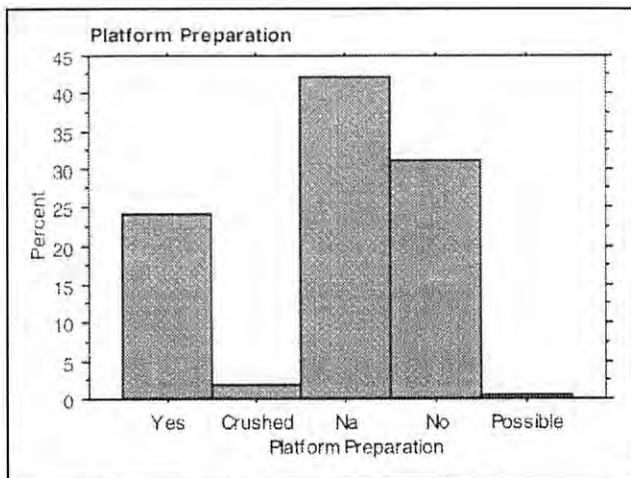


Figure 80. Amounts of different kinds of platform preparation found on complete flakes or those with intact platforms.

Platform preparation is another important attribute for identifying biface thinning with soft hammers (Crabtree 1972:84; Whittaker 1994:98-104). Some 24% of the flakes have prepared platforms, whereas <1% have possible preparation and 31% have no preparation visible on their platforms (Fig. 80). Another 2% have platforms that were crushed (Fig. 80). Crushed platforms can occur during both hard and soft hammer reduction when the platform is hit several times in an effort to detach a flake. Crushed areas are visible on some of the bifaces from this site. So, how do we interpret the above findings? I believe these findings show that soft hammer percussion was an important approach to working stone at this site. The small percentage of lips may have to do with the kind of material worked. Platform preparation was very hard to ascertain, but abrasion and scrubbing was identifiable as well as platform crushing. Most of the bifaces manifest small step terminations along their edges; these most likely result from the repeated blows required to remove thinning flakes. As we tried to replicate knapping of quartzite

cobbles we commonly had to use several blows to remove large flakes, sometimes even flakes of any size! Step terminations were common on our products, and they are visible on the implements from site 34RM507. Not all flakes classified as soft hammer in origin displayed all attributes associated with such force application, but the numerous bifacially flaked objects described for the site certainly demonstrate that biface knapping was an important process at the site.

Platform angles or exterior platform angles (Pelcin 1996:102, 120; 1997a; Witthoft 1957:17) play an important role in the successful detachment of flakes as well as in the size of the flakes. Such angles relate to the angle in which a flake is detached from a core or biface, and lower platform angles are often associated with the use of soft hammers in the thinning of bifaces. A number that is a baseline, but not necessarily the best number to identify biface thinning flakes is 45 degrees. Flakes with exterior platform angles below 45 degrees are considered biface thinning flakes, and these usually have lipped platforms (Figs. 79 and 81). Like the quantity with lips, the number of flakes with preserved exterior platform angles are minimal. Most likely, this is again the result of attempting to bifacially thin Ogallala quartzite.

Finally, platform variables like width and thickness (Theoretical Platform Thickness; Pelcin 1996, 1997a, 1997b) are important to identifying kinds or stages of lithic reduction. The larger these measurements are, the more likely the flakes were detached with hard hammer (Fig. 82). This also relates to the general size of the flake. Biface thinning flakes are usually wider than hard hammer flakes of similar length.

It is important to remember that I categorized these as soft and hard hammer flakes as I was recording the above attributes (bulb character, lip, platform width, flake thickness, etc.) and in combination with my personal experience while knapping Ogallala quartzite. I believe that a blind test with Ogallala quartzite would be an excellent way to determine if my conclusions are valid. In lieu of that, I am confident that biface thinning was taking place at 34RM507. The evidence is in the number of unfinished and broken bifaces at various stages of reduction and in the quantity of debitage that I have tried to show originated from such reduction.

Summary

The occupants of site 34RM507 knapped many kinds of tools but left mostly debitage, broken bifaces, and expended tools behind. From the number of artifacts recovered here, one can just imagine how many tools they made. It may be that these quantities reflect them returning to this location several times over a few years to exploit the nearby gravel deposit or others exposed in the neighborhood. From my preceding analyses I believe these people were undertaking several tracks in reducing Ogallala quartzite. I offer Figure 83 as a visual model of these tracks.

I believe this was more than just a retooling camp. They

undoubtedly stayed here for more than a few days. Why else would they have made the varied flake tools we recovered? It certainly involved more than making projectile points. Tool edge angles are potential clues to the varied tasks undertaken prehistorically. Generally, tools with more acute edge angles are good for cutting items that are soft, whereas implements with larger edge angles are more functional for scraping, chopping, and other rough tasks (Andrefsky 1998:154-155). I separated the 141 tools from this site into two categories: those with edge angles between 30 and 60 degrees and those with angles exceeding 60 degrees. I found that 57% of the tools had edge angles of 30 to 60 degrees; 43% had edge angles greater than 60 degrees. With this information, plus that found in the discussion of the tools, I conclude that many tasks were undertaken by this site's occupants. Food preparation has to be considered, and some of the implements from here most probably were made by women. Cat tails, berries, and nuts probably were locally available. Notably, only one grinding stone was recovered, but others may be in other parts of the site or washed down Higgins Creek.

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Figure 83.

On the following two pages is illustrated a graphic flow chart showing the reduction sequence for Ogallala quartzite as manifest by artifacts recovered from site 34RM507. This is a somewhat abbreviated model because space doesn't allow for a full depiction of all products and byproducts made by this site's occupants some 1900 years ago. However, it conveys some of the major products evident from the analysis discussed on the preceding pages. Generally, as one moves from left to right objects are smaller, thinner, and manifest more flake scars, especially narrow ones that could result from pressure flaking. The chart starts on the left side of page 80 where cobbles of Ogallala quartzite manifest varying degrees of flake removal. Basically, three strategies were practiced: flakes were removed, undoubtedly with hard hammer, from several directions (top left), from one direction (center left), or were bifacially removed (mainly from more tabular cobbles, such as lower left).

Large primary and secondary decortication flakes were prevalent products from the different kinds of cores. Some of these large flakes were suitable for making bifaces (top track), whereas others were made into diverse flake tools like graters, gouges, and scrapers (several tracks in the center). Non-cortex (or tertiary) flakes, if large enough, could be blanks for scrapers, flake knives, and possibly even projectile points. Soft hammer percussion and pressure flaking are more evident in the making of objects on page 81.

Several Ogallala objects display reddened coloration and a semi-glossy sheen: a biface, a projectile point, and an end scraper in the figure. These objects are considered to be evidence that Ogallala quartzite was heated, probably rather late in the process of producing large flakes and bifacially flaking them.

The biface cores served as sources for usable flakes, but some evidence indicates such cores were being thinned into more finished blanks for bifacially flaked tools. Soft hammer percussion was likely integral for this track (bottom row).

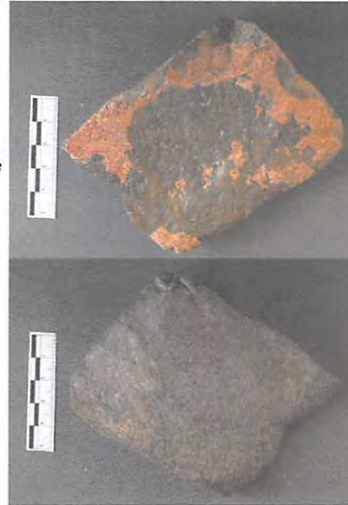
Gaps in our understanding of the techniques and processes result from notable segments of the production not being recovered, undoubtedly due to the prehistoric people carrying off finished products.

All products made from flakes have their platforms at the top. All scales are in centimeters.

