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About the Cover: A photo at Falcon Reservoir showing drying up process. Note the level of the reservoir at horizon with Marker No. 13 to left. See article by James Boyd and Timothy Perttula beginning on Page 6.

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NOTES ON SOUTH TEXAS ARCHAEOLOGY 2000-3: Mortuary Offerings from a Burial on the Rio Salado, Tamaulipas

Thomas R. Hester, T. L. Donohoo, and Rochelle Leneave

Introduction

In this paper, we document a series of mortuary offerings from a burial found near the mouth of the Rio Salado, Tamaulipas. This is on the Mexican side of Falcon Reservoir, southwest of Zapata, Texas (Figure 1).

A relic-collector, a "winter Texan" who is now deceased, exposed the burial north of the confluence of the Rio Salado and the Rio Grande in 1990. Wave action on Falcon Reservoir washed out the human remains and grave goods at 277.22 feet above sea level (ASL). At the time, the level of the lake was fluctuating, rising to 278.20 feet ASL subsequent to the burial's discovery. A rough sketch map was obtained from the collector by T. L. Donohoo. The skeletal remains were very poorly preserved, with cranial fragments to the west, scattered teeth, and roughly aligned vertebrae (apparently, again, an west-east orientation). A cache of triangular bifaces was found in the cranial area, and a thin-walled sandstone tubular pipe near what might have been the eastern edge of the grave. It may have been at the "feet" of the burial, but we cannot determine from the sketch whether it was extended or flexed. Also found with the burial were three *Oliva* shell artifacts.

The collector sent pieces of the cranium, several vertebrae and 17 teeth to a friend in Wisconsin. The number of triangular bifaces was either 27 or 28, nine of which were sold or given away by the collector (who asserted that they were all Tortugas points). The stone pipe apparently had charred residue in the bowl, which was washed out of the pipe at the burial site.

Documentation of the Artifacts

Through the intervention of Mr. Donohoo, the artifacts from the burial (minus the nine points noted above) were thoroughly documented in March 1990. Rochelle Leneave made a 510-mile round trip to Mr. Donohoo's home, where the specimens had been made available. There she photographed all the materials both in black and white and color slides. Additionally, she sketched each artifact, recorded basic dimensions, and the raw material of which the items (e.g., the bifaces) were manufactured.

Leneave had worked with A. J. Taylor and Lynn Highley (1995) on the report of the Loma Sandia Archaic cemetery (Leneave 1995), focussing especially on the tubular stone pipes from that site. Indeed, the Rio Salado burial is highly reminiscent of the pattern of grave goods found at Loma Sandia, as will be noted below.

Figure 1. Falcon Lake area showing Rio Salado entering the lake (center of map).

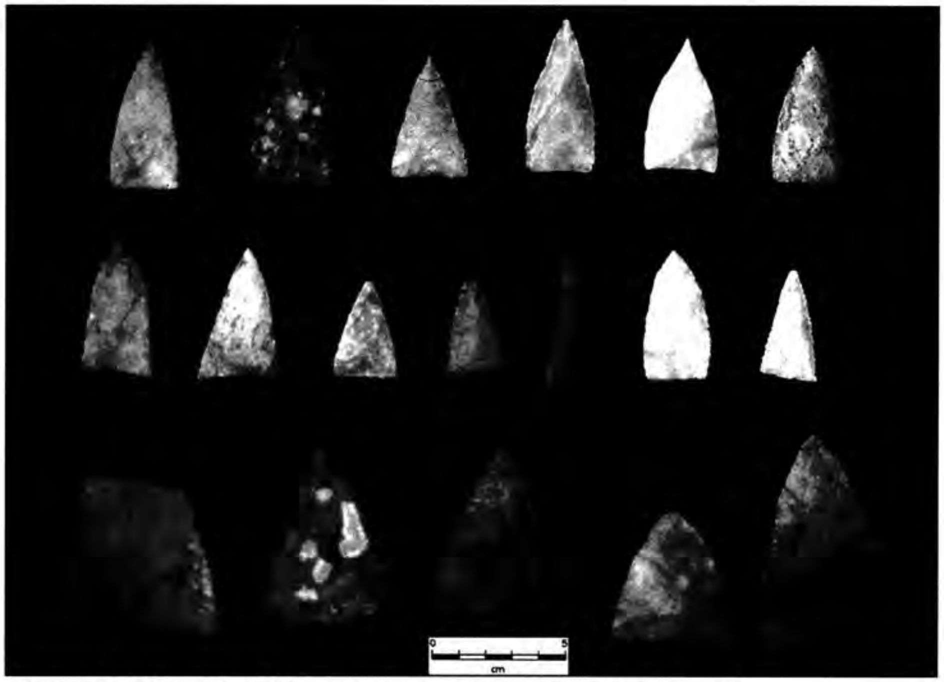

Figure 2. Triangular Bifaces Found with the Rio Salado Burial.

Figure 3. Selected Triangular Bifaces from the Rio Salado Burial.

Table 1. Data for 17 Triangular Bifaces Found With Rio Salado Burial.

Specimen	L	W	Th	Wt	Material/Notes
1	6.5	5.0	0.7	25.9	moss agate; one edge damaged
2	(6.0)	6.0	0.7	(28.3)	gray chert; distal half missing
3	6.3	4.6	0.8	20.3	amber chert; gray inclusions, corners missing
4	8.4	(4.8)	1.0	(31.7)	speckled tan chert; l corner missing
5	5.0	4.7	1.0	19.5	tannish gray chert (not photographed)
6	5.9	2.7	0.7	7.8	light tan chert, w/ light patina
7	6.1	3.2	7.8	15.5	tan chert; possible potlid at tip
8	6.0	2.7	1.1	14.7	
9	5.3	3.0	0.6	8.8	light tan chert w/ speckled inclusions
10	5.3	2.8	0.8	10.8	same material as #9
11	4.9	3.1	0.7	7.5	tan-gray chert, black speckles
12	4.8	2.8	0.7	7.0	tan chert
13	5.1	2.7	0.7	9.0	tan chert, white speckles
14	3.6	2.3	0.6	4.3	tan/gray chert
15	3.7	2.2	0.5	4.4	moss agate
16	4.9	2.7	0.8	9.2	light tan chert
17	4.2	2.0	0.8	5.2	finely-serrated lateral edges

All linear measurements are in centimeters; weight is in grams. Incomplete measurements are indicated by parentheses.

Description of the artifacts

Biface cluster (Figure 2)

Of the 27 or 28 triangular bifaces found with this burial, 17 were available for photography and documentation. It is likely that they are all projectile points, and most of them could be classified as Tortugas (Turner and Hester 1999). However, there is a wide range in size, from five larger bifaces that might be late stage preforms, to four smaller specimens that, if found at random on the surface, would be classified as Matamoros (Table l). This wide range in the size of triangular bifaces among the mortuary features was documented at Loma Sandia (Taylor and Highley 1995). Table l and Figures 2 and 3 provide documentation of the Rio Salado biface cluster.

Oliva Shell Artifacts

Three *Oliva* (olive) shells were found with the Rio Salado burial (Fig. 4). The tips or spires of each shell had been ground away, creating an opening that would have allowed the specimens to have been strung as beads or suspended in some other fashion.

Figure 4. *Oliva* Beads from the Río Salado Burial. Two of the three specimens are shown.

Lengths (cm) are: 4.1, 4.6, and 4.0; widths are 1.8, 2.1, and 1.2; weights (gr) are: .8, 1.2, and .8.

Tubular Stone Pipe

Although tubular stone pipes are well-documented in southern Texas (Leneave 1995) and at Falcon Reservoir (Chandler and Kumpe 1994), the pipe found with the Rio Salado burial is distinctive in terms of its careful manufacture and extremely thin walls (Fig. 5). It is made of fine-grained sandstone and is 9.0 cm in length. At the distal ("bowl") end, it measures 4.1 cm; at the proximal end, it is 2.9 cm. Weight of the artifact is 102.2 grams. The "bowl" opening is 3.2 cm, while at the proximal (stem) end, the inside dimension is 1.1 cm, and outside, 2.2 cm.

Although the bowl area is clearly burned, the pipe upon discovery reportedly contained a charred residue, which the collector said that he subsequently washed out.

Discussion

The Rio Salado burial cannot be directly dated at this time. However, the associated grave goods—especially the group of bifaces and the stone pipe—suggest, on the basis of findings at Loma Sandia (Taylor and Highley 1995) that it dates to the late part of the Middle Archaic, perhaps 600-800 B.C. However, Boyd et al. (1997) have published a detailed report on the Southern Island cemetery at Falcon Reservoir, which appears to date mainly to the Late Prehistoric. Included among grave goods at that site are Matamoros (small triangular) and Catan points, *Oliva* shell artifacts, and a tubular stone pipe. These come from Burial 1, while other burials at the site contain Caracara arrow points and large numbers of small tubular bone beads. While Burial 1 does share artifact traits with certain aspects of the Rio Salado assemblage, the *Oliva* shells are modified in a different fashion, and the small triangular Matamoros points are of consistent size (e.g., there is not the wide, Loma Sandia-style variation seen in the Rio Salado burial). Moreover, Burial l at Southern Island contained a diverse array of other artifacts that set it apart from the Rio Salado burial. As we learn more about mortuary traditions in southern Texas, we will doubtless see great variation. Many of the Southern Island grave goods resemble the Brownsville Complex (in terms of material culture), while Rio Salado seems very much like Loma Sandia. Hester (1969: 159) wrote that, on the basis of data available then, most burials in South Texas were single interments. Fortunately, we have learned a lot more in 31 years—especially the presence of a number of South Texas prehistoric cemeteries—and the Rio Salado data are part of the continuing growth of the data reflecting ancient mortuary practices in the region.

It is unfortunate, as this paper has demonstrated,

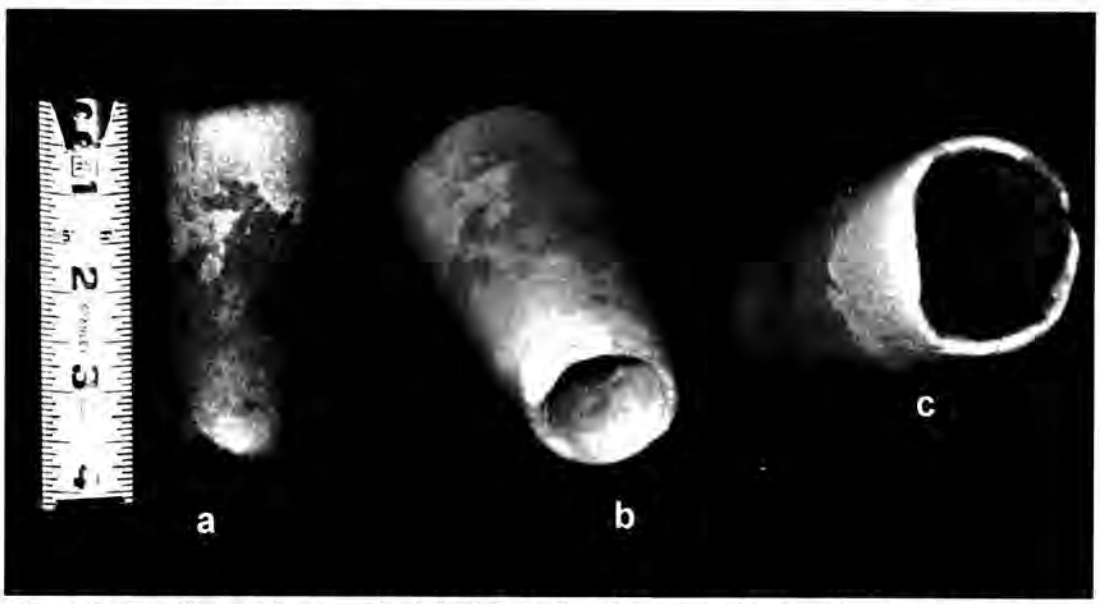

Figure 5. The Stone Pipe from the Rio Salado Burial. a, overall view; b, view from the distal end; c, view at the bowl (proximal) end. Scale is in inches.

that the Rio Salado burial is another example of the destruction of important archaeological resources that has occurred for well over a decade on both sides of Falcon Reservoir. Collectors have included "winter Texans," local collectors, some from the Rio Grande Valley, and beyond. Their motives have ranged from hobbyist collecting (with some of the collections well documented) to an increasingly commercial focus by some relic-hunters. Fortunately, many issues of *La Tierra* have contained papers that document some of the sites and the material culture found at Falcon Reservoir. In this regard, we can be grateful to C. K. Chandler, James B. Boyd, and Don Kumpe, as well as to many of the hobbyist collectors who have made specimens available for study. Other notable contributions include the volume by Pertulla et al. (1996) and the Southern Island study (Boyd et al. 1997) in the *Bulletin of the Texas Archeological Society*.

As archaeologists, professional or avocational, we could lean effortlessly on our accumulation of codes of ethics (state, regional and national), and stand by and do nothing, except perhaps condemn the publication of artifacts collected or excavated without permits in Mexico, or collected without permits from lands controlled by the International Boundary and Water Commission on the Texas side. Certainly, none of us encourages such activity and we deplore the destruction that is being wrought. But the looting of Falcon Reservoir is reality, it cannot be (or will not be) controlled by the United States or Mexico, and it is robbing archaeologists of invaluable knowledge on a key area of the Borderlands. If we are made aware of important data and fail to record it, or even dare publish it, from this poorly known region, it would be a disservice to current and future scholars working on the archaeology of this section of Texas and in Mexico.

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THE DESERTIFICATION OF SOUTH TEXAS AND NORTHEASTERN MEXICO AND ITS EFFECTS ON ARCHAEOLOGICAL SITES

James B. Boyd and Timothy K. Perttula

ABSTRACT

The effects of long-term drought-like conditions on archaeological sites in portions of South Texas and adjacent northeastern Mexico are examined, particularly the gradual desertification of some areas near the lower Rio Grande. This has resulted in several apparent changes in the landscape, including the drying up of various species of plants, increased exposure of soils, and changes in the character of these soils. Specific instances of desertification are also illustrated. The implications of other droughts in Historic and Prehistoric times is considered.

INTRODUCTION

For nearly 20 years the senior author has explored and documented archaeological sites along the lower Rio Grande, on both sides of the river, and has made detailed notes on various subjects in addition to archaeological field notes. Much data has been gathered on the geography, geology, soils, flora, and fauna observed in the region, along with weather conditions, and general impressions of sites in the region as a whole (Boyd n.d.).

In recent years, most especially recent months (mid-2000), stark changes in the appearance of various areas in the region have become apparent, most notably the lack of any appreciable precipitation and the resultant desiccation of the landscape. This is probably due, in part, to seasonal factors (e.g. the region is currently in the summer season), with elevated temperatures and below average rainfall. Other factors, such as modern human alteration of the landscape and overgrazing by cattle, contribute to the process as well.

The primary reserve of water in the area, Falcon Reservoir, has recently reached its all-time record low elevation (May 2000), and it continues to drop. The few other sources of water in the area are severely depleted due to a sustained lack of any appreciable rainfall.

Drastic changes in the appearance and character of various prehistoric archaeological sites in the area have taken effect in recent times. The primary change observed is the general desertification of many of the sites. Specifically, much of the vegetation has withered away and died, and the character and consistency of the soil in some of the archaeological sites has changed noticeably. The result is that many portions of the region are beginning to appear desert-like. Based on information collected by the senior author over the years, desertification appears to be a phenomenon that occurs periodically in this region.

THE STUDY AREA

The area encompassed in this study is generally centered around Falcon Reservoir, located on the lower Rio Grande, some 60 miles south of Laredo, Texas (Figure 1). It includes portions of Webb and Zapata counties in South Texas, and portions of the Mexican states of Tamaulipas and Nuevo León. This area is included in Blair's (1950:102-105) Tamaulipan Biotic Province, generally characterized by its semi-arid weather and megathermal climate, and a landscape dominated by thorny brush. Black (1989b: 39) has categorized the geographic region where the study area is located as the Rio Grande Plain, one of five recognized biogeographical areas in South Texas.

The region is geographically large, but water as a resource is scarce. The primary watershed is the Rio Grande, which normally has abundant water. However, the flow of the Rio Grande is regulated by the amount of water discharged through various dams located along its course upstream from the study area. The nearest upstream reservoir (and dam) is Amistad Reservoir, near Del Rio, Texas. In the study area itself, Falcon Reservoir impounds water for downstream use, primarily in the lower Rio

Grande valley of Texas and northeastern Mexico. The majority of the water is used for the irrigation of agricultural lands.

In addition to the Rio Grande, the Rio Salado also flows generally southeastward through the study area, and merges with the Rio Grande just west of Zapata, Texas (Figure 1). This river provides a (usually) perennial source of water, although in recent years the amount has diminished considerably (Figure 2). Still another river, the Rio Sabinas, flows and they are generally derived from tropical storms that originate in the Gulf of Mexico.

In addition to the three rivers, innumerable dry washes, or arroyos crisscross the study area. These usually have flowing water only after appreciable rainfall in the area. Many of these arroyos have *tinajas*, or naturally formed waterholes, in their beds. In wetter periods, these tinajas often retain considerable pools of water for extended periods of time (Figure 3).