Multifaceted core



Large Primary Decortication Flakes



Flaked into a Biface



Unifaceted Core with Flaked Platform

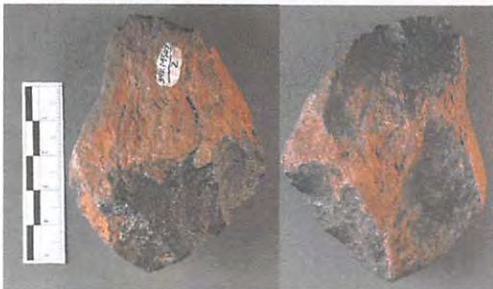


Primary and Secondary Decortication Flakes



Bifacially Flaked Cobble

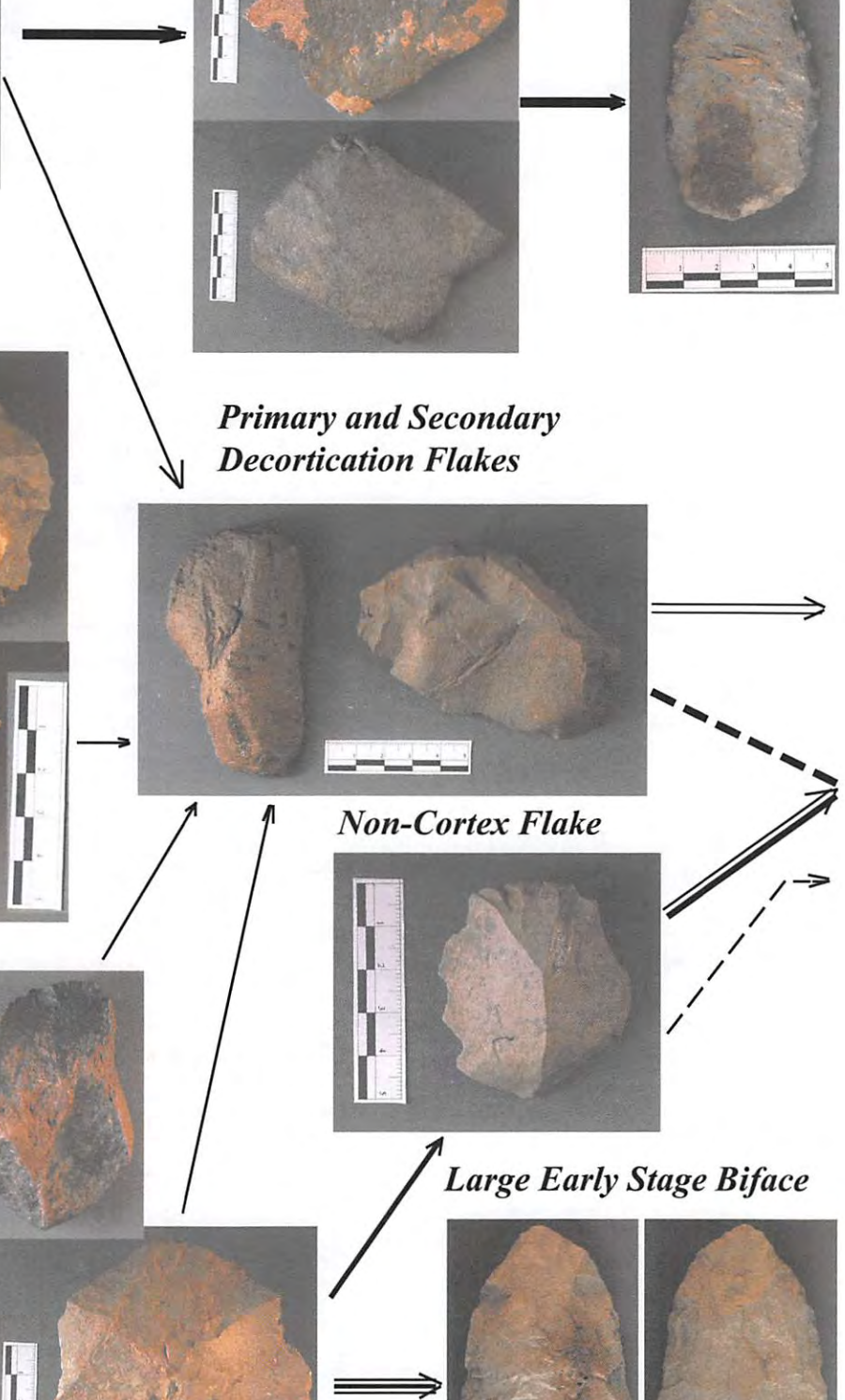
Non-Cortex Flake



**B
i
f
a
c
e**



Large Early Stage Biface



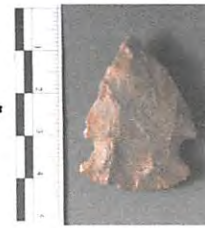
(Opposite Face)



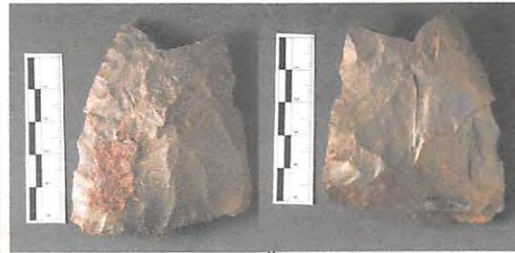
Biface from Flake (Heat Treated?)



Projectile/Knife (Heat Treated?)



Flake: Extensive Bifacial Flaking



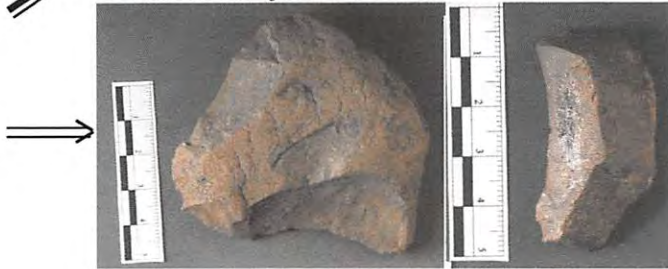
Projectile/Knife from Flake



Flake: Initial Bifacial Flaking



Gravers made from Decortication Flakes



End Scraper (Heated Decortication Flake)



Flake Tool Category 3a



Flake Tool Category 3b



Gouge from Decortication Flake



Biface Blanks



Site 34RM507 in Other Perspectives

Karin J. Rebnecker, Don G. Wyckoff, and J. Peter Thurmond

To really appreciate this site, it should be compared with other Late Archaic sites in the region. Among those for which there are detailed reports are Twilla, Bell, Collier, Little Sunday, Certain, Sitter, Strong, Finch, Lake Creek, and Beaver Dam (Fig. 84). These sites have similar styles of projectile points (Figs. 85 and 86), other similar tools, and manifest an extensive use of Ogallala quartzite (see references cited with Figure 84).

Some measurements of projectile points were recorded from these sites and compared with projectiles found at 34RM507. The results are interesting because the 34RM507 points are smaller, whereas the range of bifacially flaked artifacts from 34RM507 is greater than manifest at these other sites. Figure 87 shows the thickness and width of bifaces (projectile points to biface failures; see Fig. 50) from 34RM507 plotted in a scattergram. In contrast, Figure 88 is a scattergram of the biface thicknesses and widths from 34RM507 com-

pared to those from Twilla, Bell, Collier, Little Sunday, Certain, Sitter, Strong, Finch, and Lake Creek. The pattern is the same with a heavy concentration on the projectile points. If the artifacts are separated out by site, then it is obvious that three of the sites have a wider range of biface stages (Fig. 88). Little Sunday, Bell, and 34RM507 have a wide variety of bifacially flaked tools, many more than the other sites compared. This variety included biface failures, larger bifaces, and blanks. Does this mean that bifaces were manufactured at these sites? Clearly, that is implied by the presence of large, wide biface sections which most probably represent stages of making finished bifaces like knives, preforms, and projectile points. But without analysis of the debitage from these sites this implication remains unverified. However, it is possible that Little Sunday, Bell, and 34RM507 were either occupied longer or had more tasks undertaken there than the other sites. These were not just bison kill sites. Late Archaic people most likely stayed there for a while, at least to butcher the bison and

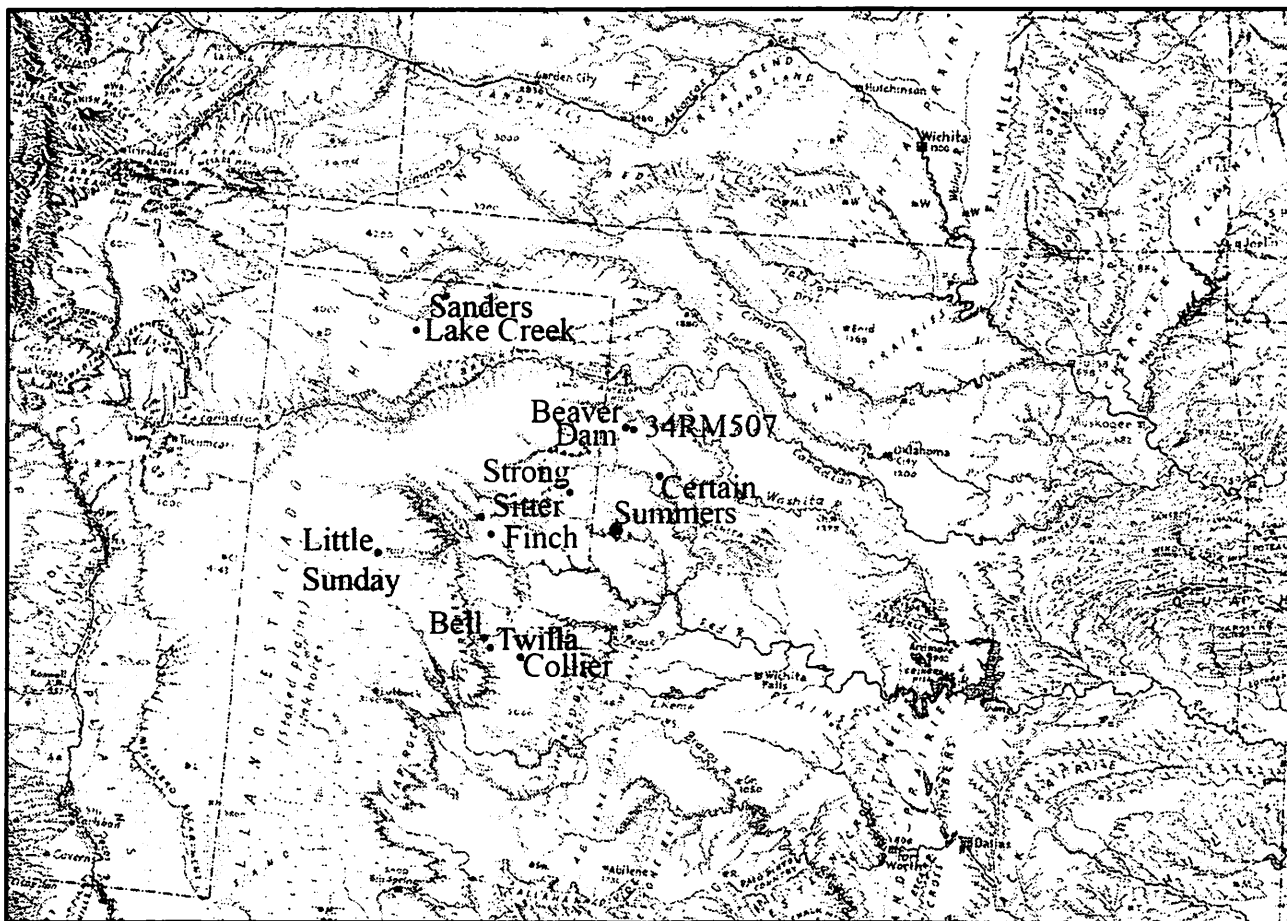


Figure 84. Late Archaic sites with material culture assemblages like that recovered at site 34RM507. Key references for these sites may be found in Bement and Buehler 1994; D. Hughes 1977, 1989; J. Hughes 1955; Kraft 2005; Leonhardy 1966; Quigg et al. 1993. Map adapted from Raisz 1957.



Figure 85. Projectile points/knives recovered from the Twilla site in the Texas panhandle. Photo courtesy of Pete Thurmond and the Panhandle-Plains Museum of Canyon, Texas.

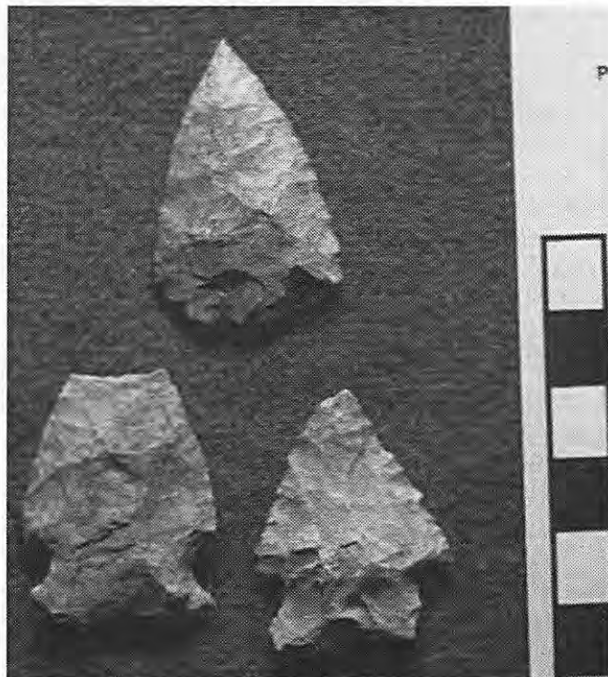


Figure 86. Examples of Ogallala quartzite projectiles recovered at the Beaver Dam Site (34RM208). Scale in centimeters. Photo courtesy of the Sam Noble Oklahoma Museum of Natural History.

prepare hides.

As we see at 34RM507, remarkable landscape changes were occurring around 2000 years ago. With so much erosion and rapid deposition, habitation areas near sites like Certain, Strong, and Twilla may now be gone or deeply buried. Hopefully, this analysis of 34RM507 provides a basis for better comparing and assessing how Late Archaic groups were adapting to the dynamic conditions of their time. At the very least, the findings presented herein should be useful for making better comparisons of the camps and kill sites left by these people.

A Local Archaeological Perspective

From another perspective, site 34RM507 should be viewed from its relationship to three other sites within 300 yards of it (Figs. 89 and 90). In particular, site 34RM334 sits on the valley floor just across the gully from 34RM507 (Figs. 89 and 90) and has yielded mainly Ogallala quartzite flakes along with some tools (Fig. 91), including segments of Ensor and Palmillas style spearpoints (Thurmond 1991:145). Four radiocarbon dates on hearths exposed at 34RM334 indicate occupations occurred there between A.D. 295 and A.D. 580 (Thurmond 1991:Table 2). Site 34RM470 is just upstream (south) and across Higgins Creek from 34RM334 (Fig. 89).