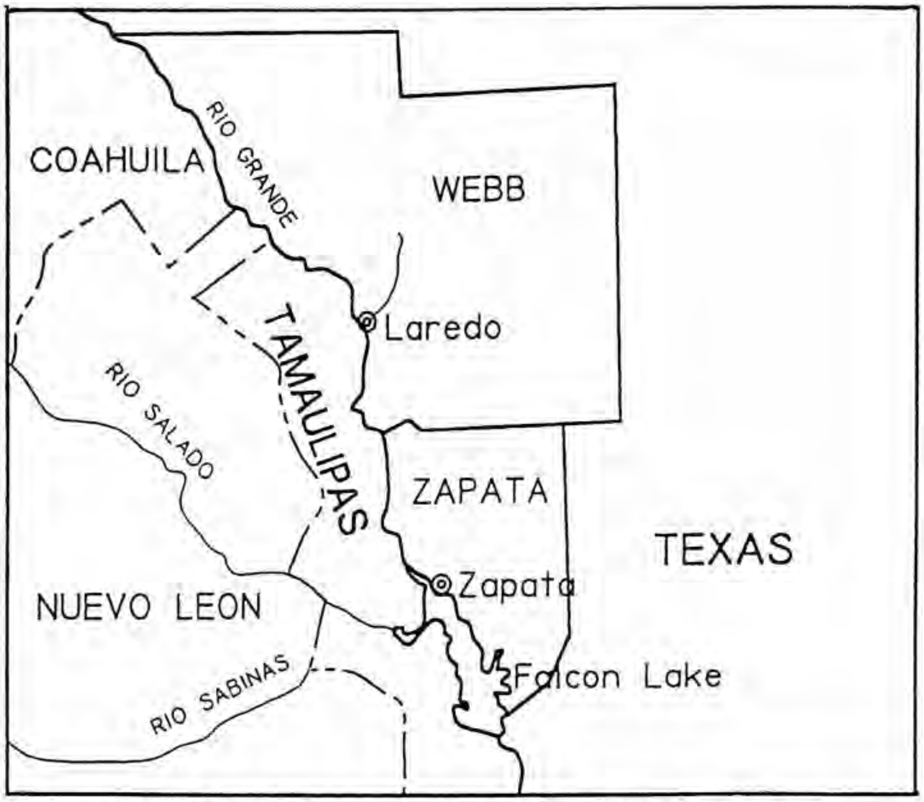

Figure 1. Map of the study area, showing portions of South Texas and northeastern Mexico. Laredo is near the center of the map. Note Falcon Reservoir, on the lower Rio Grande, near the bottom. The distance from Laredo to Zapata, Texas is about 50 miles.

generally northeastward, forming a portion of the border between the Mexican states of Tamaulipas and Nuevo León, and merges with the Rio Salado approximately 20 miles west-southwest of Zapata, Texas. However, this river is generally dry along much of its course, flowing only after infrequent heavy rainfall in the area. The Rio Sabinas became a raging torrent when Gulf of Mexico-borne Hurricane Gilbert dumped record amounts of rain into this drainage system in September 1988, causing massive flooding of the Rio Sabinas and Rio Salado watersheds. Such calamitous rainfall events are rare here,

Natural lakes or ponds are rare in the region, although man-made lakes, primarily stock tanks, are numerous, mainly on the ranches that are located on both sides of the U.S.– Mexico border (Figure 4). The largest man-made lake in the area is Falcon Reservoir, located near Zapata, Texas. This lake was formed in the early 1950s subsequent to the building of Falcon Dam and the impoundment of the Rio Grande. At its conservation pool elevation of 301.2 feet above mean sea level (amsl), the lake covers some 87,226 acres (IBWC 1994:11). Falcon Reser-

Figure 2. Dry riverbed of the Rio Salado, in Tamaulipas, Mexico, ca. 10 miles southwest of Zapata, Texas (just south of the abandoned city of Guerrero Viejo). Photo taken July 15, 2000. This portion of the usually perennial river is normally inundated by the waters of Falcon Reservoir.

Figure 3. *Tinaja*, or waterhole, in sandstone bedrock *arroyo* bottom at the Rancho San Fabián, Tamaulipas, Mexico. Photo taken on October 30, 1988. Note the dense, thorny brush around this temporary water source.

Figure 4. One of several stock tanks on the Rancho San Fabián, Tamaulipas, Mexico. This photo was taken on August 27, 2000. Due to the drought, the tank is reduced to a puddle a few meters across; it normally covers more than two acres.

Figure 5. Falcon Reservoir, near Zapata, Texas, in the process of drying up. Note the tops of mesquite trees protruding above the silt. These trees were killed when the waters of Falcon Reservoir were impounded by Falcon Dam in 1954. Note channel marker #13 at top left. When the lake is full, the mesquite trees in the foreground are under about 40 feet of water. View southeast. Photo taken in May 1998.

voir has been below its conservation elevation since 1992, reaching an all-time record low elevation of 247.21 feet amsl on May 12, 2000, almost 54 feet below the conservation elevation (IBW C, personal communication 2000). The low elevation of the lake is a direct result of the continuing drought-like conditions in the region, and the resultant draining of water for use downstream (Figure 5).

THE RECENT DESERTIFICATION PROCESS

Although Blair (1950:102-103) characterizes the Tamaulipan Biotic Province as being megathermal, and the native flora are generally adapted to the higher temperatures and low precipitation in this area, even the native brush and cacti are being adversely affected by the drought in the study area (Figure 6). By July 2000, nearly all of the native, thorny brush had dried up and was in a state of shock. The only consistently green flora in the region was mesquite (*Prosopis glandulosa*), though even this hardy species was in a state of shock in some areas of Webb County, Texas by early September 2000, due to the continued drought and record-setting high temperatures. In some areas, several species of very hardy cacti (i.e., that usually thrive in arid regions) have recently been observed in very poor condition, as there has been insufficient rainfall even to sustain this type of flora. Some of the (usually) hardy species observed in poor condition include lechuguilla (*Agave lechuguilla*), sotol (*Dasylirion texanum*), Century plant (*Agave americana*), strawberry pitaya (*Echinocereus enneacanthus*), coyotillo (*Karwinskia humboldtiana*), guajillo (*Acacia berlandieri*), guayacan (*Porlieria angustifolia*), and several others (Boyd n.d.).

Many areas in the geographic region have drastically changed in appearance over a relatively short period of time (Figure 7). Where native brush and cacti once thrived, there is now only bare and sterile soil, or at minimum, a much lower spatial density of plant species or cacti. This has had a direct effect on many species of fauna, including domestic varieties, most markedly on the innumerable local ranches (Figure 8). With less flora, the diverse animal species are forced to become even more competitive than usual in order to survive.

Another effect of the drought is that previously dependable sources of water, such as Falcon Reservoir, the Rio Salado and Rio Grande, and strategically-placed stock tanks on most ranches, are far below their normal levels. In many cases, stock tanks have completely dried up, forcing both wild and domesticated animals to move (or be moved) to other areas in order to survive (Figure 9). Also, the many tinajas in the arroyo bottoms have largely dried up due to the lack of rainfall for a sustained period of time. The drying up of formerly dependable sources of water has had a negative, domino-like effect on the wildlife and domesticated animals. This has been compounded by the dying-off of various floral species, on which many of these animals also depend to survive.

Dr. Gonzalo Ivan Lopez-Garcia, of the Rancho San Martín on the Rio Sabinas in Nuevo León, Mexico, reports (personal communication 2000) that he has been forced to import feed for his cattle from Nuevo Laredo to the ranch, supplemented by the native prickly pear cacti, for approximately 10 months out of the year for several years. He resorted to these measures only about two months of the year during "wetter" years. Prickly pear cactus, or *nopal*, is regarded as a last resort food source for cattle in this region. Ranchers use flame-throwing equipment to burn the thorns off the cacti in order to make it more edible for the cattle (Dr. Lopez-Garcia, personal communication 2000). Rancher José María Martinez-Villarreal, of the Rancho San José de Los Brazos on the Rio Salado, reports (personal communication 2000) that his ranch was able to produce a good corn and bean crop until about three years ago, when conditions became too dry to sustain the crop.

Dr. Lopez-Garcia relates (personal communication 2000) that a well was recently drilled on the Rancho San Martín in an attempt to access a dependable source of water. The well was drilled to a depth of approximately 300 feet, at which time the well filled with water to a level ca. 20 feet below ground level. The water was so salty that it was unfit even for cattle, and therefore useless. Due to this factor, windmills have been practically rendered useless in this area near the Rio Sabinas (Dr. Lopez-Garcia, personal communication 2000). However, José María Martinez-Villarreal installed a windmill two years ago on the Rancho San José de los Brazos, approximately 16 miles west-southwest of the Rancho San Martín. This windmill is still currently producing adequate, good-quality water, despite the drought conditions. The construction of the windmill on this ranch has alleviated the need to make arduous trips over rough roads to Guerrero Nuevo (New

Figure 6. Typical view of native brush at the Rancho San Fabián, Tamaulipas, Mexico. Species in photo include mesquite, tasajillo, acacia, guayacan, coyotillo, sage, and strawberry pitaya. Note the lack of grasses. View west. Photo taken in November 1999.

Figure 7. Fence line at the Rancho San Fabián, Tamaulipas, Mexico. Note the barren nature of the landscape and the lack of brush. View south. Photo taken in November 1999.

Figure 8. Dead bull at the Rancho San Fabián, Tamaulipas, Mexico. Most of the reliable waterholes, mainly stock tanks, in the area have dried up in the first half of 2000. Photo taken in June 2000.

Figure 9. Ranch dogs enjoying a cool drink and bath at a stock tank on the Rancho San Fabián in February 2000. This stock tank was completely dry by June.

Guerrero), Tamaulipas, some 30 miles distant, to transport water in large tanks back to the ranch (José María Martinez-Villarreal, personal communication 2000).

The diminished flora in the region is a direct result of the lack of adequate rainfall. This is compounded by the elevated temperatures of the current summer season. Although significant rains *have* occurred sporadically in the region in the last few years, it often falls very suddenly in one isolated event, over a generally small geographic region, and much of the rainwater is wasted through runoff (Boyd n.d.; Black 1989a:9). Additionally, yearly evaporation rates in this area far exceed the annual rainfall totals for any given station: the evaporation rate for areas in extreme South Texas is approximately 53.9 inches annually (Black 1989a:9), whereas the evaporation rate average in the years 1956-1993 at Falcon Dam, in the study area, was just over 107 inches (IBWC 1993:124). This is considerably higher than the recorded evaporation rate average (1949-1993) for the Presidio recording station in West Texas, where it was recorded at just over 87 inches (IBWC 1993:124). The average (1956-1993) rate of evaporation at the Falcon Dam re-recording station is usually highest in the month of July, when it reaches 15 inches per month (IBWC 1993:124).

The Rancho San Martín received a total of only about 7-8 inches of rain during the entire year in 1999 (Dr. Lopez-Garcia, personal communication 2000). In a "good wet year," the total precipitation at the ranch is approximately 17-18 inches. The effect of the current deficit in the amount of rainfall is profoundly evident in the landscape, where some areas have taken on a desert-like appearance (Figure 10). It will take significant and prolonged rain to reverse this trend. Other portions of the study area *have* received more rain than areas such as the Rancho San Martín, as the patterning of precipitation totals varies considerably, even in this small geographic region. In 1999, Laredo, Texas, for example, had 16.54 inches of rain (Richard Berler, personal communication 2000; Table 1). Based on data recorded in the period 1931-1979 at Laredo, Texas (Sanders and Gabriel 1985:104), the three wettest months of the year have traditionally been September (3.2 inches), May (2.7 inches), and June (2.6 inches), whereas the three driest months have been March (0.5 inches), January (0.9 inches), February (0.9 inches) or November (0.9 inches).

Figure 10. Desert-like terrain on the Rancho San Martín, near the Rio Sabinas, Nuevo León, Mexico in June 2000. This is approximately 22 miles west-southwest of Zapata, Texas. Note the lack of any brush or cacti, and the total lack of grasses. View south.

Table 1. Yearly Rainfall Average for Laredo, Texas, 1990-1999 (in inches).

1990 - 23.18	1995 - 24.04
1991 - 18.82	1996 - 22.94
1992 - 20.84	1997 - 21.05
1993 - 13.19	1998 - 10.41
1994 - 21.54	1999 - 16.54

THE GREAT DROUGHT OF THE 1950s AND OTHER DRY PERIODS

Droughts in the region are common, and have been recorded many times on a periodic basis. For example, Price and Gunter (1943:11) report that numerous oak trees in South Texas were reportedly killed by a severe drought in the early 1880s – some of these oaks were estimated to be as much as 100 years old. Another severe drought was reported in South Texas in 1896-1903, and a drought in South Texas in Dimmit, La Salle, Maverick, Webb, and Zapata counties reportedly killed thousands of mesquite trees at the end of the 19th century or the beginning of the 20th century (ibid.:11-12).

Therrell's (2000:Table 9) summary of tree-ring data from south central Texas points to the regular occurrence of droughty years from 1649 to the present. Low growth index values suggest that droughts lasting more than two years, however, took place in 1703-1705, 1714-1717, 1750-1752, 1915-1917, and 1950-1956. The two poorest growth years on record happened in 1925 and 1971.

Longer tree-ring records from the United States, Canada, and New Mexico (see Stahle et al. 2000:Figure 1; Cook, Stahl and Cleaveland 1995) indicate that a drought that took place in the mid-16th century was "the most severe prolonged drought over much of North America for at least the last 500 years" (Stahle et al. 2000:121). This period of persistent droughts occurred between about 1560-1590 in Texas and 1540-1580 in northern Mexico, with the worst years in the mid-1570s in Texas and about 1570 in the Durango, Mexico area (the tree-ring data for the Durango area extends back to 1380; see Stahle et al. 2000:Figure 2), with very low summer precipitation. According to Stahle et al. (2000:121), the "most intense episode of drought occurred over Mexico in the 1560s, and appears to have then spread to the north and east during the later half of the 16th century."

Many of the older-generation residents in the area still talk of a sustained and pronounced drought in South Texas and northeastern Mexico during the early years of the 1950s. The Rio Grande apparently went completely dry in the areas north of where Falcon Reservoir is now located. Byfield (1966:29) relates that hydrographic reports indicate that during the summer of 1953 the river was extremely low or without any flow whatsoever. Records maintained by the International Boundary and Water Commission (1993:57) indicate that the Rio Grande, in the vicinity of Laredo, Texas, had "no flow" days in June and July 1953, and on July 24, 1956. Although the current drought seems severe, José María Martinez-Villarreal, a 78 year-old resident in the region, states (personal communication 2000) that the drought of the 1950s was "much worse." Stephens and Holmes (1989:5) report that the worst drought in modern times was the one during 1950-1956, when 244 of Texas' 254 counties were declared disaster areas by the end of 1956.

Richard Berler (personal communication 2000), a meteorologist in Laredo, Texas, stated that the drought of the 1950s was a widespread, regional drought, and it affected the whole state of Texas as well as portions of Oklahoma and New Mexico. Using tree-ring data, Stahle (et al. 2000) also suggest that the drought also affected northern and northwestern Mexico, and parts of the central Plains of North America (see also Cook et al. 1999; Woodhouse and Overpeck 1998). Berler noted that the drought was a prolonged event, lasting from 1950-1956. Table 2 provides the total yearly precipitation amounts for Laredo during the drought years (see also Table 1). In South Texas, the drought was broken by increased rainfall in 1957 and 1958. For example, Laredo, Texas had 20 inches of rain in 1957 and 30 inches in 1958. The average yearly rainfall for Laredo, based upon totals tallied for the

Table 2. Yearly Rainfall Average for Laredo, Texas, 1950-1956 (in inches).

1950 - 10.63	1954 - 13.50
1951 - 15.48	1955 - 9.61
1952 - 10.54	1956 - 9.95
1953 - 16.66	

entire 20th century, is 19.8 inches (Richard Berler, personal communication 2000). According to Therrell (2000:34), the 1950-1956 period experienced the "most prolonged period of sustained poor growth in the 347-year tree-ring chronology" [1649-1995]. The National Climatic Data Center (1998) indicates that 1956 was the worst drought year in its entire century-long database (Therrell 2000:34).

Berler (personal communication 2000) cautions that rainfall data at a given station may be skewed considerably depending upon how it is assessed. That is, the recorded rainfall average for a given station during a relatively short period of time may differ considerably from the average for the same station over a long period of time. For example, the precipitation total for Laredo was only 0.92 inch during the period from October 20, 1970 through June 20, 1971. However, the following six-month period (06/20/71 through 10/21/71) was exceptionally wet by regional standards, with 41 inches of rain. Thus, in a one year period, nearly 42 inches of rain fell at the Laredo recording station, more than double its "average" yearly total of 19.8 inches. On the other hand, a 30-year average for the same station, from 1961-1990, was 21 inches of rain. It is interesting that the dendrochronological value index for south central Texas in 1971 indicates it was a year of very poor growth (Therrell 2000: Table 9).

Specific portions of the study area are prone to long periods of consecutive days without rainfall. For example, the records indicate that Laredo goes without any measurable rain for 30 consecutive days at least once every other year, and 50 consecutive days without rain at least one year out of four, on the average. Longer periods of consecutive days without rainfall for the Laredo station are not unheard of. For example, in 1993 there was no measurable rainfall for 57 consecutive days, while 1978 had a long dry spell of 93 days (Richard Berler, personal communication 2000). This was also a year of very poor growth in the post oak tree-ring chronology for south central Texas (Therrell 2000: Table 9). Dr. Lopez-Garcia (personal communication 2000), at the Rancho San Martín, states that although the yearly totals of rainfall at any given station may indicate a significant amount of rain, often it falls very heavily and for a very short duration, followed by long dry spells during which the land becomes parched.

The Laredo station recorded the hottest and driest year on record in 1998. Berler (personal communication) states that from January 1 through August 13, 1998, only 2.3 inches of rain was recorded. The total recorded rainfall for the whole year was 10.42 inches, comparable to the driest years in the 1950-1956 drought. Also during 1998, the recorded temperatures for the Laredo station were higher than average, with 115 days of temperatures rising above the 100°F mark, 80 days with the temperature above 105°F, and 15 days where the temperature rose to over 110°F. José María Martinez-Villarreal (personal communication 2000), at the Rancho San José de los Brazos, states that even the white-tailed deer population was adversely affected in 1998, and the unusually hot, dry weather resulted in significant population losses.