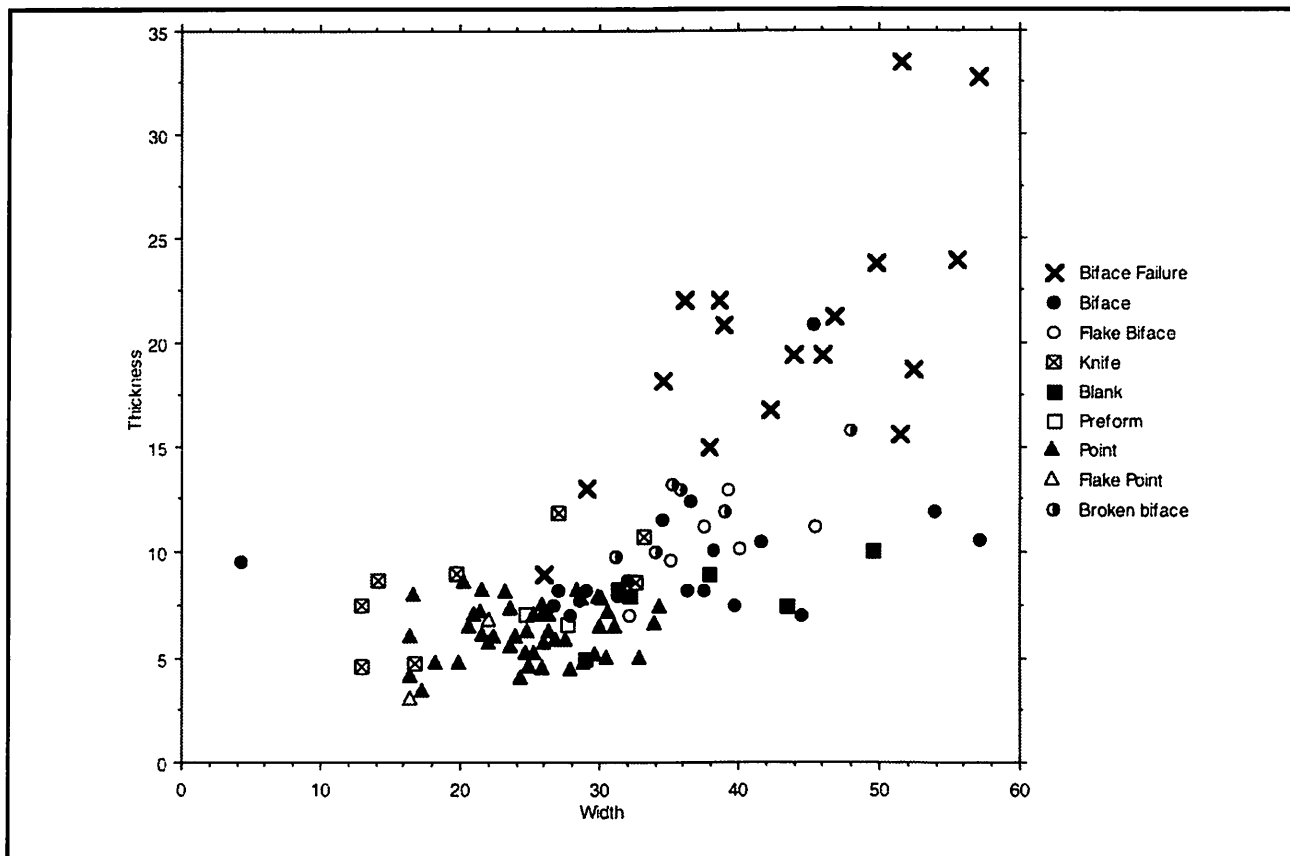


Figure 87. Thicknesses and widths of the various biface categories recovered from site 34RM507.

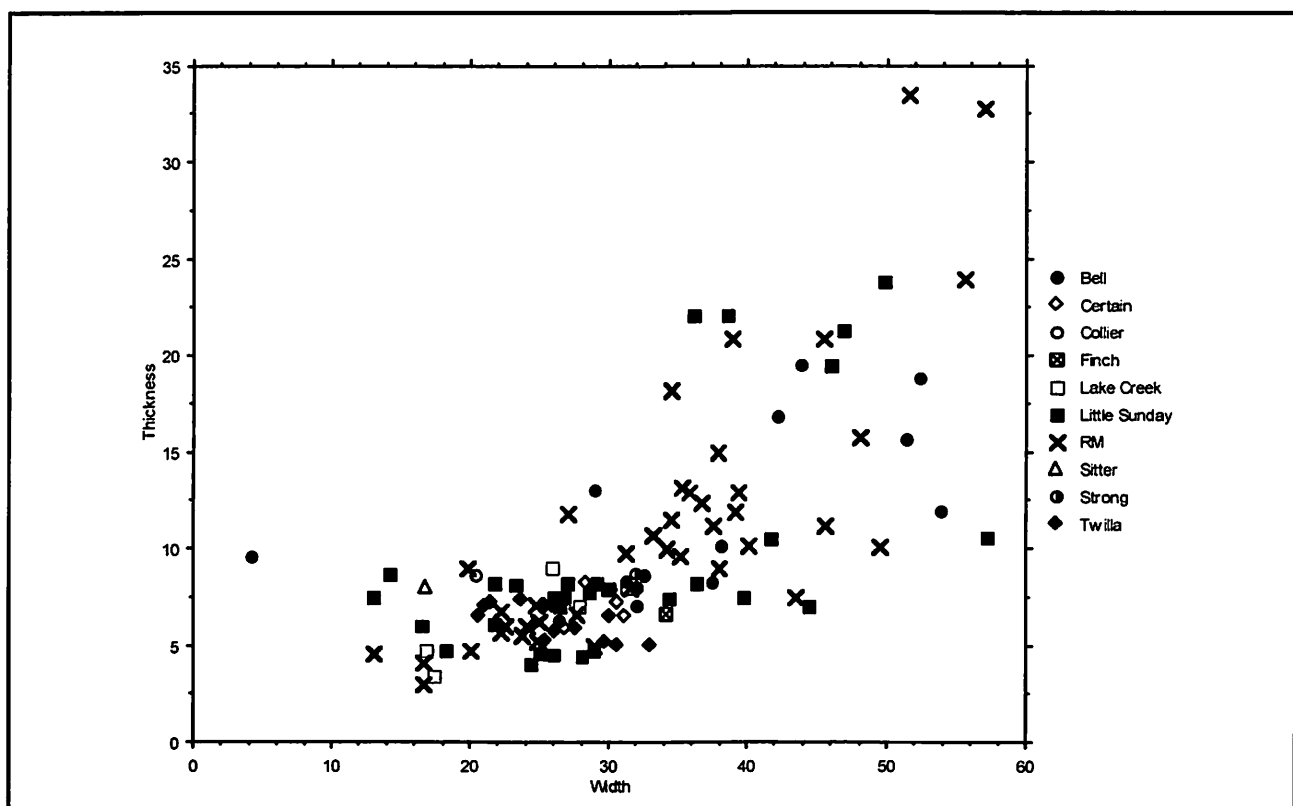


Figure 88. Thickness:width correlations for all biface categories from the Twilla, Bell, Collier, Little Sunday, Certain, Sitter, Strong, Finch, Lake Creek, and 34RM507 sites.

An Ensor point from 34RM470 typologically links it with 34RM507 as does a prevalence of Ogallala quartzite debris, including "numerous biface failures: (Thurmond 1991:147). Finally, on an eroded knoll of Permian bedrock west of, and across Higgins Creek from, 34RM507 (Fig. 90) occurs site 34RM812 where a lagged-out exposure of Ogallala gravel contains tested cobbles and the resulting flakes. Although

no time or culture diagnostic artifacts have been found here yet, site 34RM812 clearly was a source for the kinds of knappable stone observed and recovered at sites 34RM334, 34RM470, and 34RM507.

Regrettably, detailed lithic technological studies have not been undertaken of the artifacts from all four of these sites.

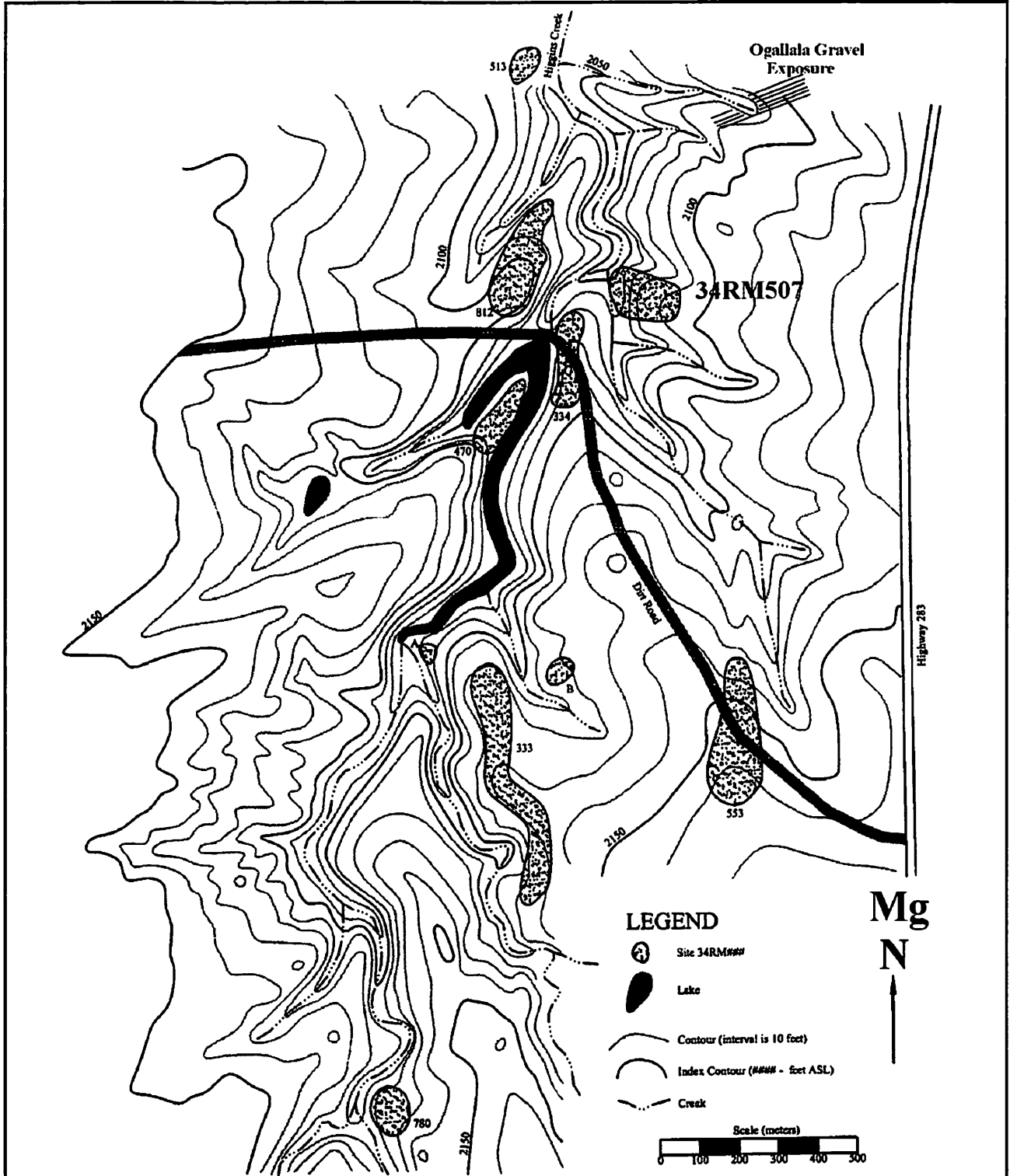


Figure 89. Location of site 34RM507 relative to other archaeological sites manifest along the upper segment of Higgins Creek, Roger Mills County, Oklahoma.



Figure 90. View west from Area B of archaeological site 34RM507. Sites 34RM334 and 34RM812 are shown on the nearby settings along Higgins Creek. Site 34RM470 that is mentioned in the text is off the picture's left side.

But their proximity to each other and their shared diagnostic projectile points (where present) are clues that these four locations are related. We believe that rather than representing four separate sites they are actually different activity areas used by the same people. It is not difficult seeing a

band of hunter-gatherers frequenting this location from time to time because of its water, wood, shelter, exposures of knappable stone, and easy accessibility to grasslands where bison might be found.

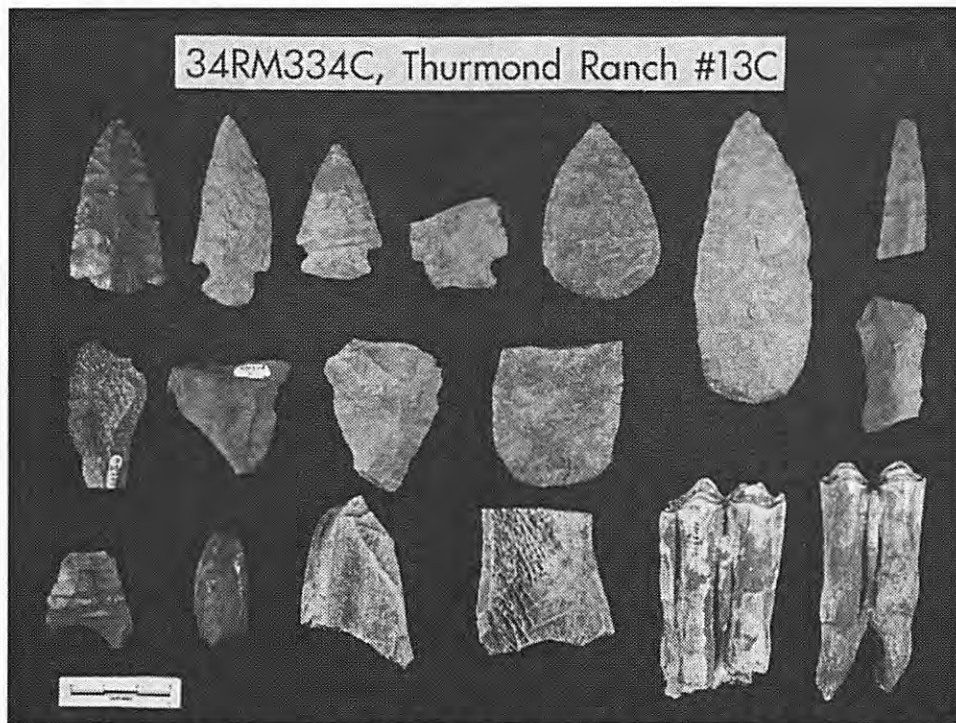


Figure 91. Artifacts from site 34RM334C: finished and unfinished bifaces; flake scrapers, knives, and graters; and bison skeletal parts. Scale is in centimeters. Photo by J. Peter Thurmond.

The setting at 34RM507 contrasts markedly with such contemporaneous, nearby sites as Beaver Dam and Certain (Fig. 84). Located only four miles west-southwest, the Beaver Dam site is a multiple component, open camp adjacent Brokenleg Creek (Fig. 92). Remnants of the camp contemporaneous with 34RM507 are buried two to three meters in alluvium and colluvium (Fig. 93), the latter coming from the adjacent steep (5 to 20% slope) hillsides covered with loamy sand and gravel derived from the Ogallala Formation. The Late Archaic component at Beaver Dam consists of several rock-lined hearths, a flexed burial, various chipped or ground stone implements, and a few plant (cheno-ams, marshelder, bulrush, purslane, etc.) and animal (deer, bison, some small mammals, and mussels) remains (Kraft 2005:271-281). The diverse plants and animals used by the hunter-gatherers at Beaver Dam largely attest to this site's location in a deeply incised valley on the north edge of the Dempsey Divide, the high, dune-capped ridge that lies between the Washita River valley and that of the North Fork of Red River (Thurmond 1991).

As a camp, the Beaver Dam location afforded its occupants access to the diverse plant and animal resources present among the mixture of grassy glades and shinnery oak on the uplands of the Dempsey Divide as well as to knappable stone (Ogallala gravels) exposed along the valley slopes, and to

the potable water of spring-fed Brokenleg Creek (Fig. 92). Such resource diversity would not have been so evident around site 34RM507. More than likely, these two sites are at locations frequented at different seasons. Beaver Dam would have been ideal as a winter camp with its flowing water, firewood, southern aspect (for solar warmth), and protection from cold north winds. In contrast, the location of which 34RM507 is a part would position Late Archaic groups in the grasslands where bison herds could be spotted, tracked, and hunted. Consequently, this location's use was likely in the fall when bison were prime from summer grazing.

Some 20 miles east-southeast of site 34RM507 is the Certain site, a Late Archaic bison kill of major proportions. Tests and sizeable excavations reveal at least nine areas where partially to completely dismembered bison skeletons occur (Bement and Buehler 1994; Buehler 1997; Kraft 2005). Accompanying these remains are occasional spearpoints of Late Archaic style and frequently of Ogallala quartzite. Other tools are rare although resharpening flakes are reported (*ibid.*). Typically, these finds are in ancient arroyo settings that are now completely filled and buried, mostly by colluvium. Today, these finds are two to three meters below the ground surface (Fig. 94). Exposure of this site was by historic erosion, mainly gully cutting that at places is more than 30 feet below the surface (Fig. 20).