IMPLICATIONS OF DROUGHTS DURING HISTORIC AND PREHISTORIC TIMES

It is clear from the archaeological record that many areas in Texas were probably wetter, in general, than they are today. Davis (1992:5) states:

> ...during the period of human occupation in Texas, the Late-Glacial (14,000-10,000 B.P.) and the Post Glacial (10,000 B.P. – present), there has been a shift from mesic to xeric conditions through time, probably prompted by a gradual rise in the ambient temperature causing higher evaporation rates and a lower water table.

More recent paleoenvironmental research in Texas suggests that between ca. 7000-5000 years ago it was drier and warmer than present. Along the lower Rio Grande, it is probable that with decreasing precipitation, there would have been a significant decline in available biomass for Native American populations in the region, with a reduction in vegetation cover and an expansion of more xerophytic plant communities. In a parallel with modern conditions along the lower Rio Grande, Ricklis and Cox (1998: 127) note that the landscape—in their case the central and lower Texas coast—during this time would have been "more susceptible to extensive slope erosion during episodic storm events."

The Late Holocene period after ca. 5000 years ago in Texas appears to have been that of fluctuating and variable climates—with moist and dry cycles—like in modern times, and perhaps with a 20-70 year periodicity (see Kerr 2000; Mann 2000). It is possible that climatically speaking, it was generally wetter than during the preceding climatic interval, but not wet enough to change the overall xeric climate of the lower Rio Grande.

Paleoenvironmental data for the last 1000 years suggest that there has been a general decline in temperatures from about A.D. 1000 (if not earlier) to 1900, with a rapid warming after that time (Bradley 2000; Crowley 2000:Figure 1). Crowley's (2000) studies suggest that prior to 1850, decadal-scale changes in temperature variation is due to low frequency changes in solar irradiance and pulses in volcanism as forcing mechanisms (see also Bradley et al. 1996). In turn, Crowley (2000:270) argues that the very large late 20th century warming is due to anthropogenic greenhouse gas forcing "that has no counterpart in the millennial record" (Bradley 2000: 1355; see also Clark et al. 1999).

Proxy reconstructions by Crowley (2000:Figure 1) of Northern Hemisphere annual temperature records show a warm period between ca. A.D. 1300-1580, a colder period through the 17th century, a warmer 18th century, and then another colder period in the early part of the 19th century. He also notes a mid-20th century warm period (between about 1935-1965).

It is interesting to compare this proxy reconstruction to the tree-ring data from south central Texas. The reconstructed colder 17th century (Crowley 2000:Figure 1) seems to be supported by the tree-ring data in that only three droughty years occurred between 1649-1699 (6% of the years) in south central Texas; these years were probably colder and wetter. The reconstructed warmer 18th century is marked by at least 26 dry and droughty years in south central Texas (26% of the years), with major droughts in 1703-1705, 1714-1717, and 1750-1752. The 19th century tree-ring record from south central Texas is little different than the 18th century, with the comparable frequency of dry and droughty years (23%), even during the early part of the 19th century. The same can be said for the 20th century, in that dry and droughty years occur about 21% of the time, albeit with a slightly higher 30% during Crowley's (2000) mid-20th century warm period. Most of the dry and droughty years in the region, and including the lower Rio Grande, occurred during the 1950-1956 drought.

Based upon an examination of the distribution of prehistoric archaeological sites in the study area, it is clear that the selection of the location of the sites was primarily based upon the availability of water. The presence of other natural resources, in addition to water, was obviously also of critical importance in site location selection. Even along the innumerable, long dried-out arroyos that crisscross the study area, there is evidence of long periods of occupation by the prehistoric inhabitants of the area (Boyd n.d.). The presence of numerous major occupation sites on what are now dry arroyos seems to indicate, in fact, that the climate in general was once wetter than it currently is, and that water tables were much higher than they are today. Also, large numbers of prehistoric occupation sites are found many miles from the rivers in the area, often far from present-day sources of water (ibid.).

Droughts have occurred on a periodic basis during the last 300 years in the region. Therrell (2000:Figure 7 and 34-35) correlates the occurrence of droughts since the mid-1600s with the El Niño-Southern Oscillation, an atmospheric circulation system with a periodic warming of sea surface water in the central and eastern Pacific Ocean (Glantz 1996; Fagan 1999; Stahle and Cleaveland 1993). Droughts occurred, at least periodically, during the much more protracted period in the prehistory of the area, along with longer-term or millenial changes in temperature and precipitation (Stahle and Cleaveland 1995; Bousman and Brown 1998). This, no doubt, influenced the settlement patterns of the prehistoric peoples on a regional basis. Verification of this may be possible in the future, after an extensive examination and assimilation of data collected in regards to the distribution of prehistoric archaeological sites in the area, and the accumulation of a long-term paleoenvironmental record in the lower Rio Grande. To date, no detailed studies of this kind have been undertaken in the local region. Some progress is being made in better understanding specific paleoenvironmental conditions in the lower Rio Grande. Stable carbon and nitrogen isotopic values obtained from soil samples at 41ZP39 suggests that more xeric vegetation, including grasses and succulents (such as prickly pear and Agave), "dominated the last 5,000 years with a dramatic increase in C_3 vegetation [brushes and trees] over the last 300 to 500 years. This...increase...is potentially related to the introduction of domesticated animals and the reduction of fire in the historic period" (Quigg and Cordova 1999:9-7). Quigg and Cordova (1999) also noted a similar isotopic fluctuation at 41ZP39 above 8000 years ago.

In historical times in the study area, the archaeological record indicates a proclivity of early settlers in the area to construct their homes or villages mainly in the more fertile areas along the few rivers in the region, namely the Rio Grande and the Rio Salado. This contrasts, somewhat, with the observed (Boyd n.d.) settlement patterns of prehistoric peoples in the region, in that they often established campsites well away from the rivers.

The earliest settlement in the area was the Villa de Nuestra Señora de Dolores, which was founded on August 22, 1750 (Byfield 1966:4) on the east bank of the Rio Grande, in present day Webb County, Texas. In October 1750, the Villa del Señor San Ygnacio de Loyola de Revilla (Flores-Gutierrez 1994:201), later known as Guerrero, Tamaulipas, was founded in the area of the Rio Salado (Byfield 1966:3). Both were founded during droughty conditions in the early and mid-1750s (Therrell 2000: Table 9). Subsequent to the establishment of these settlements, numerous others soon followed, usually within a short distance of the rivers. Byfield states (1966:1):

> ...in an area where the winds blow hot and dusty, and the land is barren and dry, the river *vegas* (first bottoms) were for many years the only arable acres. For more than two centuries, descendants of the original Spanish settlers of the area have tilled the same soil and borne the same burdens as their ancestors; their history is the history of the river, its dry spells and its floods, its bounties and its forays.

It is obvious that during the historic settlement of the region that food and water were of the utmost importance when determining where settlements would be established. Since naturally occurring sources of water such as rivers attract wildlife, the establishment of settlements on the rivers made living there doubly attractive. Also, the soils bordering the river were extremely fertile, deposited over the centuries as river-borne sediments during massive floods. Lott and Martinez (1953:1), in their discussion of early settlers in the area of present day Falcon Reservoir, state:

> For two hundred years the same families have lived on these ranches, a contented, happy people, unperturbed by passing world events. If patience is a virtue, these people are the most virtuous on earth, for their land is a hard land in some respects; a land of little rain and dry arroyos. In the hinterland eroded hills mar the landscape. Their only farm lands are along the river on the first bottoms, or vegas, and these are only fit for agriculture when they are irrigated...

Chipman (1992:6, 8-9) relates that the Spanish settlers in the region were less influenced by climate than were the later Anglo-American and European settlers. It seems that the climate encountered by the Spaniards in the southern part of Texas was more-or-less similar to the climate of their native land (Chipman 1992:9). Nevertheless, even the early Spanish settlements within the study area appear to be distributed along the margins of the two rivers, most notably the Rio Grande.

OBSERVED EFFECTS OF THE DROUGHT ON ARCHAEOLOGICAL SITES

There are literally thousands of archaeological sites in the study area (Boyd n.d.), although only a few hundred have been formally recorded. Most of these sites are on the U.S. side of the Rio Grande. Surveys on the U.S. side of Falcon Reservoir have not been comprehensive in scope, and have mainly been limited to salvage operations performed just prior to the building of Falcon Dam and Reservoir (cf. Cason 1952:218-259; Hartle and Stephenson 1951; Krieger and Hughes 1950). More recent surveys (e.g., McCulloch and Warren 1998, n.d.; Perttula et al. 1996) and excavations (Quigg and Cordova 1999, 2000) have greatly complimented the earlier 1950s surveys.

Very few formal archaeological surveys of any magnitude have been performed on the Mexican side of the river. A small number of limited surveys were completed on the Tamaulipas side of the Rio Grande just prior to the building of Falcon Dam (cf. Aveleyra Arroyo de Anda 1951:31-59). Only the work in the last few years of a few avocational archaeologists (e.g., Boyd et al. 1997:387-425) has brought to light the character and diversity of some of the archaeological sites on the Mexican side of the river. Much archaeological work remains to be done in this part of Mexico and adjacent locales in Texas.

During recent surveys of various archaeological sites in the study area, it has been noted that the appearance and character of the landscape has changed dramatically during the last few years, to an especially pronounced degree within the last year. The sustained lack of rainfall has caused a gradual decline in the amount of vegetation on most of the prehistoric sites in the region. This has increased the percentage of ground surface that is visible, and in turn, extensive exposure of the archaeological surface and near-surface deposits has also occurred. The overall effect is that sites that were previously visible only to a limited extent at the surface are now fully exposed. The increased exposure of archaeological deposits on or near the surface has had secondary effects, including exposure to the sun and its drying effects, and exposure to the wind. In many of the sites the archaeological deposits near the surface have dried to such a degree that the character of the surrounding soil matrix has become desiccated. The result is that the soil near the surface, once fairly stable, has been altered to a sandy or dusty consistency, and is prone to being blown away during windy periods. During most of the year, there is a steady southeasterly wind in much of the study area.

The soil matrix near the surface in many of the archaeological sites in the region is now nearly fully exposed to the elements. This degree of exposure is increasing steadily as the current drought-like conditions persist. Although erosion by rainfall is not occurring during the drought, the drying of the sites and the loss of plant cover is resulting in such a bleak and barren landscape that they will be subject to severe erosion during the next period of sustained rainfall. Thus, the cyclic combination of sustained droughts, followed by a general desiccation of the landscape, and subsequent exposure to heavy rainfall once the drought terminates, is capable of causing severe erosional effects on archaeological sites.

In other prehistoric archaeological sites in the region, the consistency of the soil matrix near the surface has changed to a hard, sun-baked and cracked appearance (Boyd n.d.). This is the opposite effect of that discussed above, where the character of the soil near the surface has changed to a sandy or powdery consistency. The differences observed between these various sites appear to be a result of, at least partially, the types of soil present within each particular site. In archaeological sites where the surface has hardened, there is less susceptibility to erosion by wind, or by eventual rainfall. However, the consistency of soil in these sites makes it much more difficult to perform excavations.

SUMMARY

The current drought-like conditions in South Texas and northeastern Mexico are having an adverse effect on the countless archaeological sites located there. Such drought conditions have occurred at various times in the past, even to a much greater degree, and are likely to recur on a periodic basis in the future in this semi-arid region. It appears that preservation conditions for archaeological sites may, in fact, be stabilized to a degree during periods of regular precipitation. The precipitation stimulates plant growth, including grasses, which in turn shield the surface soil. The promulgation of plant growth creates a shield that effectively inhibits erosion to a considerable degree, preventing deflation of archaeological deposits by wind erosion, or undercutting or gullying of the deposits during periods of heavy precipitation.

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PETROGLYPHS AND OTHER RELATED FEATURES IN THE LOWER PECOS REGION OF SOUTHWEST TEXAS

Joseph H. Labadie

ABSTRACT

Rock art encompasses pictographs, produced by painting or drawing on rock surfaces; and petroglyphs, produced by carving, pecking, incising, or abrading patterns directly into the rock surface. The Lower Pecos River Region of southwest Texas is internationally known for its world-class pictographic rock art. But petroglyphs in the region are few, with the notable exception of the Lewis Canyon petroglyph site, where two petroglyph styles have been defined. This paper discusses many of the lesser known petroglyph sites in the Lower Pecos River Region and provides additional information on cupule sites for the area.

BACKGROUND

The Lower Pecos River Archeological Region is located in southwest Texas (Figure 1). The region encompasses several hundred square miles of Texas and northeastern Mexico adjacent to the Middle Rio Grande Valley. This region, where the Pecos and Devils Rivers enter the Rio Grande, is a veritable biotic paradise by comparison to adjacent geographical regions. The relatively flat and rolling hills of limestone in the region have been deeply incised by three great river valleys. The region contains literally thousands of cliff overhangs and dry rock shelters and dozens of caves. The Lower Pecos River region contains one of the longest, best preserved, and most thoroughly researched archaeological records of human prehistory in Texas.

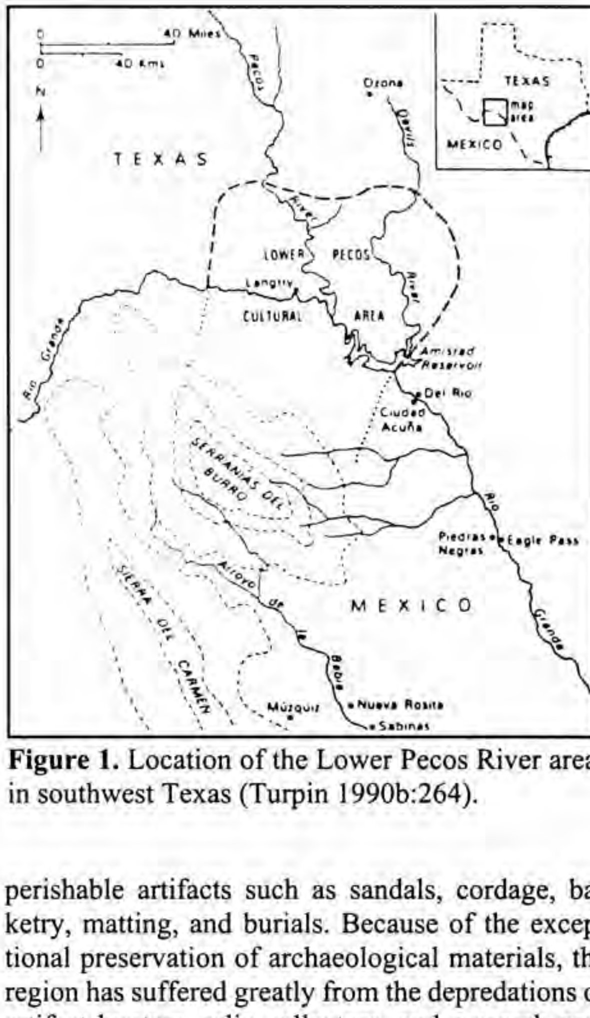

Figure 1. Location of the Lower Pecos River area in southwest Texas (Turpin 1990b:264).

PREVIOUS RESEARCH

Relatively constant annual temperatures and humidity levels in the dry rock shelters are responsible for the excellent preservation of archaeological materials in sites throughout the region. Many sites contain the desiccated remains of plants, the by-products of prehistoric subsistence activities, and perishable artifacts such as sandals, cordage, basketry, matting, and burials. Because of the exceptional preservation of archaeological materials, the region has suffered greatly from the depredations of artifact hunters, relic collectors, and research projects.

The first known archaeological excavations occurred in the region during the late 1920s. In the 1930s alone, five different institutions (Smithsonian, University of Texas, Gila Pueblo, Texas Tech, and Witte Museum) sponsored major field projects to excavate the region's many rock shelters to dig for museum specimens. A second major period of intense field research occurred from 1958 to 1970, when National Park Service (NPS) funded preinundation research for Amistad Reservoir (originally called Diablo Reservoir), surveyed about 300 archaeological sites and excavated 22 major sites in the region. Native American sites range in age from about 10,000 BC to the mid-nineteenth century. The NPS preinundation research for Amistad Reservoir resulted in the systematic recovery of the largest single collection of archaeological materials from the Lower Pecos, estimated to contain in excess of 1,000,000 individual objects (Labadie 1990). To date, archaeologists have documented roughly 1,000 prehistoric sites adjacent to Amistad Reservoir (Labadie 1999).

In addition to the archaeological materials, the Lower Pecos River region contains world-class pictographic rock art sites. Research on the pictographs began in the 1930s and remains the prime focus for most regional research (Jackson 1938, Kirkland and Newcomb 1967; Labadie 1990, 1992a, 1992b; Labadie, et al 1997; Newcomb 1961; Shafer 1986; Turpin 1982, 1984, 1986a, 1986b, 1986c, 1986d, 1988a, 1988b, 1989, 1990a, 1990b, 1990c, 1993, 1994; Turpin and Bass 1997; Zintgraff and Turpin 1991). A total of five distinct prehistoric pictograph styles have been defined (Turpin 1990b) for the region, each with specific implications about the prehistoric societies that produced them (Figure 2). Four different temporal periods for historic period Native American pictographs have also been reported (Labadie, et al 1997).