Figure 92. View north of the Brokenleg Creek drainage on the north side of the Dempsey Divide. Note the mixture of shinnery and grass in the foreground, which is underlain by the Ogallala Formation. In the background the short grass prairie is evident on soils formed from Doxey shale. The Beaver Dam site is at the base of the canyon-like valley at the far left. Photo by J. Peter Thurmond.

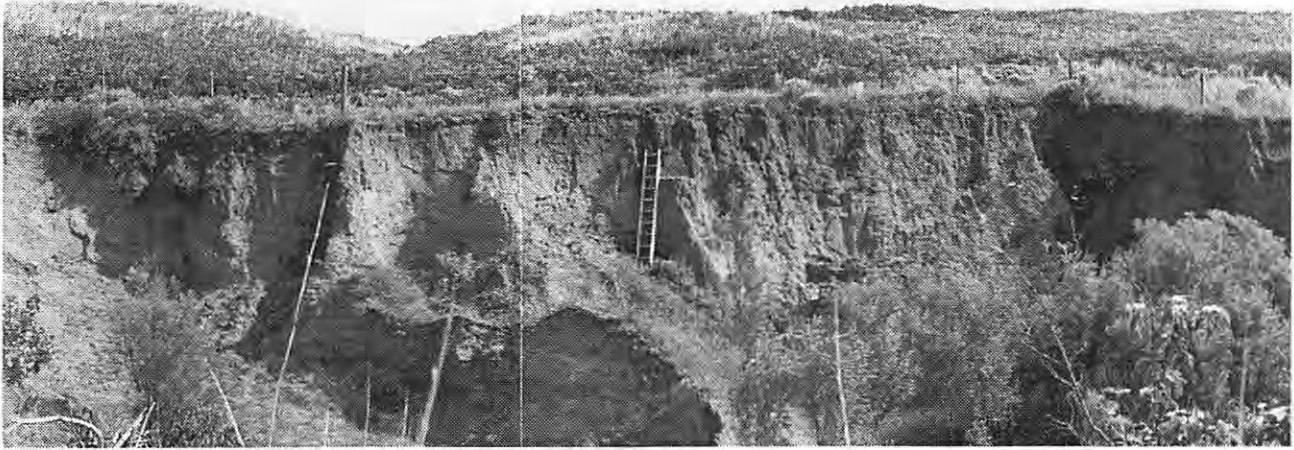


Figure 93. View north of profile at the Beaver Dam site (34RM208) with remnant Ogallala Formation sand and gravel on uplands in the background. A burned rock hearth has eroded out to the right of the ladder: Photo by J. Peter Thurmond.

Like the Beaver Dam site, the Certain bison kill site is on the eroding north edge of a ridge capped with Ogallala Formation sediments and gravels. This ridge is a little lower than that of the Dempsey Divide but could be viewed as an extension of that landform (Thurmond 1991). It is easy to envision Late Archaic hunting bands moving east and west on these uplands in search of game.

Most of the bison killed at Certain are believed to have been driven up multi-fingered arroyos to nickpoints where, trapped by nearly perpendicular walls, they were speared from above (Buehler 1997). However, one location yielded clues argued to be evidence that bison were driven over the edge of a deep gully (Green 2002). Tooth eruption patterns of bison mandibles implicate that the Certain site was a heavily favored fall hunting location (Buehler 1997; Kraft 2005).

If the seasonality interpretations of human presence at 34RM507, Beaver Dam, and the Certain site are correct, then the Dempsey Divide was indeed a busy setting during Late Archaic times. And, as has been noted for earlier hunter-gatherers in this area (Thurmond and Wyckoff 1999), these east-west trending ridges were easily traveled routes out to the Southern High Plains. There, we know that Late Archaic groups were also successfully taking bison (Fig. 84).

Late Holocene Landscape Dynamics along the Dempsey Divide

Archaeological sites 34RM507, Beaver Dam, and Certain inform us about Late Archaic people's adaptive strategies and lifeways. They likewise provide evidence of notable geomorphic processes occurring along the Dempsey Divide between roughly 2000 years ago and the present. These processes clearly impact archaeological site preservation and contextual integrity in different ways depending on the site's location in the landscape. These processes also can be linked to climatic fluctuations that have occurred over the past 2000 years.

From the available radiocarbon dates, the Beaver Dam, Certain, and 34RM507 sites were being frequented by spear-using late Archaic groups between A.D. 100 and A.D. 300 (Buehler 1997:Table 1; Green 2002; Kraft 2005). At that time the occupation surface at Beaver Dam was nearly eight feet below the historic surface (Fig. 93). The former surface must have been close to that of the aggraded valley fill manifest where Brokenleg Creek emerges from the north slope of the Dempsey Divide (Fig. 95). It may be that the rock-lined hearths and occupation surface were only slightly above this spring-fed stream. Subsequent to this occupation nearly eight feet of sandy sediments accumulated. While some of these sediments may have come from overbank deposition, small stringers of gravel and sand implicate that material was washing down from a ravine and slope to the north (Fig. 93). Corner-notched arrowpoints, thick cordmarked pottery, and other tools indicative of a Woodland cultural period occupation were recovered from the upper two feet of the accumulation over the later Archaic component and indicate that this aggrading continued until around A.D. 900 or so. Today, these deposits are extensively exposed (Fig. 93) by a cut bank that approaches 15 feet in height. The erosion responsible for this cutting most likely occurred since historic farming.

Like the Beaver Dam site, but some 20 miles to the south-east (Fig. 95), the Certain site is also situated on the north edge of high uplands capped with the basal portion of the Ogallala Formation. Today, traces of numerous late Archaic bison kills are exposed in the walls of a deep canyon and its tributaries (Fig. 94). As noted previously, by far the majority of the bison kills result from driving bison up ancient gullies. Clearly, today's canyon with its bottom 40 to 50 feet below the bone beds was not a feature of the prehistoric landscape. Like at Beaver Dam, the canyon's deep incision is believed (Green 2002) to have occurred in the past century. Debbie Green's (2002) detailed study of the setting, bone beds, and gully fills indicate the location was repeatedly used to trap