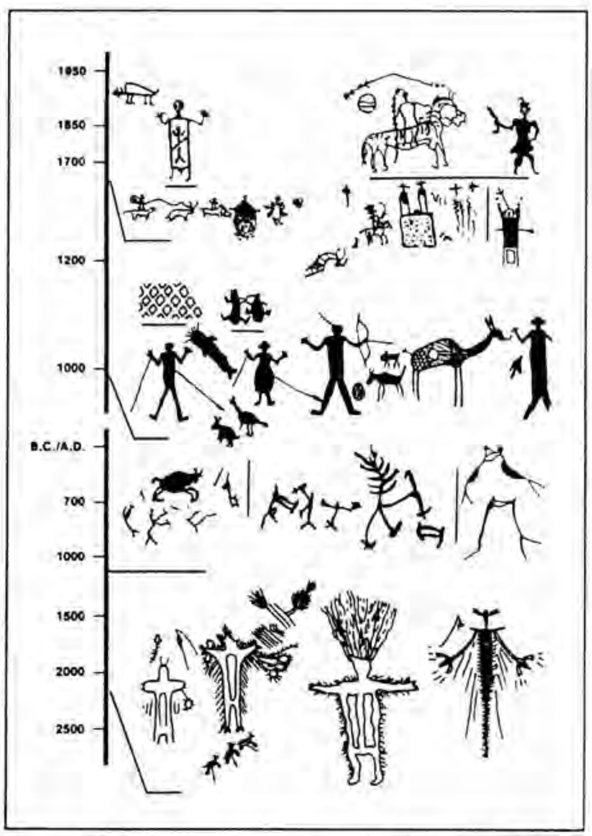

Figure 2. Pictograph sequence for the Lower Pecos River region (Turpin 1990a:118).

With over 300 known pictograph sites in the region, the area is among the densest concentrations of Archaic pictographs in the country. Some rock art sites consist of only one or two small (5 cm) painted images in red or black. At other sites, there are multiple pictograph panels, with 4-meter-tall images, in polychromatic colors, stretching over 95 meters along the rear wall of some shelters.

RESEARCH ON PETROGLYPH SITES

Rock art research in the Lower Pecos began in the 1930s with the concurrent work of A. T. Jackson (1938) and Forrest Kirkland (1937a, 1937b, 1938, 1939; Kirkland and Newcomb 1967). Between them, these two individuals recorded about 75 pictograph and three petroglyph sites. From their research, two distinctive styles of petroglyphs emerge based on design elements and methods of manufacture as determinants. Neither of the two styles was ever formally named.

The most common of the two types of petroglyphs consist of design elements made from shallow pecked grooves that are U-shaped in profile and exhibit considerable natural weathering. Such grooves generally average about 1 cm in depth by about 1-1.5 cm in width. Design elements frequently are circles or are composed of curvilinear lines. These petroglyphs may have been made using a small hammerstone or pick-like instrument. Jackson (1938) notes that it was common to find small, thin, flat hammerstones at petroglyph sites in a number of west Texas counties such as Brewster, Culberson, and Terrell (all west of the Pecos River and Val Verde County).

The second type of petroglyph was made by incising or scratching designs into the rock surface using a sharp-edged instrument, such as the edge of a flint flake, which produced a V-shaped groove about .1-.2 cm in both depth and width. The walls of the grooves are generally rough. This is in stark contrast to the smooth, polished, and occasionally lipped grooves of another type of archaeological feature common in the region known as incised grooves.

Incised grooves commonly range from .2 to .8 cm in width and up to 2.0 cm in depth. Such grooves rarely are more than 15-20 cm in length and often occur randomly in great numbers or as isolated grooves at the edges of rock shelters, in bedrock ledges at the rear of shelters, or on roof spalls within the interior of rock shelters; they are infrequently found in unprotected areas (Labadie 1992b). These V-shaped grooves are always deepest and widest in the center and gently taper to each end. The often highly polished and smoothed interiors of the grooves have led most researchers to believe that they were used to sharpen bone awls or wooden or antler tools (Kirkland and Newcomb 1967:59).

In general, the number of known petroglyph sites dramatically increases as one goes west from the Pecos River (Shafer 1986:170). As with the pictographs, most researchers believe that indigenous groups made some of the region's petroglyphs while other examples are the products of intrusive groups from the Great Plains or Northern Mexico. Jackson (1938:459-460) notes that the distribution of petroglyph sites he recorded in Texas produced by pecking were generally limited to the Trans-Pecos area of west Texas and Northern Mexico, while petroglyphs with carved designs were generally farther to the east, suggesting to him that the petroglyphs were produced by two different cultural groups.

Petroglyph sites in the Lower Pecos region have received very little attention in the archaeological literature. Most of the research has been focused on the Lewis Canyon Petroglyph site on the Pecos River (Jackson 1938; Kirkland and Newcomb 1967; Bass 1989; Turpin 1993, 1994; Turpin and Bass 1997). Recent research by Bass (1989, Turpin and Bass 1997) has focused on the possible astronomical interpretation for several of the petroglyphs at Lewis Canyon.

Except for the Lewis Canyon site, researchers have generally side-stepped most of the questions on the antiquity, function, and authorship of the petroglyphs. There has long been the temptation, by archaeologists at least, to view petroglyphs and pictographs only in terms of the materials excavated from nearby archaeological contexts.

PETROGLYPH SITES IN THE LOWER PECOS REGION

This section of the paper presents information on most of the known petroglyph sites in the Lower Pecos region. Undoubtedly, a few sites have been overlooked which is due, in part, to the failure of some archaeologists to publish or to effectively communicate with all interested people in the research community. The nomenclature used in this report to describe petroglyph design elements has been borrowed from the Texas Parks and Wildlife Department's Rock Art Recording Manual (TPWD 1990). The TPWD Manual is based on the final report of the American Rock Art Research Association Nomenclature Committee (ARARA 1983).

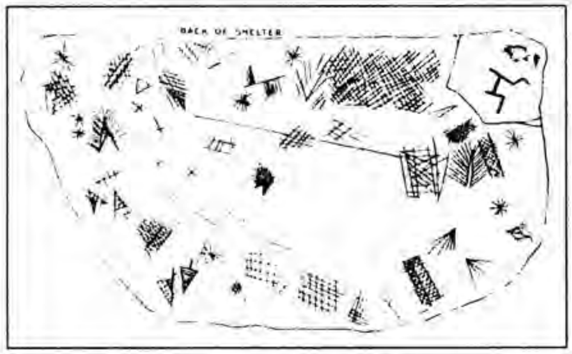

Figure 3. Kirkland's illustration of the petroglyphs at his Pecos River Site 7 (Kirkland and Newcomb 1967:90, Plate 50).

Kirkland's Pecos River Shelter 7

This site was described by Kirkland (Kirkland and Newcomb 1967:Plate 51, No. 2) on July 12, 1938, as:

> ...a small shelter at the base of the cliff about 15 feet wide by 10 feet deep. It is semicircular, with a layer of ashes on the floor and smoke-blackened ceiling. The only pictographs are a small design in red and a couple of splotches in the same color that may have been handprints. They were painted on parts of the ceiling where the soot had flaked off. The principle designs were scratched on the black ceiling with a fine-pointed tool, appearing light against the dark background. The copy shows them in reverse. Most of the designs had been smoked since they were made and now appear grey. Names and dates as early as 1881 on the same surface are still fresh and white. The nature of the scratchy designs made absolutely accurate copying impractical. Only the general effect and approximate location of each design was attempted. No attempt was made to represent every line correctly.

Kirkland's illustration (Figure 3) indicates that a number of design elements are present at this site. Recognizable designs include crosses, asterisks, one-pole ladders, diamonds made from multiple parallel intersecting lines, and grid-like geometric designs made from parallel lines intersecting at various angles.

Kirkland's Tardy Draw Site

Kirkland described the site (Kirkland and Newcomb 1967:Plate 50, No. 1-4) on July 4, 1938, as:

> ...a shelter being about 100 feet long, seven feet high in front and about 20 feet deep. It has no deposit on its rock floor, but the ceiling is smoked very black. There is a deep permanent waterhole in front of the shelter, beside which are a few mortars. Across the draw are several large burned rock mounds. Just back from the painted pictures were small ledges on the ceiling blackened with smoke. A great deal of scratchings and carvings had been done on these surfaces with a sharp instrument. It appeared white on black background, but was copied in reverse. The work was unquestionably that of the Indians because several arrowhead-like designs had been painted over with the same red paint used to make the hand prints. No attempt was made to copy every scratch exactly, but general style and shape of the designs is well represented.

The red hand prints Kirkland notes are today considered (Turpin 1990b:273) as a minor motif common at many Red Monochrome style pictographs sites in the region. A major design element of the Red Monochrome style pictographs is the depiction of the bow and arrow, which would date such pictographs to sometime after A.D. 600 (Turpin 1990b: 274).

Recognizable design elements in Kirkland's illustration include asterisks, parallel lines, lines with attached rows of short lines, and diamonds made from multiple intersecting lines. There are at least 11 arrow designs of which three have contracting stems and six have parallel stems.

Kirkland's Lookout Shelter (41VV230)

Kirkland visited a site he called Lookout Shelter on July 8, 1937 and documented about half-a-dozen Pecos River style pictographs on the rear wall of the rockshelter. One of the anthropomorphic figures has, since 1995, been illustrated on T-shirts given out by Amistad NRA to volunteers assisting with archaeological field projects. Kirkland also described several large rocks within one of the shelter's overhangs as being almost completely covered with grooves and tree-like designs which he believed had been cut into the rocks for sharpening tools (Kirkland and Newcomb 1967:59, Plate 22).

The waters of Amistad Reservoir have periodically inundated this shelter since 1969. Although the site was re-recorded by Turpin (1982:97-98), the reservoir level prevented a reexamination of the boulders with grooves and designs described by Kirkland. In August of 2000, the author visited this site and it was completely exposed due to near-record low lake levels. The depth of the lake at the confluence of Seminole Canyon at the Rio Grande was less than 3 feet in depth, prompting the National Park Service to remove the boat dock at Panther Cave and close the site to visitors until higher lake levels return.

Lookout Shelter consists of several small overhangs that collectively have been designated as site 41VV230. There are in excess of 60 bedrock mortar holes (10-12 cm in diameter) in addition to dozens of grinding facets and slicks scattered across the floor. There are several boulders outside the shelter's primary dripline that are covered with mortar holes like the boulder on the interpretive trail within Fate Bell shelter. There is a dense scatter of fire-cracked rock and dark, ashy soils on the talus slope below the shelter. The pictographs documented by Kirkland could not be found and presumably have been covered by silt and other organic matter from years of inundation

The large boulders described by Kirkland are situated in the middle of one of the several overhangs at the site. They are covered on all sides by more than 150 individual incised grooves of which only a few intersect each other. Mixed in and among the incised grooves are at least 5 distinct sets of chevrons that have V-shaped grooves incised into the rock surface. There are also a few tree-like designs, asterisks, asterisks on poles, and a few zig-zag lines. The designs are very similar to ones described in this paper for the Satan Canyon site (41VV39).

Satan Canyon Site (41VV39)

Grieder (1965:2) recorded two pictograph sites (41VV39, 41VV40) in Satan Canyon about one mile from the Devils River. He notes that there are petroglyphs at site 41VV39 although he did not document them:

> ...41VV39 has a semicircular interior wall about 300 feet long with badly faded paintings covering the whole length of the wall, from floor to ceiling in many places. The front part of the ceiling collapsed in ancient times and simple petroglyphs appear on the fallen rocks.

The writer visited the site in the spring of 1989 with Buck King and documented many, but not all, of the petroglyphs. A large pile of roof spalls is situated at and within the shelter's dripline and covers roughly three-fourths of the shelter's interior. The ancient roof collapse stacked the rocks, some of which are over 3 meters by 1.5 meters, 5 and 6 rocks high. At the highest point, the rock pile rises nearly 4 meters above the shelter's floor. Petroglyphs on 12 different roof spalls were drawn and photographed during our visit.

Many of the roof spalls exhibit a dizzying variety of scratched lines and designs. Most of the petroglyphs are situated on flat rock surfaces that were not parallel of the floor. No more than one side of any single rock held petroglyphs.

Figure 4. Incised groove petroglyphs at site 41VV39.

The majority of petroglyphs at this site have V-shaped grooves incised into the relatively smooth limestone rock surfaces by using a sharp instrument. The interiors of the grooves, which range from .1 to .15 cm in width, are generally unweathered. There is a variety of different design elements, few of which are repeated, including designs composed of diamonds and nested triangles (Figure 4), intersecting parallel and curvilinear lines, arrows (chevron with a single line extending from the apex), and connected wavy lines with crosshatched interiors.

Four petroglyphs with U-shaped grooves were found. The grooves range from 1 to 1.5 cm in both width and depth. The design elements are of simple linear composition, including meandering curvilinear lines, a chevron with a long single line extending from the apex (Figure 5), a one-poled ladder attached to an extended line, and a short groove with rows of short lines at one end.

Additionally, several rock surfaces with petroglyphs are literally covered with shallow pecked splash dots and cupules. On one rock surface there

Figure 5. Pecked groove petroglyphs at site 41VV39.

are several isolated lines of cupules in addition to a chevron design made from two lines of cupules (Figure 6). These cupules are nearly uniform in size (1-1.25 cm in width). A second rock has more than 70 small (.2-.5 cm in width) splash dots pecked into the only smooth surface on the boulder. In some areas, there appears almost to be a pattern to the splash dots while in other areas it seems the dots are randomly dispersed across the rock surface.

Figure 6. Lines of cupules at site 41VV39

Lewis Canyon Petroglyph Site

The Lewis Canyon Petroglyph site was recorded by both Jackson (1938:199-205) and Kirkland (Kirkland and Newcomb 1967:98-104). Additional information about this site can also be found in Shafer (1986:168-169), Bass (1989), Zintgraff and Turpin (1991), and Turpin and Bass 1997). This site has long been considered an enigma by all who have studied the rock art in the Lower Pecos.

The Lewis Canyon site is situated on an east canyon rim above the Pecos River located about 25 miles north of the river's junction with the Rio Grande. The site covers roughly 8-9 acres of nearly level exposed limestone bedrock which slants at a surface angle of about 2-3 degrees, east to west, towards the river. In addition to the petroglyphs, there are at least two nearby pictograph sites (Pecos River and Red Monochrome style), a long linear accumulation of fire-cracked rocks adjacent to the canyon rim overlooking the river, three circular rock features east of the petroglyphs, and a general surface scatter of lithics concentrated along the lower margins of the 8-9 acres.

Figure 7. Petroglyphs made in the bedrock surface, Lewis Canyon petroglyph site.

The primary concentration of petroglyphs covers an area of about 2-3 acres. All petroglyphs are pecked into the horizontal bedrock surface. The limestone ground surface over much of the site has a near continual, well-established growth of dark lichens. Most petroglyphs are easy to see and are well defined by the dense lichen growth (Figure 7). Although every single petroglyph has not been studied, the writer has found only petroglyphs made with U-shaped grooves.

Two major concentrations of petroglyphs contain about 95% of the total number of petroglyphs currently known at the site. Jackson (1938: 201) classifies 161 individual design elements. Kirkland's drawings of the site (Kirkland and Newcomb 1967:Plates 56-63), depending on their interpretation, contain more than 577 separate elements. Kirkland notes (Kirkland and Newcomb 1967:99) that "...only three or four unimportant designs fell outside the area included in the copies" (Plates 56-63).

Figure 8. Petroglyphs composed of connected outlined circles, Lewis Canyon.

The most common design element is the outlined circle (Figure 8). There are at least 225 separate design elements utilizing the basic design of a circle. The majority of the designs range from 10 to 20 cm in diameter. There are isolated circles, clusters of circles, connected circles, chains of circles, tailed circles, tasseled circles, rayed circles, concentric circles, bisected circles, circles with a single dot in the center, dot ringed circles, and circles made from dot patterns.

There are at least 179 linear design elements. There are single lines, parallel lines, wavy lines, curved lines, U-shaped lines, enclosed wavy lines, zigzags, rake-like elements, and rectilinear and

Figure 9. Petroglyphs resembling projectile points, Lewis Canyon.

curvilinear meandering lines. There are only a few elements which could be called counterclockwise spirals, maze patterns, chevrons, crosses, squares, grids, diamonds, steps or projectile points (Figure 9). The general surface area of the site is naturally pitted with small symmetrical holes ranging rom 1 cm to over 4 cm in diameter. Some of these pits could very well be cupules. There are at least 23 cases where petroglyphs incorporate pecked dots (or perhaps natural pits or cupules) as the basic design element. These include tailed dots, rows of dots, paired dots, dots used to form triangles and squares, single dots bisected by lines, and dot patterns which form circles. In some design elements, dots are used as accents around circles, adjacent to curved lines, and, on two of the three 8-spoked asterisks, dots have been placed on the tips of five of the eight rays. There are petroglyphs that apparently depict lizards, insects, turtles, spiders, animal tracks, hand prints, and several human representations.

Based on recent conservation work at the site, Turpin (Turpin and Bass 1997:1) has defined two distinct styles among the 1,000 or so petroglyphs at the site, based on iconography, sophistication of the design, horizontal distribution, and relative elevation within the site. The older of the two styles, termed Lower Pecos Serpentine Style is dominated by curvilinear lines, both separate and nested in series of two and four. A design interpreted as an atlatl is the most common representational motif among the many abstract designs and is used to tentatively assign an Archaic date (prior to A.D. 600-1000) to the style (ibid).

Occurring at slightly higher elevations at the site are a style termed the Lower Pecos Discrete Geometric Style (Turpin 1997:1). About 770 of the roughly 1,000 petroglyphs at Lewis Canyon are grouped within this stylistic type. Although this style also contains mostly geometric designs, they are not ..."conceptually joined by any other artistic device such as horizontal baselines, enclosures, or vertical system"(ibid). A design interpreted as a bow and arrow is used to place this petroglyph style in the Late Prehistoric period, post A.D. 600.

Fate Bell Rock Shelter (41VV74)

Fate Bell rockshelter (named after one of the original landowners, Patty Fate Bell Moorehead Sullivan) is one of the largest and best known rock shelters in the region due mainly to the public tours that are offered to the site by Seminole Canyon State Historical Park. The site has massive burned rock midden deposits and numerous Pecos River style pictographs which cover over 100 meters of the shelter's rear wall (Kirkland and Newcomb 1967:Plates 12-13). A single petroglyph has been reported (Turpin 1982: Table 5; Shafer 1986:168) but was not described in detail.