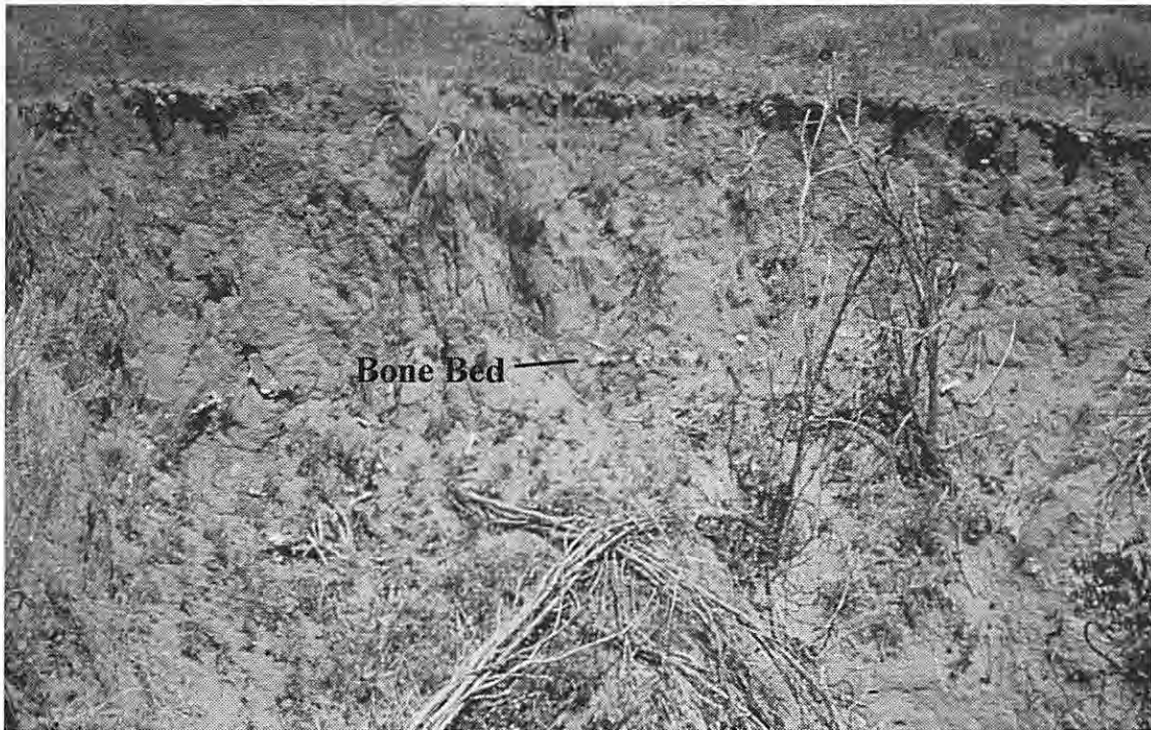


Figure 94. A view of gully cutting at the Certain site (34BK50) in Beckham County, Oklahoma. A thin layer of bison bones is visible about eight feet below the surface. Photo taken in 1970 by Don Wyckoff.

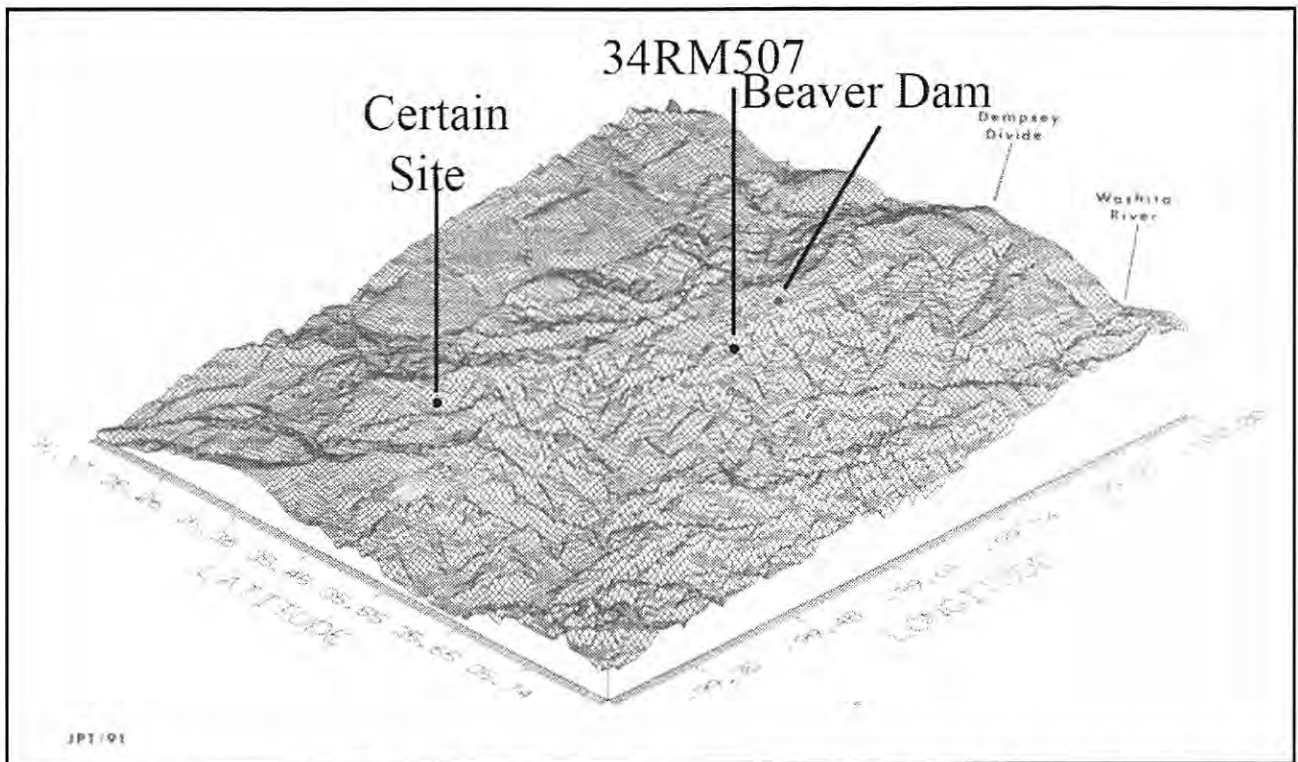


Figure 95. Orthographic projection (looking southwest) of the Dempsey Divide and late Archaic sites in Roger Mills and Beckham counties, Oklahoma. Courtesy of J. Peter Thurmond.

bison between 200 B.C and A.D. 300. Afterwards, human use of this setting ceased and the gullies began filling. Green (2002) found little evidence for soil development in the gully

fills and thus believes sediment deposition has been continuous since the last kill event. However, sufficient time has passed that the gully fills manifest some accumulation of soil

carbonates.

In contrast to the somewhat homogenous profiles at Beaver Dam and the Certain site, the profiles at 34RM507 contain a remarkable record of accumulating, alternating layers of shaley gravel and silt (Figs. 12 and 13; Green, this volume). Bits of charcoal from some of these layers yielded radiocarbon dates that indicate this nearly 20 feet of sediments accumulated between 2800 and 1600 years ago (Fig. 15). Moreover, this aggrading was followed by several episodes of erosion and gully cutting, one dating some 1200 years ago, another around 1000 years ago (Fig. 15).

The 34RM507 findings for aggrading and erosion also compare fairly well with a shorter record manifest a mile upstream (south). In January of 1996, the small archaeological site of 34RM780 (Fig. 89) was threatened by gas well drilling at this more southern location along Higgins Creek. To assess site 34RM780 and the soils and sediments associated with it, a long (25 meters) backhoe trench was dug into the low alluvial terrace (Fig. 96). The resulting profile, called Higgins Creek Exposure #1, revealed a very complicated sequence of filling and cutting mantled by fine sediments in which a soil formed (Fig. 97). Fifteen radiocarbon dates help place these alluvial and pedogenic processes in time. The available dates indicate that here, near the head of Higgins Creek, sediment began to accumulate in the channel sometime after 100 B.C. (Units 10, 9A, and 9B in Fig. 97). Notably, Unit 9 contains some Doxey shale gravel like the coarse strata at 34RM507, and this accumulated between 2050 and 1900 years ago, or near the end of such deposition at 34RM507. Fine sediments in units 7 and 8 at Higgins Exposure #1 attest to slow stream flow and sedimentation, but sometime around 1800 or 1700 years ago the stream cut away the western extents of units 9, 8, and 7 (Fig. 97). Around 1600 years ago began a lengthy period of low stream flow that resulted in the relatively thick layer of fine sediment recognized as Unit 6 (Fig. 97). As this unit accumulated, short periods of stability enabled the development of three black lenses believed to be organic-rich mats of decayed boggy vegetation; the middle such mat-line (Fig. 97) dates to 1450 years ago. These black layers are often distorted and broken, possibly due to large animals walking through the boggy deposit. Subsequent to the deposition of Unit 6, units 5, 4, and 3 bear witness to modest cutting and filling around 1400 years ago, an aggrading episode around 1350 years ago, and cutting and filling around 1000 years ago (Fig. 97). By 800 years ago, a final deposit of gravel and fine sediments provided the parent material for a darkened mollisol on which people camped, leaving the knapping debris and bison remains that characterize archaeological site 34RM780.