There are several large roof spalls, fallen from the ceiling in ancient times, that are situated roughly at and slightly within the shelter's dripline. Several of the smaller roof spalls have multiple shallow grinding facets on the upper surfaces of the rocks. On one of the smaller roof spalls, a single petroglyph has been pecked into the rock's surface (Figure 10). The petroglyph is located on a side of the rock that is roughly perpendicular to the ground surface. The abstract design covers an area about 80 cm by 90 cm.

Figure 10. Petroglyph on side of fallen rock spall at 41VV74 (Fate Bell Shelter).

The design is composed of a series of connected lines and circles which are all about 1 cm in width by .6-.8 cm in depth; the grooves are all U-shaped in profile. The interior walls of these grooves exhibit some weathering, but nothing like that of the adjacent rock surfaces. Turpin (Turpin and Bass 1997:2) notes that there is a similar petroglyph made from sinuous lines similar to this one located at site 41VV643 on the Rio Grande.

The rock surface on which this petroglyph has been packed is very shiny; the interiors of the petroglyph's grooves are relatively unweathered by comparison. The polish on the rock surface is apparently natural, looking much like desert varnish or a deposit of silcrete, and is fairly common on other rock surfaces throughout the region. Due to the proximity of this rock to the interpretive trail at the site, some of the surface polish may also be attributable to the many visitors who tour the site twice daily in organized groups.

Painted Canyon Shelter (41VV78)

Painted Canyon Shelter is located in a side canyon near Seminole Canyon on the Rio Grande. The site is most noted for its pictographs which stretch nearly 90 meters along a canyon wall just above the stream bed (Jackson 1938:Frontispiece, 229; Kirkland and Newcomb 1967:Plates 47-49). The site is unusual in that there are three different styles of pictographic rock are represented; it is most noted for its Red Monochrome style pictographs. There is also a large burned rock midden and a historic homestead (circa. 1880) which have a commanding view of the numerous rock art panels across the canyon.

The canyon in which portions of site 41VV78 is located is subjected to frequent flash flooding which has taken a tremendous toll on the rock art panels. There are a number of large, stream-rolled limestone boulders directly in front of a long panel (over 12 meters) of Red Monochrome pictographs. Several of the large rocks with mortar holes, now lying on their sides, attest to the force of canyon flooding.

One boulder in the streambed, less than three meters from the Red Monochrome pictographs, contains numerous cupules. The cupule(s) (Figure 11) are in an upright position, whereas a boulder 1.5 meters away has one deep cylindrical mortar hole on the side of the rock–this boulder has 9 cupules pecked into the upper surface of the rock. The cupules range from 2.0 cm to 4.0 cm in depth.

The writer had been to this site dozens of times before noticing the cupules. I had thought little about them until Ken Hedges (San Diego Museum of Man) told me that, in California and the desert southwest, such features were known as cupules and were considered to be a type of petroglyph. As Sanger and Meighan (1990:38) have noted, unless you have cupules in mind and are looking for them, you aren't likely to notice them.

Figure 11. Cupules pecked into an upright boulder at site 41VV78. The rock with cupules is situated in a canyon bottom less than 1.5 meters away from a panel of Red Monochrome style pictographs.

Site 41VV237

This site is located on the west bank of the Pecos River about 8 km from the Rio Grande. The site is a large rock shelter most noted for its well-preserved Pecos River style pictographs and deeply buried perishable cultural deposits. The pictographs at the site have been documented by a number of researchers (Jackson 1938, Kirkland and Newcomb 1967: Plate 33, Shafer 1986).

In 1990, the author visited this site and set down his backpack and camera bag on a large roof spall situated just inside the shelter's dripline, and proceeded to photograph the nearby pictographs. This boulder has numerous grinding facets and mortar holes on the horizontal rock surface. When preparing to leave the site, a petroglyph (Figure 12) was found (much to the author's surprise) on the boulder's surface underneath where the camera bag had been placed. Upon closer examination, two separate concentric circle design elements were identified. The larger of the two circle designs has eight lines radiating from the outer circle. The second design element consists of two smaller concentric circles without radiating lines.

The El Caido Site

The El Caido site, located a short distance south of the Rio Grande in Coahuila, Mexico was previously reported by Labadie (et al. 1997). A unique aspect of this site is that there are both petroglyphs

Figure 12. Petroglyph at site 41VV237.

and pictographs in addition to elements that combine both techniques into a single image. Panel B has at least 13 images consisting of both pictographs and finely incised drawings with painted highlights. The petroglyph design elements include depictions of tepees, individuals attired in breechcloths, and several figures with feathered headdresses and lance.

These depictions are consistent with design elements collectively termed the Plains Biographical style (Keyser 1987) which are considered to be the product of intrusive Native American groups that traversed the Lower Pecos River region beginning in the late 16th century and continuing all the way up to the late 19th century. For an in depth discussion of historic petroglyph and pictograph sites in the Lower Pecos the region, the reader is referred to Turpin (1988a, 1988b, 1989) and Labadie (et al 1997).

41VV123

Located in a small side canyon on the east bank of the Pecos River, this site contains badly deteriorated pictographs some of which have been classified as Red Monochrome rock art. The rock overhang on which the pictographs have been painted could be a poster-child for all the natural processes that are affecting rock art sites throughout the region: spalling, insects, lichens, calcium carbonate staining, whewellite and calcium oxalate crusts, salt and plant-root wedging, and abrasion by wind and water.

The floor of this overhang is littered with both large and small rocks, many of which are the product of flash flooding which brought the materials down the drainage from the slopes and uplands above. This area is also vegetated by well-established plants and trees and affords the modern visitor a bit of shade (while providing lunch to a healthy mosquito population) along an established trail that terminates below the White Shaman site (41VV124).

Among the small boulders that litter the overhang's floor, several rocks nearest the rear wall of the overhang have small, conical-shaped depressions. These small depressions do not appear to be the product of kettling (bedrock erosional features created by sediment trapped in flowing water) as the cupules are situated on a number of different rocks which are in a variety of microtopographic settings. One rock with a single cupule is less than one meter from a severely deteriorated Red Monochrome (?) pictograph.

41VV72 (Seminole Watering Hole)

Located in Seminole Canyon State Historical Park, this site is among the region's better known Red Monochrome rock art sites and has been discussed in Kirkland and Newcomb:1967:82-85), Turpin (1982:56-61), and Boyd (2000). Boyd provides a description of the remaining rock art and a detailed discussion of the site's dizzying number of mortar holes within a broader regional discussion of grinding features. Boyd (ibid.:58) notes: "Also present, and quite rare in the geographic region, are 'cupules', possibly representing former nut-processing activities at this site" and also mentions that these features are present at sites 41VV78 and 41VV123.

41VV75

This site is a large rock shelter, with deeply stratified archaeological deposits, located in Seminole Canyon about .5 miles from Fate Bell Rockshelter. The site contains a great number of poorly preserved Pecos River style pictographs. It was at this site that Texas A&M University researchers obtained the first radiometric date for Pecos River style rock art (3865 ± 100 years B.P.) for a red pigment sample taken from a detached roof spall (Russ, Hyman, Shafer, and Rowe 1990; Russ, J., M. Hyman, and M. Rowe 1991).

There are several large roof spalls within the dripline at the down-canyon end of this shelter. The upper surface on two of these roof spalls contains a number of shallow, elliptical grinding facets (some may term them grinding slicks) and several large (10-12 cm in diameter) mortar holes. Both Jackson (1938:209) and Turpin (1982:89) note the presence of the large mortar holes in boulders.

Within the interior of one of the shallow grinding facets, very near a deep mortar hole, a single tree-like design has been carved into the rock surface (Figure 13). The groove used to make the design is

Figure 13. Boulder in 41VV75 with several shallow grinding facets and large mortar holes. Note tree-like groove in center of one facet.

roughly 1 cm in width by .6-.7cm in depth; the groove is V-shaped in profile. Some have speculated that the design is a petroglyph while others believe that the grooves are a subsistence related feature used to channel liquids to the center of the depression. It's difficult to say with any certainty what this feature really is as the author knows of no other similar case in the region.

SUMMARY

Turpin (1997) has persuasively argued that there are two distinctive petroglyph styles present at Lewis Canyon based on a variety of attributes. She believes that hunting magic was the impetus for ritual behaviors whose by-product was the petroglyphs that we see today. Lewis Canyon is, however, unique within the Lower Pecos Region in terms of its overall size and number of petroglyphs. This writer does not wish to rush to typological judgment on whether or not the U-shaped grooved petroglyphs described in this paper (41VV39, 41VV74, 41VV327) can be confidently placed within either style defined by Turpin for the Lewis Canyon site due mainly to the differences in topographic settings and archaeological contexts.

There are two distinctive techniques used to make the Lower Pecos region petroglyph design elements: one that produced U-shaped grooves (and cupules) such at those at Lewis Canyon (and sites 41VV39, 41VV74, 41VV643, 41VV237) and one that produced V-shaped grooves which are most often found on isolated boulders in rock shelters or under overhangs (Kirkland's sites Pecos River Shelter #7, Tardy Draw, and Lookout Shelter [41VV230]; El Caido, and 41VV39). Admittedly, the specific technique chosen to execute a design, be it a petroglyph or pictograph, is only one aspect of style (Shaafsma 1980:25) and cannot alone be used to define multiple styles.

Although the sample size is relatively small (N=9), there are distinctively different design element inventories associated with the two methods of manufacture. Part of the difference in design elements is attributable to the method chosen to make the petroglyphs. Direct or indirect percussion techniques produce bold, well-defined designs while incising tends to produce delicate linear designs with more detail. The design element inventory of the incised-groove petroglyphs is much more restricted than the inventory for the pecked-groove petroglyphs. The incised-groove designs are limited to fine-line linear patterns of intersecting parallel lines and geometric designs with crosshatched interiors; conspicuously absent are the circles, curvilinear lines, and zoomorphic and anthropomorphic representations common to the pecked U-shaped groove design element inventory.

Cupules in the Lower Pecos region have received little attention in the literature (Boyd 2000, Labadie 1992) and were first reported at sites 41VV39 and 41VV78 (Labadie 1992). They have been interpreted as being a type of petroglyph often found in direct association with Red Monochrome rock art and unrelated to subsistence activities (ibid). It would appear that there are now at least four sites in the Lower Pecos where cupules are present (41VV39, 41VV72, 41VV78, 41VV123) suggesting that this feature type may be more pervasive than previously believed. At three of the four sites, the cupules are found pecked into boulders in stream bottoms situated in a contextual association with Red Monochrome pictographs. How did cupules function within the societies that originally created them— as petroglyphs (Labadie 1992) or as acorn processing features (Boyd 2000)? More work is definitely needed in order to verify their function (ibid.)

The distribution of the nine petroglyph and four cupule sites discussed in this paper all fall well within the geographic area known for Lower Pecos River pictographic rock art. Most sites are multicomponent, indicating near continuous use over several thousand years with the exception of the El Caido site, which is thought to date to the late 19th century. There appears to be no direct connection between the petroglyph sites discussed here and any specific land forms, natural springs, river crossings, or known game trails.

The question(s) of how the various types of Lower Pecos Region rock art may have functioned within the prehistoric societies that created them will never be satisfactorily answered. Direct interpretations from ethnographic and historic accounts are not possible as there is very little ethnographic or historic accounts concerning any Native American Groups at, or after, European Contact (1590) in the region. The presence of Plains Indian groups in the Lower Pecos increased significantly after the Great Pueblo Wars of 1680. Tribes identified by the Spanish as raiders of northern Coahuila include Apache, Kiowa, and Comanche. There are no Native American Groups who currently claim any portion of the Lower Pecos Region as an ancestral homeland, as sacred lands, or as the loci for traditional use. As of yet, indirect interpretations using archaeological remains have not been very fruitful. Several types of portable art forms have been known for years, such as painted pebbles and unfired clay figurines, but no specific relationships between these, or other artifact types, and the pictographs have been established.

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A KAOLINITE PENDANT FROM CROCKETT COUNTY: TRADE OR TRAVEL?

Solveig A. Turpin

ABSTRACT

An incised pendant found on the surface of a complex camp site in Crockett County is made of commercial quality kaolinite, not found in Texas. The geometric design consists of crosshatched and parallel lines with little interpretive potential but the raw material represents either long distance trade or travel.

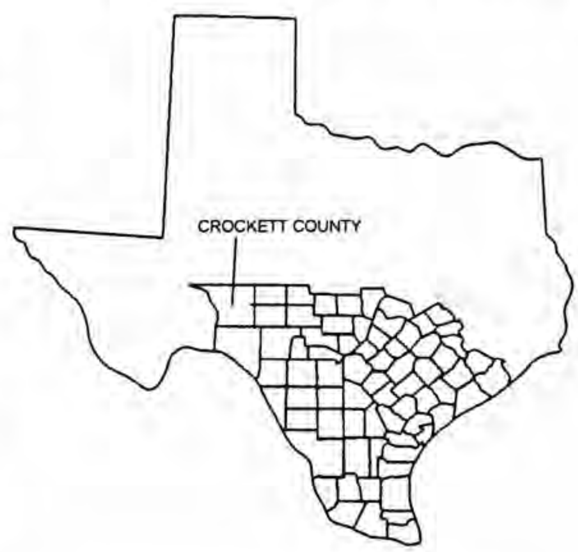
BACKGROUND

As countless articles in *La Tierra* and other venues confirm, the desire for ornamental objects is timeless and that desire is often expressed by incising or engraving stone, bone, shell, pottery, and any other medium that will hold a design. Thus, the finding of a delicately incised pendant fragment of lustrous white material on an isolated site in the arid lands of Crockett County is more notable for its implications for long-distance travel or trade than for the intrinsic beauty of the object, although the latter is undeniably of interest.

This unusual piece of jewelry was found on 41CX880, one of the more complex oasis sites recorded on University Lands in Crockett County (Figure 1). In the midst of the arid plain east of the Pecos River, an intermittent tributary has eroded down to limestone bedrock, forming a rock-bottomed tinaja of considerable size. The tinaja was a desiccated mudhole during my first two visits to the site but the later two recording trips found it full and holding water for at least three weeks in the absence of additional rains. The reliability of this water hole can be estimated from the scores of mortar holes that line its banks, the dozens of burned rock mounds and hearths that blend into a solid carpet of burned rock above it, a series of unusual stone alignments and cairns, and, a few hundred meters away, the dried-laid rock walls of what may have been a late 19th century relay station. Dart point styles and historic artifacts reflect Early Archaic to Historic use of the site, not unexpectedly given the rarity of water in this part of the county. The pendant was exposed on the surface on the far perimeter of the site, several hundred meters from the tinaja and even further from the historic occupation, but it could not be associated with any feature or other artifacts. It is, however, clearly Native American in origin although its bearer may well have arrived on horseback.

DESCRIPTION OF ARTIFACT

A thin disc of fine-grained, blindingly white kaolinite, decorated on both sides, broke along a line that transected a perforation that suggests the piece was strung on a cord, but how is no longer determinable. Thus, pendant is an imprecise term that simply implies that the object was fastened in some manner to a person or their clothing. The fragment is 3 mm thick and its remaining dimensions are 39 by 38 mm. Projecting the curvature of the perimeter from the fragment, assuming that the object was originally somewhat round or at least roughly bilaterally symmetrical, arrives at a diameter of 60 mm prior to breaking. The disc is well polished on both faces and the unbroken rim. The three broken edges are angular and imply that the object broke into at least three and more probably four pieces. Microscopic examination of the piece showed that the drill hole was



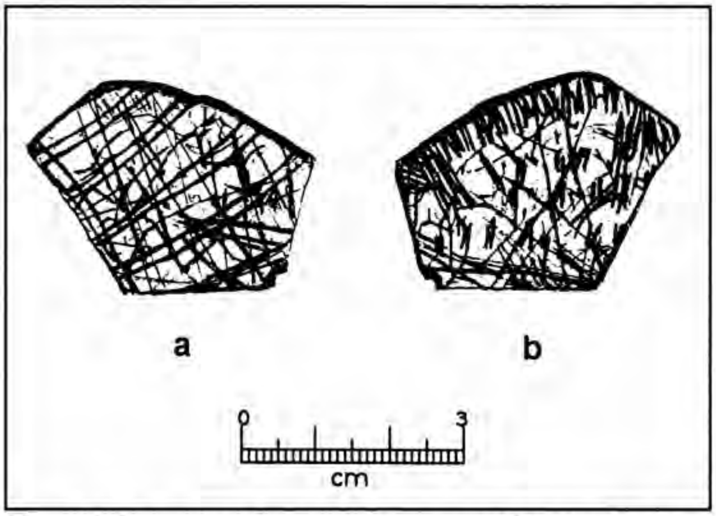


Figure 1. Fragment of pendant found at 41CX880 in Crockett County, Texas. Note indications of hole at bottom of center break.

polished asymmetrically, almost certainly from prolonged abrasion by the cord (Caran, n.d.).

One side of the disc bears a series of crosshatches made up of deeper parallel lines cross cut by more random intersecting shallower lines (Figure 2a). One pair of deeper grooves parallels one of the broken edges, suggesting the original disc was divided into panels or segments by lines that bisected or trisected this face. If the object was hung on a cord worn around the neck or waist, the polished side of the hole indicates that this side faced away from the body (Caran, n.d.).

The obverse is outlined with a fringe-like arrangement of short and long parallel lines incised perpendicular to the outer rim (Figure 2b). Tiny paired divots, resembling two-toed deer tracks so often seen in petroglyphs, are sprinkled across the face amidst shallow intersecting scratches. Caran made the following observations about the technique and implements used to make this design. One end of each deep groove tapers, narrowing abruptly at the end, but the other end terminates bluntly below the plane of the surface. The latter are nearer the rim, indicating that the graver was inserted there and pulled or pushed toward the center. The deep grooves are uniform and are probably the work of one artisan, later superimposed by irregular scratches. The other side was, in Caran's opinion, inferior in technique and tool.

Crosshatched and parallel lines are common motifs on scratched, incised, engraved, and painted stones around the world and their interpretations are both manifold and open to rampant speculation. Of more importance here is the rarity of the raw material and the distance it traveled to Crockett County.

Tests of specific gravity (2.54) and hardness (2.5), ultraviolet fluorescence (reddish-violet), and finally X-ray diffraction were used to determine that the pendant was almost pure aluminum silicate hydroxide or kaolinite, a clay mineral prized for porcelain manufacture and paper surfacing (Bates and Jackson 1980). Although kaolin suitable for making firebrick is found in Texas, kaolinite of the quality seen in this pendant is not. This rare form is commercially mined in Georgia from whence it is shipped to all parts of the country (Dr. Edward Jonas, personal communication). Although there is no way to determine the origin of this particular specimen, there can be little doubt that it traveled a great distance, probably as personal adornment, before it was lost in the arid wastes of West Texas.

ACKNOWLEDGMENTS

I am grateful that the pendant excited the interest of Chris Caran, Dr. Mark Helper, UT-Geology Department, and Dr. Edward Jonas, Professor Emeritus, UT-Geology. Mark Helper arranged for the X-ray diffraction that proved the material to be kaolinite. Steve Swinnea of the Texas Materials Institute, UT-Austin, contributed the analysis and Dr. Jonas discussed possible sources of kaolinite. I owe

Tommy Gray of UT-Lands a debt of gratitude for pointing out 41CX880 to me. The site was recorded by Larry Riemenschneider, Greg Sundborg, Jeff Turpin, Billy Turner, Ron Ralph, and Lisa Middleton who also drew the illustration of the pendant. Ron Ralph and Jeff Turpin made the site map with the help of Billy Turner and Lisa Middleton. Finally, UT-Lands is commended for encouraging the recording of significant sites on the public lands they manage.

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ERRATA

In the *La Tierra* Volume 27 No. 2 issue, 2000, there was an error in the spelling of the landowner's name, Peikert (pronounced pi kert [long 'i'], Site No. 41WH14 in Wharton County. Consistent misspelling occurred during excavations and finally, upon checking the local telephone directory, the spelling was noted as Piekert. Unfortunately, the directory was in error, and so the error was made in the site's publication. Please note in your copies that the proper spelling is "Peikert." We are sorry to have further compounded the problem.

EXAMPLES OF LITHIC DEBITAGE ANALYSIS

Leland W. Patterson

ABSTRACT

Various types of analysis of lithic debitage are reviewed, for lithic procurement, lithic manufacturing, and some subjects outside of the lithic manufacturing process. Examples are based mainly on data from prehistoric sites in Southeast Texas, and some experimental data. Archaeologists are encouraged to become aware of the full potential of debitage analysis.

INTRODUCTION

The analysis of lithic debitage, the byproduct of the manufacture and use of stone tools, is an important part of analysis of lithic assemblages from archaeological sites. Because of the low level of instruction in lithic technology at some universities (Patterson 1980a), many archaeologists do not seem to be aware of the full potential of the analysis of lithic debitage. It is common to see tabulations of lithic flakes in site reports without much explanation regarding the significance of debitage in the lithic manufacturing process. In this paper, I would like to offer a primer on types of debitage analysis that can be made for various stages in the *chaine operatoire* of lithic technology, based on examples from sites in Southeast Texas, and some experimental examples.

The analysis of debitage is most effective when integrated with other items in the lithic manufacturing process, such as cores, bifacial preforms, and finished stone tools and projectile points. Analysis of lithic procurement and the lithic manufacturing process should be done on a case-by-case basis, because of variations that can be caused by factors such as raw material types, geographic locations of process stages, and types of products. Examples of debitage analysis given here are mainly for the inland part of Southeast Texas. As discussed below, there are low levels of lithic manufacturing and stone tool use at sites on the coastal margin of this region as reflected in debitage assemblages.

This paper has sections where debitage analysis is applied to lithic procurement, lithic manufacturing, and other types of debitage analysis. It is noted that debitage analysis can be useful for some subjects outside of the manufacturing process, such as displacement of artifacts, temporal trends in lithic technology, and tool resharpening. Analysis of debitage can also be useful in distinguishing human lithic manufacturing from natural fracture of rock and from flakes made by modern gravel crushing.

A discussion is also given here on the limitations of lithic analysis to the study of aspects of human behavior not directly related to the manufacture and use of stone tools.

CHARACTERISTICS OF DEBITAGE IN SOUTHEAST TEXAS

At sites of inland Southeast Texas, quantities of debitage vary from site-to-site, which is an indication of degree of site usage. However, the attributes of debitage are rather uniform from site-to-site. This may be explained by the fact that there are few special activity (logistic) sites in the inland portion of this region. Most prehistoric sites of inland Southeast Texas are residential sites of mobile hunter-gatherers, with faunal remains indicating a broad-based subsistence pattern for all time periods (Patterson 1995b:Table 2). Earth ovens at some inland sites may indicate seasonal processing of plant foods, such as bulbs and roots (Patterson 1995c). However, even at sites with earth ovens there is evidence of a full range of subsistence activities. Most sites of inland Southeast Texas have a significant amount of lithic manufacturing activity.

There is a sharp contrast between the characteristics of debitage at inland and coastal margin sites of this region. Inland sites have debitage assemblages that reflect a significant amount of lithic manufacturing, especially for the manufacture of bifacial projectile points. In contrast, coastal margin shell midden sites have small quantities of debitage, with a high proportion of flakes under 15 mm square in size (Aten 1983:257; Kindall and Patterson 1993:Tables 2,3). The coastal margin of Southeast Texas is a lithic-poor area. Instead of importing large quantities of lithic materials from inland sources, Indians of the coastal margin of Southeast Texas used a large proportion of bone tools and projectile points (Aten 1983:262; Patterson and Ebersole 1992:27), and oyster shell tools (Aten 1983:265; Patterson 1990b: 3).

At coastal margin sites where stone spear points are occasionally found, there are seldom enough large size flakes (over 15 mm square) to account for manufacturing of the spear points. Finished stone spear points may have been imported to the coastal margin from inland sources. In the Late Prehistoric period after AD 600, use of the spear was abandoned on the coastal margin with the bow and arrow then the only weapon system in use (Aten 1983:306). In contrast, there was concurrent use of the spear and bow and arrow at Late Prehistoric sites of inland Southeast Texas.

Subsistence at coastal margin shell midden sites is characterized by high use of fish and shellfish as well as some use of terrestrial animals such as deer. With the high use of marine and brackish water food sources, there was less need for stone tools in this lithic-poor area.

LITHIC PROCUREMENT IDENTIFICATION OF LITHIC SOURCES

A basic problem for the analysis of lithic assemblages at sites remote from lithic sources is the identification of lithic sources used for procurement of raw materials. It is common for the quantity of debitage at a site to be much greater than the quantity of stone tools. Therefore, analysis of material types to identify raw material sources usually involves the analysis of debitage.

The identification of lithic sources usually involves the appearance of materials, such as color, luster, texture, and fossil inclusions. Lithic sources are, of course, related to material type, such as chert, obsidian, petrified wood, rhyolite, and fine grained basalt. Lithic sources can sometimes be related to types of remaining cortex on debitage. For example, cortex on local chert cobbles from Southeast Texas stream beds is usually a weathered, dark colored rind. In comparison, cherts from Central Texas often have light colored cortex with a high carbonate content.

The identification of lithic sources by the appearance of materials has limitations when similar materials can be found at different locations. Use of trace element analysis has been used to identify lithic sources, such as chert (Spielbauer 1984) and obsidian (Hammond 1976). Trace element analysis is not commonly used, however, because of cost or lack of a data base for lithic sources. Luedtke (1992) has published a detailed discussion on the properties of chert.

Raw material size can sometimes be useful in identifying lithic sources. For example, in Southeast Texas chert cobbles in the lower Brazos River are small, less than 80 mm in length. In contrast, chert cobbles from the lower Colorado River are generally large, with some over 200 mm in length. The size of chert cobbles limits the size of flake blanks and finished stone tools that can be produced. Experiments show that it is difficult to produce bifacial projectile points over 50 mm in length from lower Brazos River chert cobbles (Weber 1991). Most bifacial projectile points over about 50 mm in length found in Southeast Texas are likely to have been made from lower Colorado River cherts.

PRIMARY REDUCTION LOCATION AND TYPE

Lithic raw materials are generally not found in forms suitable for direct production of stone tools. The first stage of lithic manufacturing usually involves production of flake blanks that are suitable for tool manufacture. This stage of lithic manufacturing is referred to as primary reduction. Analysis of debitage can be used to identify the location of primary reduction, at the source or at a remote location.

It is common for primary reduction to be done at the lithic source. This allows for testing of materials and selection of suitable flake blanks. Primary reduction at the lithic source also reduces weight and volume of raw materials for transport to remote campsites. Debitage from primary reduction commonly has an irregular flake size distribution, as shown in Figure 1 for a chert cobble reduction area at site 41CD70 in Colorado County, Texas (Patterson 1981a). Because hard percussion is used for primary reduction, the flakes at location of primary reduction would be expected to have a high proportion of well-developed bulbs of percussion.

A high percentage of flakes with remaining cortex is another indication of primary reduction, along with a significant number of thick, crude flakes from trimming of raw material pieces for core preparation. There can be considerable variation in quantities of flakes with remaining cortex at locations of primary reduction, because of variations in shapes and sizes of raw material pieces, and because some flakes with remaining cortex were selected as

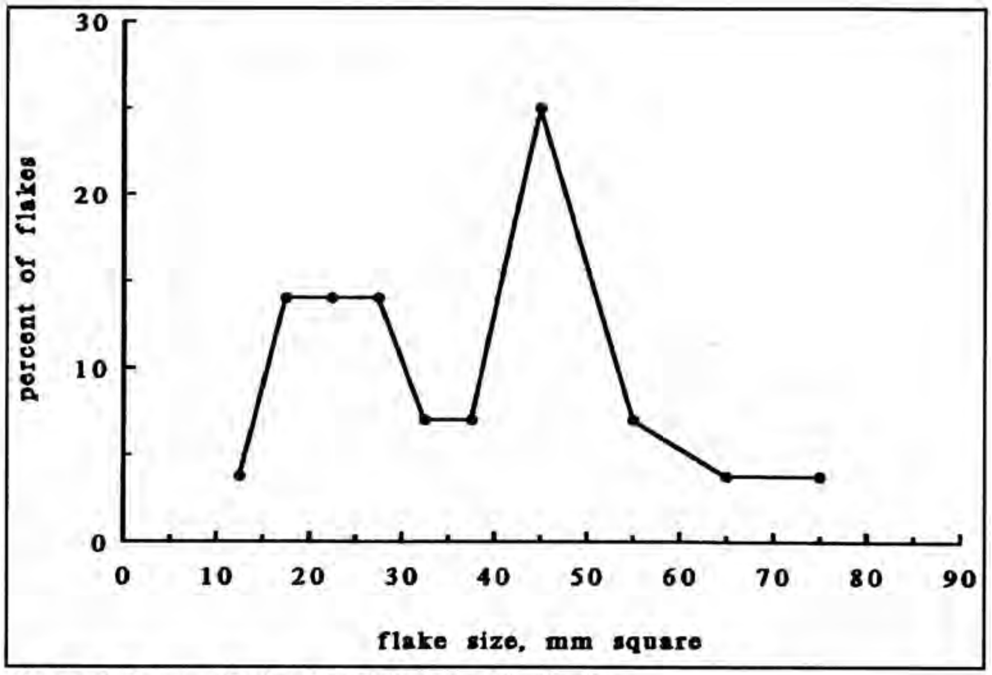

Figure 1. Primary Reduction Flake Size Distribution.

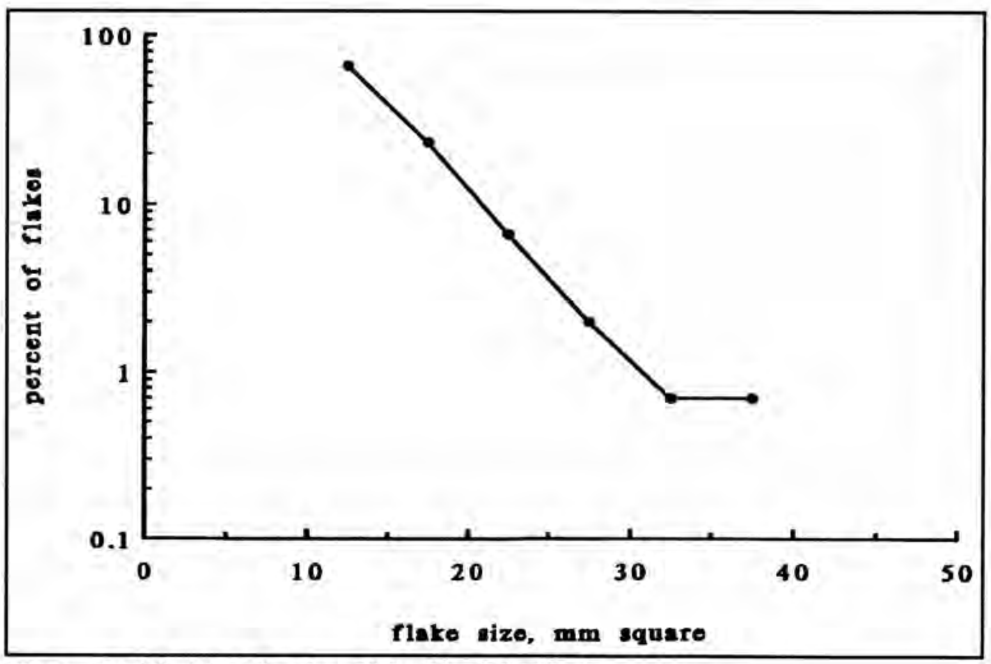

Figure 2. Bifacial Reduction Flake Size Distribution.

flake blanks for transport to remote campsites (Patterson 1981c).

The manufacturing process can be taken beyond the production of flake blanks at the location of primary reduction, commonly the lithic source. The production of bifacial preforms at the lithic source may be identified by areas with high percentages of small flakes, under 20 mm square, and the presence of broken early stage preforms.

In Southeast Texas, primary reduction of raw materials generally involved the production of flake blanks at lithic sources, with transport to remote campsites for subsequent heat treatment of chert and then bifacial reduction to make projectile points. In Southeast Texas, there are usually no cores at sites remote from lithic sources that could be associated with primary reduction to produce flake blanks for manufacture of bifacial spear points.

IDENTIFICATION OF DIRECT LITHIC PROCUREMENT AND TRADE

Lithic raw materials at locations remote from lithic sources can be acquired by direct procurement or trade. Trade is most often associated with exotic raw materials, and direct procurement is most often associated with local raw materials. Long-distance trade would usually follow a drop off model at increasing distance from lithic source. This would be reflected in the percentage of exotic materials in the debitage from a site. In Southeast Texas, a drop off model can be used for exotic cherts from Central Texas. Sites in Southeast Texas have under 1% of debitage of exotic cherts from Central Texas, with sources of exotic cherts over 200 km in distance.

In Southeast Texas, local cherts can be classified as materials from source distances up to 100 km from remote campsites. Large quantities of debitage (thousands of flakes) of local cherts can be found at campsites of inland western and central Southeast Texas, regardless of distances from sources up to 100 km. It would be difficult to distinguish direct procurement versus short-distance trade for procurement of lithic raw materials in Southeast Texas. In the western part of this region, local raw materials are chert cobbles found in alluvial deposits, with cherts at different locations having similar properties. In eastern Southeast Texas, lithic raw material types are predominantly petrified wood and fine-grained quartzite from local sources up to about 100 km distance from campsites.

Church et al. (1994) have published a detailed discussion of lithic procurement with an extensive reference list. Some other discussions on lithic procurement are contained in edited volumes by Butler and May (1984) and Vehik (1985).

LITHIC MANUFACTURING

Heat-treatment of Chert.

Heat-treatment of chert was often used by prehistoric people to improve knapping quality. Heat-treatment was most often used for materials to be used for the production of thin bifaces, such as knives and projectile points. Heat-treatment of siliceous minerals lowers the tensile strength (Prudy and Brooks 1971; Patterson 1981b; Rick 1978). This permits easier fracturing and the production of longer flakes (Flennikan and Garrison 1975; Patterson 1979).

Heat-treatment can often be detected by waxy luster, color change, and small potlid surface scars. Color change often occurs only on the surface of the piece being treated. Analysis of debitage is usually the only way to find color change or potlid scars, because debitage has pieces with the original surface of the item that has been worked.

Heat-treatment of cherts is evident at most sites in Southeast Texas where tough cherts from alluvial deposits were being used. I have found experimentally that flake blanks of tough cherts from Southeast Texas are not suitable for production of bifacial spear points unless heat treatment is used. Heat-treatment of cherts at sites in Southeast Texas is usually identified by reddish coloration of specimens of debitage or waxy luster of flakes and finished artifacts.

Heat-treatment of chert is not always successful. Sometimes thermal damage can occur which can be observed on debitage (Patterson 1995a; Purdy 1975). Thermal damage has attributes such as large potlid surface fractures, crazed surface crack patterns, and irregular fracture plane surfaces.

The location of heat-treatment is not often obvious from archaeological data, because of poor preservation of earth ovens used for heat-treatment. Severe thermal damage of materials might indicate the location of heat-treatment because damaged materials would not likely be moved far from heat-treatment locations. However, thermally damaged materials might simply indicate accidental exposure to high temperature. Not much thermally damaged material would be expected from purposeful heat-treatment of chert, because prehistoric peoples had a good knowledge of how to do controlled heat-treatment. No locations for heat-treatment of chert have been identified in Southeast Texas, even though there is much evidence of use of heat-treatment in this region.