The profiles at 34RM507 and 34RM780 provide insights to erosion and deposition along Higgins Creek, a minor stream draining these north-sloping grasslands underlain by the somewhat indurated Doxey shale (Permian age). Clearly, the profiles at these two locations are not alike. At 34RM780 a

backhoe trench perpendicular to the stream's course affords a cross section (Fig. 97) of Higgins Creek channel changes near that stream's headwaters. In contrast, the 34RM507 profiles (Figs. 14 and 15) parallel the stream's course, and these profiles' alternating strata of fine and coarse sediments are believed to attest more to the importance of colluvial, rather than alluvial, processes operating on these shaley, rolling uplands. These profiles also differ because their radiocarbon dates reveal that the profile at 34RM780 is contemporaneous with only part of the period known a mile downstream at 34RM507.

Despite these differences, evidence of erosion and deposition can be correlated at these two locations. Our interpretation of this evidence is based heavily on local weather conditions and the character of Higgins Creek stream flow since 1990. Higgins Creek is a spring-fed perennial stream. As such, it flows when annual rainfall is enough above average to charge both the Ogallala Formation deposits on the Dempsey Divide to the south (Fig. 95) and the Ogallala-derived groundwater that flows through joints in the highly fractured Doxey shale that prevails in these north-sloping uplands. During droughty times, flow in Higgins Creek is greatly reduced. Also, the sparsely vegetated landscape loses forbs and some grass, thus enhancing rapid runoff and erosion. This, in time, washes off the shallow, poorly developed soils, cuts rills and gullies, and flushes sediments accumulating in the drainage. Today's soils along Higgins Creek are predominantly silty, shallow (<30 inches), on slopes varying from 3 to 30%, and sparsely covered with short to mid grasses (Burgess et al. 1963:10, 18, 21, and Sheet &&). These soils develop mainly from the red shale bedrock which breaks down into several particle sizes from a few processes. Probably most important are moisture and freezing temperatures during winter. This combination causes surface and near-surface exposures of Doxey shale to fracture into angular gravel, silt, and some clay. Plant roots growing into cracks in the shale would further enhance such fracture. Finally, surface exposures of bedrock would break down some by diurnal temperature changes and especially by prairie fires. Rain falling on exposed bedrock slopes could be expected to wash fine and coarse particles downslope and downstream to places where such sediment could accumulate and stabilize long enough for soil forming processes to take effect.

At sites 34RM507 and 34RM780 (Higgins Creek Exposure #1), the silt and shaley gravel deposits (Figs. 15 and 97) laid down between 790 B.C. and A. D. 400 are telling us that the Higgins Creek landscape was slow to recover and revegetate from the hot, dry climate of the middle Holocene (7500 to 4000 years ago). This landscape, and especially that adjacent 34RM507, must have been virtually denuded, and what soil parent material that formed was very susceptible to being washed downslope and downstream. The sequence of fine and coarse sediments manifest at 34RM507 is the reverse of how these sediments were originally dispersed over this landscape. On that basis, the alternating sequence implicates



Figure 96. Looking north at the small, low terrace by Higgins Creek a mile upstream (south) of 34RM507. The backhoe trench was cut to permit study of the terrace fill now called Higgins Creek Exposure #1. Photo taken in January 1996 by Don Wyckoff.

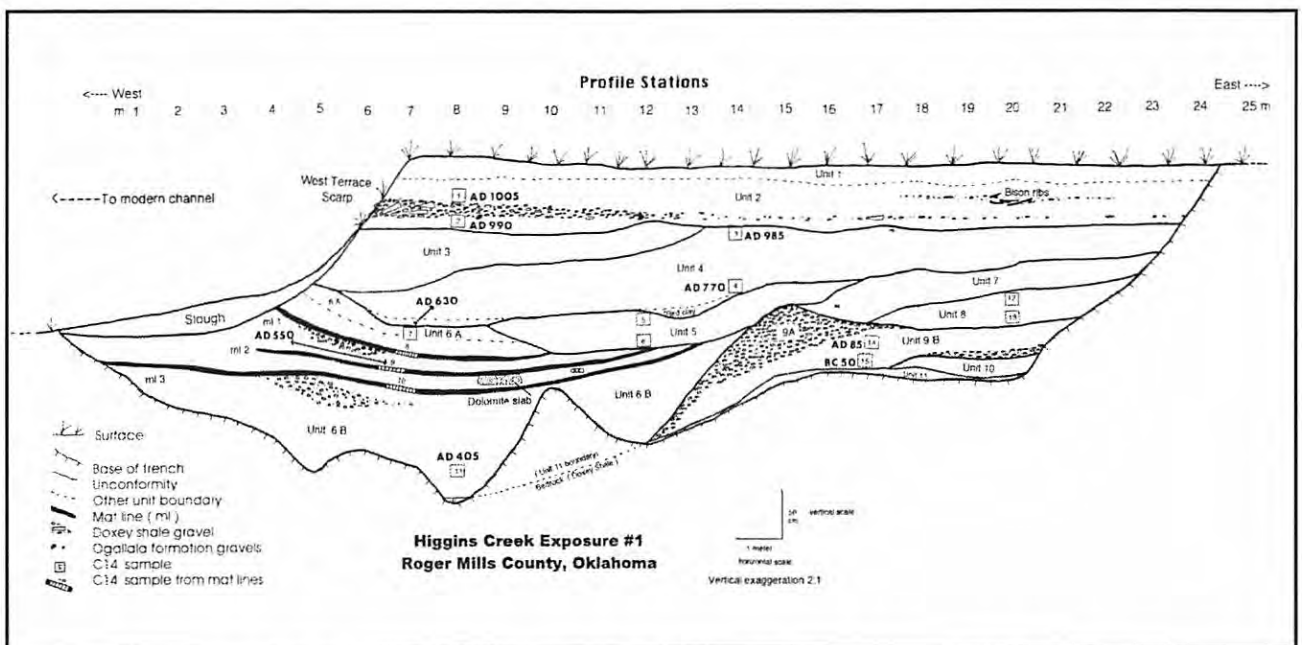


Figure 97. West to east profile at Higgins Creek Exposure #1. The radiocarbon dates are intercepts for the samples submitted and ran.

that the shale on the slopes and uplands was breaking down into coarse and fine particles, but these rarely stabilized long enough to form soils. The silt-dominated layers may be viewed as accumulations that formed on the landscape over several years (decades) of shale disintegration. In contrast, the angular gravel layers represent sediments from the near-surface disintegration of shale, undoubtedly from fewer years of deterioration than the silt layers.

Even within the potentially more mesic confines along Higgins Creek, the growth of streamside plants, brush, and trees was apparently sporadic during the 2800 to 1600 years ago deposition of sediments at 34RM507. Luther Leith's (this volume) study of snails recovered from several of the strata reveals notable assemblage changes. Standing water apparently was nearby during the earliest sedimentation at 34RM507, and brush and some trees comprising at least modest riparian woodlands are evidenced by particular snail species. Slightly higher in the profile, sediments deposited between roughly 2700 and 2000 years ago attest to dry conditions. The uppermost remaining snail samples are dominated by species associated with a dry prairie like that of today.

During the nearly three millennia manifest in the profiles at 34RM507 and 34RM780 three instances of cutting and filling are evident. This cutting is believed associated with erosion from rapid runoff from ground with poor vegetation cover. Such erosion most likely occurs during episodes of drought. A recent study of erosion in semiarid uplands in southeastern Colorado affirms that such settings are unlikely to erode when grassland cover is good, but the erosion threshold is lowered when vegetation is lost to overgrazing and/or drought (Tucker et al. 2006). Moreover, even well vegetated drainage channels undergo severe cutting when they are hit by localized flash-floods like those that occur on the Southern Plains from summer convective storms (Tucker et al. 2006:964-966).

As best as we can determine the three notable episodes of cutting evidenced at 34RM507 and 34RM780 occurred around 1900, 1400, and 1000 years ago. These times correlate fairly well with dry periods recognized at other profiles studied at a series of well dated soil and geological exposures along this north slope of the Dempsey Divide (Thurmond and Wyckoff 2002). From these findings there seems to have been a roughly 400 year dry/moist climatic cycle operating in this locality (Fig. 19). Somewhat surprisingly, the late Archaic bison hunters camping at sites like 34RM507 and Beaver Dam, and repeatedly trapping bison in gullies at the Certain site, were apparently here during one of the dry intervals.

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