Unifacial tools can be easily made without need for heat-treatment of chert. Unifacial tools with evidence of heat-treatment may indicate reuse of bifacial reduction debitage. In Southeast Texas, it is common to find unifacial tools made from flakes of heat-treated materials.

Scale of Production

The amount of lithic debitage at a site is an indication of the scale of lithic manufacturing. For example, if an assemblage has many bifacial projectile points, but few pieces of debitage, the projectile points may have been manufactured at a different location. As a rough indication, some experiments have yielded an average of 107 flakes for the production of each bifacial preform from a flake blank (Patterson 1990a:Table 2).

Debitage quantity can indicate industrial scale production of lithic artifacts. A good example is the large mounds of chert debitage at the Mayan site of Colha in Belize (Shafer and Hester 1983).

It is difficult to relate scale of production of debitage to size of social groups. A large amount of debitage can be produced by a small group with frequent site visits or by a large group with only a few site visits.

Methods of Force Application

Chipped stone artifacts are produced by the application of force to remove flakes. Force application can be done by hard percussion, soft percussion, indirect percussion, pressure flaking, and raking retouch. Archaeological site reports often state which method of percussive force was used, without offering analytical criteria. There are problems in the judgement of which type of percussive force was used. The usual criteria used for a flake produced by soft percussion (antler or soft stone) are a diffuse bulb of percussion and lipping on the ventral surface at the platform. The usual criteria used for a flake produced by hard percussion (hammerstone) are a well-developed bulb of percussion, no lipping, and a high incidence of crushed platforms. Flakes produced by indirect percussion (use of a punch) tend to be similar to flakes produced by soft direct percussion. Judgement of which type of percussive force has been used is best done on a statistical basis, because different methods of percussive force do not always produce flakes with different attributes (Bradley and Sampson 1986:43; Patterson 1982). Also, experiments show that bifaces are sometimes best made by a combination of soft and hard percussion. Soft percussion is the force application method favored by most modern knappers to produce thin bifaces, because this method produces long, thin flakes. There are some knappers, however, who prefer hard percussion for the manufacture of bifaces. When doing bifacial reduction with an antler billet, I often switch to a hammerstone to remove hard spots in chert.

In Southeast Texas, campsites that are remote from lithic sources do not have many hammerstones. At sites in this region, the production of bifacial projectile points was usually the predominant lithic manufacturing activity. It is probable that antler billets were being used for bifacial reduction, but were seldom preserved.

Fine edge retouch was often done by pressure flaking and sometimes by raking retouch. Pressure flaking involves spotloading to produce fracture. Raking retouch can be done by raking a chert flake along the edge of the piece being worked. Pressure flaking can be distinguished by edge serration, and raking retouch gives a series of edge fractures without serration (Patterson 1998). Both pressure flaking and raking retouch were used extensively at sites in Southeast Texas.

Bifacial Reduction

Bifacial reduction in lithic manufacturing at an archaeological site can be recognized by the presence of bifacial specimens in various degrees of completion (Collins 1975; Patterson 1977). When only flakes are present at a site, however, or only flakes and finished tools, other analytical techniques are needed to determine if bifacial reduction was being done. Some individuals claim to be able to recognize bifacial thinning flakes directly from flake attributes, but such study is often subjective. Rigorous analytical techniques are required for the detection of bifacial reduction by flake attributes.

Shott (1994) has reviewed various published methods to detect bifacial reduction by analysis of lithic flakes, but has some reservations about the general applicability of all methods. Shott (1994: 99) feels that Ahler's (1989) mass analysis model shows promise for further development. Ahler (1989) uses discriminant analysis to distinguish various types of lithic manufacturing processes, with flake weight and size as parameters. Shott (1994:94) concludes that Patterson's (1990a) log-linear model is a useful analytical tool for the detection of bifacial reduction, but that there can be exceptions to the model.

The log-linear model by Patterson (1990a) gives a straight line for bifacial reduction with a plot of percent of flakes with a logarithmic scale versus flake size with a linear scale. An example is shown in Figure 2 for experimental bifacial reduction of a flake blank (Patterson 1990a:Figure 3). I have now concluded that this model applies mainly to bifacial reduction of flake blanks (Patterson 1997a), which is consistent with data from several knappers used to develop the model. If a thick irregular piece of raw material or a chert cobble is used directly to produce a biface, there is some primary reduction involved to shape the piece before bifacial thinning can be done.

Shott (1996) has used the experimental production of a biface from a large chert cobble to show deviation from a log-linear model of flake size distribution. It should be noted, however, that the initial stage of this experiment actually involved flaking of the large chert cobble to demonstrate the production of large flakes by primary reduction, according to the knapper (Donald Simons, personal communication 1999). The production of a large finished biface was started only after massive initial reduction of the cobble.

The log-linear model of flake size distribution for bifacial reduction (Patterson 1990a) has the advantage of being fast and simple to use. Flake sizes can be measured by a series of templates, with no special orientation of flakes involved or sorting of flake types required. I have no examples of bifacial reduction of flake blanks that do not conform to this model. The log-linear model applies to a single biface manufacturing event, or for a mixture of flakes from several biface manufacturing events (Patterson 1981c, 1982).

In Southeast Texas, many sites have flake size distributions that fit the log-linear model for bifacial reduction, such as site 41WH19 (Patterson 1990a: Figure 4). Where deviations from the log-linear flake size distribution model occur, it is often found that, in addition to production of bifacial projectile points, there was reduction of small chert cobbles that were easily transported from close sources, to produce miscellaneous flakes for tool use. For example, at site 41FB3 (Patterson et al. 1998:Figure 4), small chert cobbles were available at the Brazos River within 8 km of the site, while chert cobbles large enough to produce flake blanks for manufacture of spear points occur at the Colorado River at a minimum distance of 44 km.

Bifacial Reduction Staging

The production of a biface is a continuum of work, although the concept of stages is sometimes used as an artificial construct to describe the bifacial reduction process for convenience of instruction (Patterson 1978). For example, Callahan (1979) has used four stages to describe biface manufacture: (1) obtaining the flake blank, (2) initial edging, (3) primary thinning, and (4) secondary thinning. The first stage represents primary reduction of raw material, and the other stages represent the bifacial reduction process. Actually, edging is repeated after the removal of each layer of flakes to reestablish a proper striking platform on the biface edge.

Patterson (1990)a has shown that the degree of completion of a biface cannot be determined from flake size distribution. Experimental data by Shott (1996: 11), Bradbury and Carr (1995), and Patterson (1981c) support the conclusion that remaining cortex on flakes should not be used as a defining attribute in assigning flakes to specific bifacial reduction stages. Shott (1996) has examined several variables, including platform type, platform width, flake weight, and dorsal surface scar count, without finding definite indication of bifacial reduction stages. Much of the variation in flake size distribution that obscures efforts to detect bifacial reduction staging is from the variation in morphologies of starting flake blanks (Mauldin and Amick 1989:67; Patterson 1990a:556).

Amick et al. (1988:33) claim that their analysis of bifacial reduction debitage from a chert cobble experiment reliably predicts three reduction stages, using discriminant analysis with several flake attributes. However, a three-stage reduction model was part of the original assumptions. Shott (1996:7) has commented on problems of arbitrary grouping of flakes for models of bifacial reduction stages. Also, Amick et al. (1988) have not demonstrated that a model derived from a single experiment has general applicability.

In Southeast Texas, there is little evidence for staging of biface production at different locations. Most data indicate that flake blanks were produced at lithic sources, and then transported to remote campsites, where finished bifacial projectile points were completely manufactured at the campsites.

Prismatic Blade Manufacture

A prismatic blade is usually defined as a flake with length at least twice width, with parallel lateral edges, and at least one ridge on the dorsal face parallel to the lateral edges (Sollberger and Patterson 1976:518). Prismatic blades are made by force application at a ridge on the core face. The fracture plane follows the ridge, producing the distinctive shape of the prismatic blade. Production of prismatic blades results in polyhedral cores with parallel fracture scars. A prismatic blade occasionally can be produced fortuitously from lithic manufacturing types not intended to produce blades.

There are several analytical criteria for detecting purposeful production of prismatic blades in assemblages from archaeological sites. Fortuitous production of prismatic blades does not occur with a significant frequency. I have found that fortuitous production of prismatic blades during bifacial reduction is well under 1% of flakes over 15 mm in size. In contrast, at archaeological sites in Southeast Texas with prismatic blade technology there are many blades, usually several percent of total flakes (Patterson 1994a:Table 1). Width distribution of prismatic blades from purposeful production is usually a bell-shaped curve, with mean width reflecting the most desired product (Sollberger and Patterson 1976:Figure 5; Patterson 1994a:Figure 2). An example of a bell-shaped curve for blade width distribution is shown in Figure 3 for site 41HR182 in Harris County, Texas (Patterson 1985). All sites in Southeast Texas with significant technology for the manufacture of small prismatic blades have blade width distributions that form bell-shaped curves (Patterson 1994a:Figure 2; Patterson et al. 1998:Figure 6).

The best indication of purposeful production of prismatic blades is the polyhedral core. Polyhedral cores are often not common even when large numbers of blades are present. After production of blades, cores were often expended by production of other types of flakes. Blade core trim flakes can represent the first flake removals from a polyhedral core after production of the last blade. These are irregular shaped flakes with several parallel flake scars on dorsal surfaces. In Southeast Texas, blade core trim flakes are usually found where there are significant quantities of prismatic blades, whether or not polyhedral cores are present. At site 41HR184, there are blade cores, blade core fragments, and blade core trim flakes that illustrate the final expenditure of blade cores to produce other types of flakes (Patterson 1994a).

Unifacial Arrow Points

The use of unifacial arrow points is strongly associated with prismatic blades in Southeast Texas (Patterson n.d.). This is an important subject because unifacial arrow points start much earlier than standardized bifacial arrow point types (Patterson 1992). Unifacial arrow points start before 2000 BC in Southeast Texas, and standardized bifacial arrow point types start at about AD 600 in this region.

Unifacial arrow points can be overlooked in assemblages of debitage (Patterson 1994b). It is necessary to examine small pointed flakes of suitable shapes for arrow points with a 10-power magnifier to detect purposeful retouch to make unifacial arrow points. Unifacial arrow points were often made in Southeast Texas using raking retouch. Impact damage patterns (Odell and Cowan 1986; Patterson 1994c) have been used by Odell (1988) and Patterson (1994a) to determine use of flakes with minimal retouch as arrow points.

OTHER DEBITAGE ANALYSIS

Reuse of Debitage as Tools

The unmodified utilized flake is a well recognized stone tool type. In Southeast Texas, flakes were often casually selected from bifacial thinning debitage for use as tools. In this region, the utilized flake was the predominant stone tool type during all prehistoric time periods. Utilized flakes can be overlooked in lithic assemblages, by not doing much observation of edge-wear patterns. There is a problem in recognizing all flakes that have been utilized as tools. Edge-wear patterns develop slowly when working soft materials, such as meat (Patterson 1981d, 1984).

Microwear analysis of edge-wear can determine specific types of materials that have been worked (Keeley 1980). However, microwear analysis is often beyond resources available for analysis of a lithic assemblage. Microwear analysis requires special equipment, special training, and is generally too slow to use for large numbers of flakes (Whittaker 1994: 285). Macrowear analysis with a high- power stereo microscope is also slow.

In contrast to microwear analysis, macrowear analysis with a 10-power magnifier can be performed on a large flake collection in a reasonable time length, with minimal training. Basic edge-wear patterns for cutting, scraping, and planing can be easily detected with a 10-power magnifier, using basic edge-wear patterns presented by Tringham et al. (1974). Basic edge-wear patterns can be easily replicated to examine wear patterns on specific types

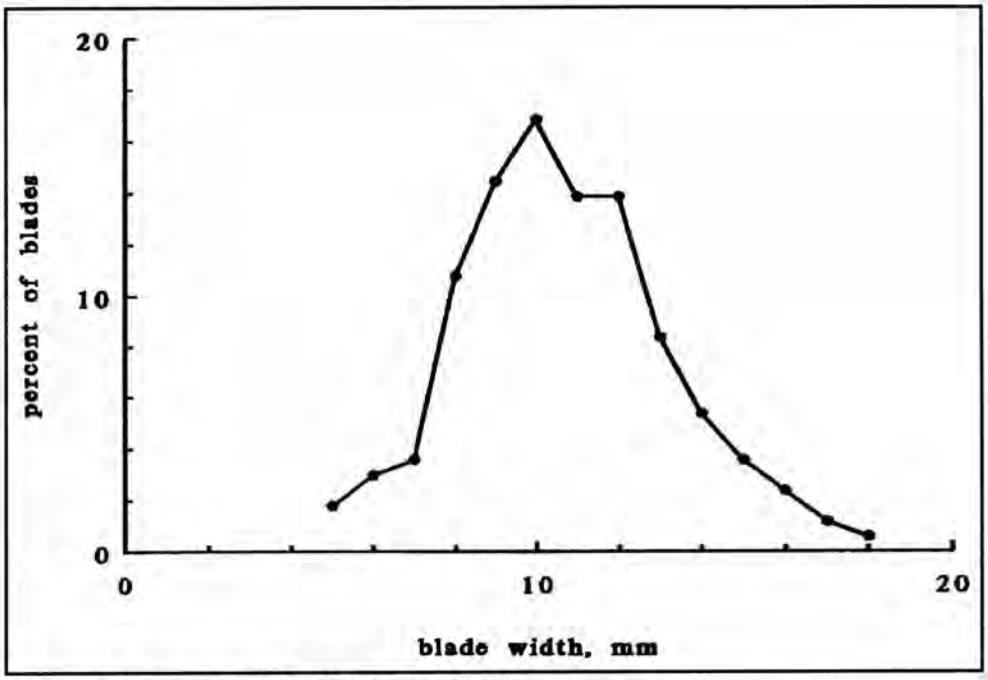

Figure 3. Prismatic Blade Width Distribution.

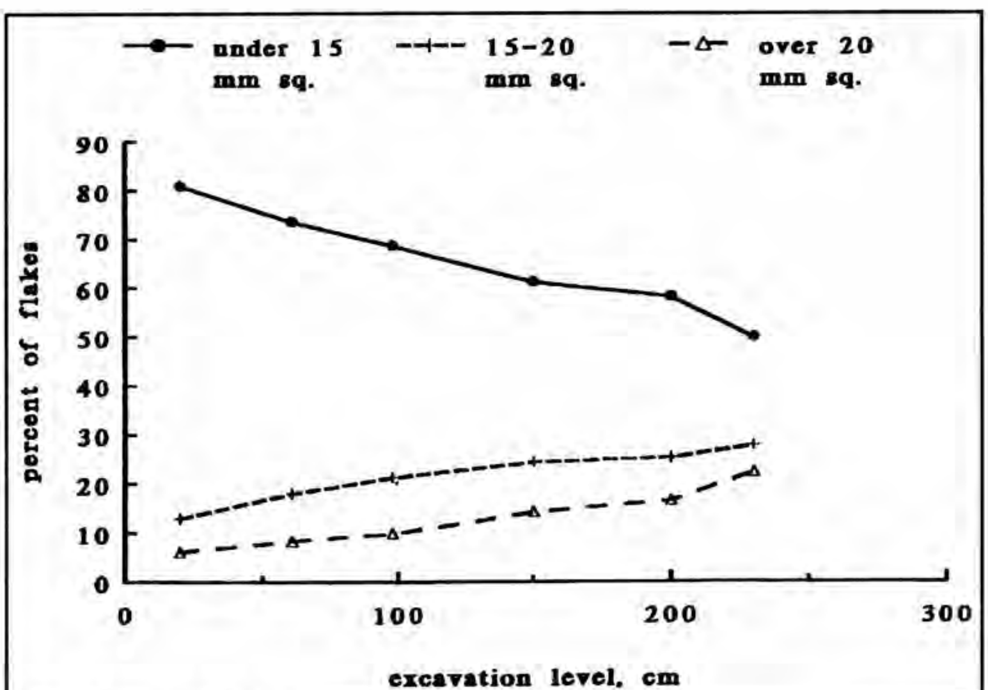

Figure 4. Flake Size by Excavation Level.

of materials.

Displacement of Artifacts

There is often a question on archaeological sites as to whether or not lithic assemblages are intact or disturbed by natural forces or human action. Flake size analysis can aid in determining if a flake collection comes from intact or disturbed context. In reference to fluvial disturbance, Gowlett (1993:51) has observed that "It is a good first sign that an archaeological site is in 'primary context' (relatively undisturbed) if the smallest waste flakes of less than 1 cm long can be found together with larger tools." Schick and Toth (1993:205) conclude from experiments that running water winnowed away most of the smaller flaking debris, leaving behind mainly larger flakes along with some cores.

At the Calico site in California, flake size distribution has been used to show that the excavated lithic flake collection is in primary context, relatively undisturbed by alluvial action (Patterson et al. 1987a:101). This enhances the conclusion that the Calico lithic collection is man-made, not the result of natural rock fracturing. There is no evidence at the Calico site for resorting of flake sizes by alluvial action.

Temporal Trends

Debitage analysis over time can be used to study temporal trends in lithic manufacturing. Jelinek (1982) has used variance over time of width-to-thickness ratio of flake tools at the Tabun site in the southern Levant to indicate an orderly and continuous progression of lithic industries from Neanderthal to modern man.

A plot of flake size ranges versus excavation levels is shown in Figure 4 for a time interval of about 10,000 years at site 41WH19 in Wharton County, Texas (Patterson et al. 1987b:Figure 20). The smooth curves with increasing percentages of small size flakes over time follow a trend toward smaller spear points in later time and finally the dominance of even smaller arrow points. Some use of the spear and spearthrower continued concurrently with use of the bow and arrow in the Late Prehistoric period (AD 600-1500) in inland Southeast Texas. There are no sharp changes in the curves of Figure 4 that would indicate any sudden changes in lithic technology. There are other sites in Southeast Texas, such as 41HR315 (Patterson 1980b:Figure 19), that have the same temporal trend for flake size distribution shown in Figure 4.

Tool Resharpening Debitage

Tool resharpening is sometimes cited as an activity at archaeological sites. The detection of tool resharpening can be difficult, however, because this type of analysis often depends on the analysis of small flakes, under 15 mm square. Small byproduct flakes can be generated by percussion and pressure flaking processes to manufacture stone tools, as well as by tool resharpening. For example, it would be difficult to distinguish small flakes from unifacial tool manufacturing from small flakes from subsequent tool resharpening. As another example, it would be difficult to distinguish debitage from spear point resharpening from debitage from spear point manufacture, if both activities were present at a site. It is desirable to use caution when concluding that characteristics of debitage indicate tool resharpening at a site.

There is a case where tool resharpening can be shown in an unambiguous manner. If bifacial spear points are the only type of stone tools present at a site, and the waste flakes are mainly under 15 mm square in size, it would be reasonable to conclude that spear points were being repaired or that spear point edges were being used for cutting and scraping with some edge resharpening. There are no examples of sites in Southeast Texas where tool resharpening can be detected from debitage analysis. In this region, the only definite indication of tool resharpening is the occasional spear point with a reworked blade section.

Detection of Human Lithic Manufacturing

At some sites, it is necessary to distinguish human lithic manufacturing activities from natural fracture of rock. It is also sometimes necessary to determine if there has been intrusion of modern crushed gravel at a site. There are several Indian sites in Southeast Texas with intrusive crushed chert road gravel.

I visited a site in eastern New Mexico where there was much fractured chert. It became apparent that chert cobbles embedded in limestone were being fractured when cracks developed in the limestone matrix. In this case, about 1000 pieces of fractured chert were examined without finding any bulbs of percussion on fracture planes.

Crushed chert used for road gravel and concrete aggregate often contains many flakes. Few flakes produced by modern mechanical crushers will have bulbs of percussion or platform areas that are not crushed (Patterson 1983: 306). Most rock fracture in modern mechanical crushers is caused by pressure rather than percussion.

The attributes of lithic flakes can be used to distinguish human manufacturing from rock fracture by natural forces (Patterson 1983). Important attributes include bulb of percussion, striking platform angle, presence of exotic materials, preparation of striking platform, and dorsal face fracture scars. Purposeful edge retouch patterns, and edge-wear patterns are also important attributes for judgement of human workmanship. There are no published examples where natural forces have produced flakes with bulbs of percussion at a high frequency. Natural forces produce most rock fractures by pressure, while it is characteristic of human lithic manufacturing to produce large numbers of flakes by percussive force.

The striking platform angle is the angle between the platform surface and the dorsal face surface. Little controlled percussive flaking can be done with striking platform angles greater than 90 degrees (Patterson 1986; Whittaker 1994:93). Therefore, acute striking platform angles are a good indication of human workmanship, if there are a statistically significant number of flakes with this attribute.

The Calico site in California is controversial because of its early age (100,000-200,000 BP). Many archaeologists attribute the lithic assemblage at Calico to naturally fractured rock. However, a study of flakes from Calico shows that these specimens have all of the attributes of a man-made lithic assemblage (Patterson et al. 1987a). Many of the flake specimens have edge retouch patterns indicating use as unifacial tools (Simpson 1989).

Limitations of Lithic Analysis

In recent years, there have been a number of attempts to expand lithic analysis beyond the manufacture and use of stone tools, to study wider aspects of human behavior. This can be a useful exercise on a case-by- case basis to interpret archaeological sites. I remain a skeptic, however, that general rules can be formulated that relate lithic technology to wider aspects of human behavior. There are several limitations to data in the archaeological record that impede detailed study of human behavior, including the fact that simple hunter-gatherer lifeways are complex, non-linear systems (Patterson 1997b). For example, Kuhn (1995) and Odell (1996) have related changes in lithic technology to changes in mobility. However, change in lithic technology can occur for a number of reasons. Ingbar (1994) has shown by simulation that there is not a good correlation between raw material source proportions and mobility pattern.

Parry and Kelly (1987) have concluded that predominant use of amorphous shaped cores and utilized flakes is an indication of a more sedentary lifeway. There are too many exceptions, however, to establish a general rule of this type (Patterson 1987). The utilized flake is the predominant stone tool type in Southeast Texas for mobile hunter-gatherer groups during all prehistoric time periods from Paleoindian through Late Prehistoric.

I have previously observed that many archaeologists concentrate on problems that available data cannot answer. One can find few kinship relationships in a pile of flint flakes (Patterson 1980c). There are few examples in the literature where testable models have been proposed that relate lithic technology to wider aspects of human behavior.

SUMMARY

This paper has discussed a number of uses for analysis of debitage, with examples from Southeast Texas, and some experimental examples. It is not common to see studies of lithic assemblages that make full use of the possibilities of debitage analysis. Uses of debitage analysis discussed here include lithic procurement, manufacturing processes, reuse of debitage, displacement of artifacts, temporal trends, tool resharpening, and detection of human manufacturing. Caution has been expressed regarding use of lithic analysis to study wider aspects of human behavior. It is hoped that this paper will encourage lithic analysts to make use of a wide range of types of debitage analysis.

Lithic materials are the most common types of artifacts at prehistoric archaeological sites. Therefore, lithic analysis should not be considered as a specialized subject, but rather a skill that should be in the repertoire of all archaeologists who do analysis of assemblages from prehistoric sites.

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AUTHORS

JAMES BRYAN BOYD is a police officer in Laredo, as well as an adjunct instructor in the Criminal Justice Division of the Laredo Community College, and has contributed many papers to *La Tierra* and other publications. Boyd's main area of interest is the archaeology and prehistoric mortuary practices of the area centered around Falcon Reservoir, on the Lower Rio Grande.

T. L. DONOHOO is a businessman in the lower Rio Grande Valley, with a long-time interest in the archaeology of the Falcon Lake Area. Donohoo has recorded a number of sites with the Texas Archeological Research Laboratory (TARL), and has placed on file photographs and records related to these.

JOE LABADIE has lived in Comstock, Texas for the past 13 years and works for the National Park Service as the Cultural Resources Program Manager at Amistad National Recreation Area in Del Rio. He is the former Chairman of the Val Verde County Historical Commission, and for the past five years has taught Anthropology at Southwest Texas Junior College in Del Rio. He was Co-Principal Investigator, along with Dr. Mike Collins, for the 1999 Texas Archeological Society's Field School at Lake Amistad. For his contributions to the TAS field school, he received the 1999 John L. Cotter Award, the National Park Service's highest award for archaeological excellence in a National Park.

ROCHELLE J. LENEAVE received her BA in anthropology in 1986 at the University of Texas at San Antonio. She was involved in numerous archaeological projects through UTSA's Center for Archaeological Research (CAR) including the 1986 season in Belize, the Loma Sandia project, the Rivercenter Mall project, Mission Concepción and other historical projects in the San Antonio area. A former member of STAA and TAS for many years, she also co-authored several articles including the groundstone artifacts portion of the Loma Sandia report. At present she is retired and spends her time traveling, quilting, painting, gardening and enjoying her grandchildren.

LELAND W. PATTERSON is a retired chemical engineer and an active avocational archaeologist. His current research interests include the prehistory of southeast Texas, lithic technology, and the early peopling of the New World. Patterson has authored or coauthored over 400 publications in archaeology. Some of his publications have been in *American Antiquity, Journal of Field Archaeology, Lithic Technology*, the *Bulletin of the Texas Archeological Society*, and *Current Research in the Pleistocene*. He is author or senior author of several major archaeological site reports, and has recently published a detailed synthesis of Southeast Texas archaeology. He has received the Crabtree Award of the Society for American Archaeology for research by an avocational archaeologist.

TIMOTHY K. PERTTULA, who lives in Austin, has a PhD in Archaeology from the University of Washington (1989), and has been doing archaeology in Texas since 1974. While his principal research interest is Caddo archaeology and ehtnohistory, in the last few years he has also become fascinated with South Texas archaeology, particularly the prehistoric, Hispanic, and Tejano archaeology at Falcon Reservoir on the lower Rio Grande.

SOLVEIG A. TURPIN holds a doctoral degree from the University of Texas at Austin where she worked as an archaeologist prior to her retirement in 1999. She is currently serving as a cultural resource consultant and carrying out research in north-central Mexico.

INFORMATION FOR CONTRIBUTORS

La Tierra publishes original papers and selected reprints of articles involving the historic and prehistoric archaeology of southern Texas and adjacent regions. Original manuscripts are preferred. Articles involving archaeological techniques, methods, and theories are also considered.

The main objective of this quarterly journal is to provide a way for STAA members and others interested in the archaeology of southern Texas to share the information they have with others. We encourage your full participation through submission of your information for publication; we are particularly interested in receiving manuscripts from those in the less well-known counties of our region, to document even surface finds and old collections. Only through such total member participation can we, as a group, build up a comprehensive picture of the archaeology of our area!

Articles may be submitted in any form, although double-spaced typed copy is naturally preferred. However, we will review and work with material in any form to encourage those not comfortable with typewritten or other formal methods; WE ARE MORE CONCERNED THAT YOU SUBMIT YOUR IDEAS AND DOCUMENT YOUR MATERIALS THAN WE ARE WITH THE FORM OF MATERIALS WITH WHICH WE HAVE TO WORK. If you can supply a 3 ½" disk, IBM or compatible, <u>in ASCII form</u> (if not in Word Perfect or Word), it will be very helpful.

We are now incorporating a small Texas map with the county represented down in the lower right-hand corner of Page 1. This is not "Figure 1" and it may be all that you want in your paper. However, if you are being more precise as to your area of Texas, please submit a map showing the general region. This would be Figure 1. We are trying not to be too precise with locations of sites—unfortunately there are those who take advantage of this information to locate and ravage archaeological sites. Those sites already in the published material are sometimes shown again, however. Also, you MUST have the landowner's permission before entering his property. This small consideration can avoid misunderstanding and ill feeling toward archaeological research. Any information regarding permits, access pemission etc. needs to be included in your paper when relevant (see publication policy statement in Vol. 27, No. 2).

Other figures can be line drawings or photographs; line drawings are preferred if they are good quality—every photograph used requires special processing which adds to the cost of the issue. Sharp Black and White photos are preferred but color can be used. If you need assistance with illustrations, please let us know—there are several STAA members who have volunteered to help with illustrations. For examples of good artifact and map illustrations, see those by Richard McReynolds and Ken Brown in previous issues.

When drawings or sketches of artifacts are included in your manuscript, please give the name of the artist responsible for the illustration(s). All figures should contain an appropriate caption and, where necessary, identification of each specimen (a, b, etc. or 1, 2, etc.) to aid referencing individual specimens in the text. The suggested procedure is to photocopy your original drawing and write in captions and identification letters on the photocopy. This saves the original for our use in final preparation of camera-ready copy.

PLEASE include a proper scale on all maps, diagrams, artifacts, etc. When any figure must be reduced, the scale must be in the original figure so that reduction will not change any proportions. Most of our artifact figures are drawn "actual size" but this is not proper publishing terminology. A scale is necessary, and may be reset in the picture through "cut and paste"—just so it is there. Remember that photocopied material is very often slightly enlarged, and care must be taken that there is no change in the scale if done separately. For area (regional) maps, a small "rake scale" will help in our final copy—just so it is the proper dimension. Any site excavation map MUST have a good scale with it, again, IN the map so that reduction will not change the proportions.

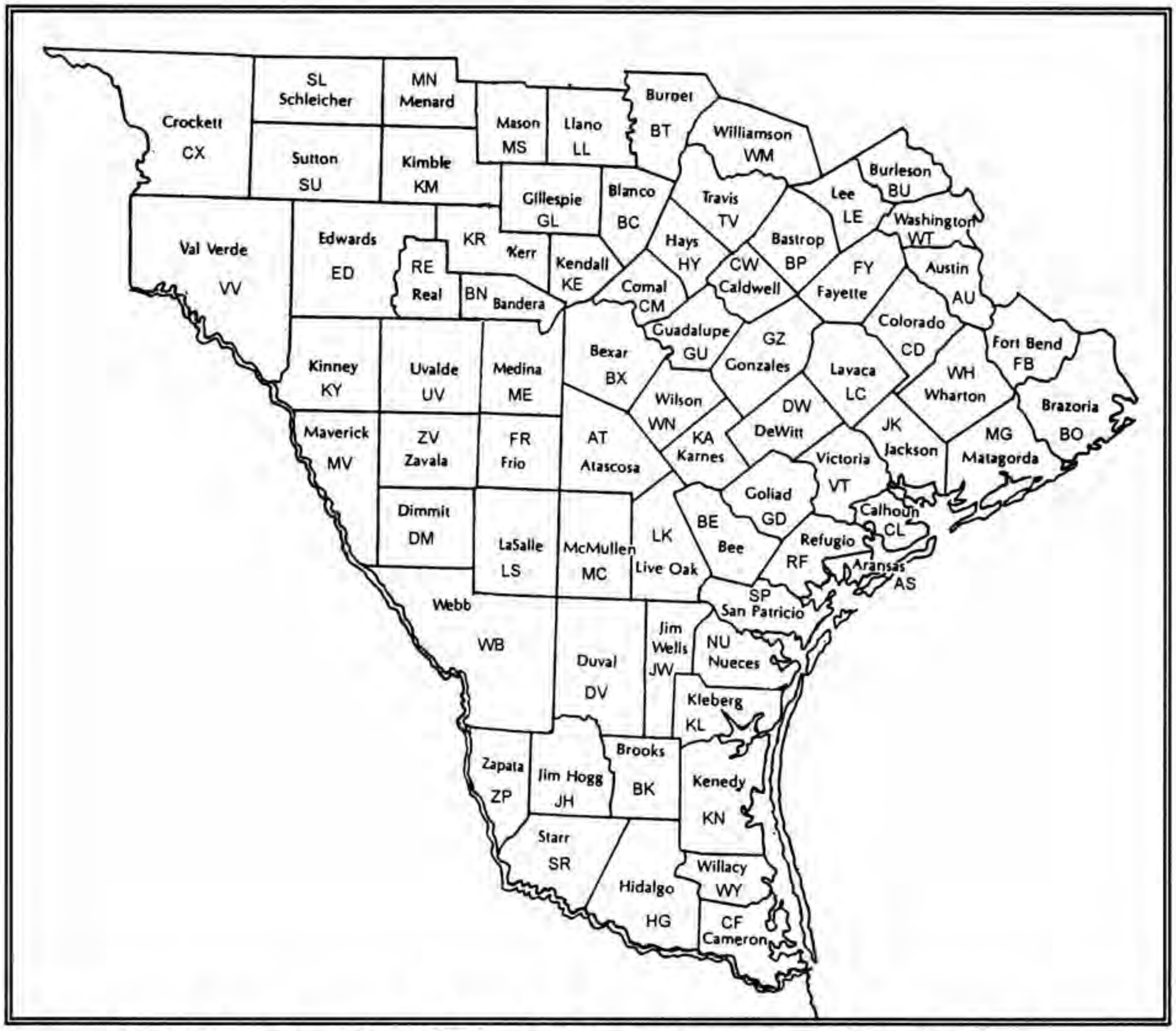
Citations of references should be embodied in the text, giving the author, date, and page (e.g., Hester 1980:33). All references cited should be included in a References list using normal archaeological form (see articles in this issue for examples). The Reference list should not include publications not referred to in the text. Personal communications are cited in the text (e.g., Anne Fox, personal communication 1977) but need not be included in the Reference list.

Be sure to include a short (4-6 lines) biography for EACH author of the paper. The principal author and one co-author will receive two additional copies of *La Tierra*. Additional coauthors will receive one extra copy each. We will need each author's address for mailing purposes.

NUMBER YOUR PAGES AND MAKE A PHOTOCOPY OF THE SUBMITTED MATERIAL FOR YOUR RECORDS BEFORE MAILING TO THE EDITOR. HAVE DUPLICATE PHOTOS TO BE SAFE.

Manuscripts and/or hard copy of disk, if used, or other information may be submitted to: Shirley Van der Veer, Editor, *La Tierra*, 123 E. Crestline, San Antonio, Texas 78201-6613. With your cooperation, much time may be saved in correspondence to clear up matters before *La Tierra* can go to press. E-mail makes for easy clear-up. Shirley's is <u>shirleyvan@worldnet.att.net</u> . Include your email address when contacting her.

APPENDIX A



South Texas counties with symbols for archaeological site designations.

CONVERSION CHART

Multiply	By	To Get	Multiply	By	To Get
millimeters (mm)	0.0394	inches	inches	25.4	millimeters
centimeters (cm)	0.394	inches	inches	2.54	centimeters
centimeters	0.0328	feet	feet	30.48	centimeters
meters (m)	3.281	feet	feet	0.3048	meters
meters	1.094	yards	yards	0.9144	meters
kilometers (km)	0.621	mile	mile	1.609	kilometers
hectares (ha)	2.471	acres	acres	0.4047	hectares

THE SOUTHERN TEXAS ARCHAEOLOGICAL ASSOCIATION

The Southern Texas Archaeological Association brings together persons interested in the prehistory of south-central and southern Texas. The organization has several major objectives: To further communication among avocational and professional archaeologists working in the region; To develop a coordinated program of site survey and site documentation; To preserve the archaeological record of the region through a concerted effort to reach all persons interested in the prehistory of the region; To initiate problem-oriented research activities which will help us to better understand the prehistoric inhabitants of this area; To conduct emergency surveys or salvage archaeology where it is necessary because of imminent site destruction; To publish a quarterly journal, newsletters, and special publications to meet the needs of the membership; To assist those desiring to learn proper archaeological field and laboratory techniques; and To develop a library for members' use of all the published material dealing with southern Texas.

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