A Technological Analysis of Lithic Assemblages from Guadalupe Mountains National Park, Texas[1]

Richard Boisvert

ABSTRACT

This report concerns the analysis of lithic artifacts collected during the 1970 Texas Archeological Society Field School from 120 prehistoric sites in Guadalupe Mountains National Park, Texas. Research is focused upon three topics: the role of raw material selection in chipped stone tool manufacture, assessment of flaking behavior on the basis of an attribute analysis of the debitage, and identification of potential cultural-temporal-ecological significance of the individual chipped stone tool assemblages. Significant patterns of raw material utilization are noted in the assemblage at large. The debitage study has revealed that certain stages of chipped stone tool manufacture can be identified. Analysis of the tool assemblages revealed no significant cluster of tool forms with the exception of one apparent tool kit that appears to have temporal and ecological significance. An assessment of the quality of the research methodologies is also presented.

INTRODUCTION

This report presents the results of an analysis of the lithic assemblage gathered from more than 100 archeological sites in or adjacent to the Guadalupe Mountains of Trans-Pecos Texas. Three research problems are defined and analyzed in detail. They are:

1) What were the raw materials selected to make chipped stone tools, and were there significant relationships between these materials and the forms into which they were processed?
2) What were the techniques applied in the manufacture of chipped stone tools?
3) What were the variations through time and space of these artifacts and of the assemblages they constituted?

These are interrelated problems and they incorporate the premise that the form of an implement is determined by (1) the kind of material used, (2) the techniques applied to fashion it, and (3) the use(s) for which it was intended and employed.

The data for this study were collected by the Texas Archeological Society (TAS) during its 1970 field school. Harry Shafer and Dessamae Lorrain

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directed the survey in parts of Hudspeth and Culberson counties, Texas, in anticipation of the area's development into a national park. The data on the ceramics and rock art have been analyzed and published by Phelps (1974) and Clark (1974), respectively, and a study of the historic sites also has been undertaken.

The purpose of this study is to increase our knowledge of the culture history of the area that is now Guadalupe Mountains National Park. The survey conducted there by the TAS accumulated a collection of artifacts dominated by lithics, primarily cores, flakes, unifaces, and numerous chipped stone implement fragments. Although the majority of these artifacts are nondiagnostic, they furnish a significant data base for the study of lithic technology.

Another goal is to explore the potential of debitage analysis as an aid to obtaining insights into prehistoric behavior and to discover what can be learned from, and what are the limitations of, this kind of data.

The systematic analysis of chipped stone artifacts has been of interest to archeologists for many years. William H. Holmes, second director of the Smithsonian Institution, devoted much of his research to the investigation of prehistoric quarry and workshop sites, first in the Potomac Basin area around Washington, D.C., and later in other parts of North America (Holmes 1897). He pioneered the study of lithic technology in North America and laid the groundwork for later studies. He roughly outlined the stages of reduction and shaping required for the manufacture of bifacial artifacts. His best-known contribution was the definition of the intermediate stage of biface manufacture that is usually termed the preform or blank. He accomplished this by systematically analyzing the broken bifaces at quarry and workshop sites. However, in order to arrive at his conclusions, Holmes did not analyze the flakes removed from the cores and preforms; rather, he inferred the flaking process from study of both intact and broken bifaces from the sites.

Another benchmark in the study of American lithic technology is the work of William H. Ellis (1940), who, elaborating on the work of Holmes, systematically carried out a series of replicative experiments in flint knapping aimed at defining the techniques of stone tool manufacture. He identified various techniques of direct and indirect percussion and pressure flaking, and he commented on their effectiveness for performing various tasks in the manufacture of chipped stone tools. He described in some detail the chippage that results from the different fabricating techniques (Ellis 1940:11-39). His work was almost totally based upon replicative experiments, and he made only peripheral reference to ethnographic analogies, except to mention that the techniques he found most suitable were not always chosen by the aboriginal knappers (Ellis 1940:61). Curiously, Ellis never applied his findings to archeologically derived data bases.

Subsequently many other researchers have taken up this neglected task and have begun to study not only the products of chipped stone tool manufacture, but also the by-products. Interpretations of prehistoric lithic technologies that draw from the experimental base have been initiated and are typified by the work of M.B. Collins (1974) and Don E. Crabtree (1972). Both men are experienced knappers, and both have applied their findings to the interpretation of the archeological record. It is with this intent that the debitage analysis component of this report has been undertaken.

This report is a technological analysis of chipped stone artifacts. It is an attempt to bring together several lines of inquiry in the hope of discovering the ways in which certain prehistoric peoples made their stone tools. The study is also an attempt to formulate, utilize, and assess certain methodological approaches toward the analysis of chipped stone technology, especially as it relates to assemblages drawn from surface collection surveys.

ENVIRONMENTAL SETTING

Guadalupe Mountains National Park is in northeastern Trans-Pecos Texas in parts of Hudspeth and Culberson counties (Figure 1). The park includes the southernmost part of the Guadalupe Mountains, which extend southward into Texas from New Mexico, as well as parts of the adjacent Patterson Hills and surrounding desert and salt flats, covering 31,371 ha (77,518 acres) and varying in elevation from 1112 meters (3,650 ft.) at the base of the western escarpment to 2667 meters (8,751 feet) atop Guadalupe Peak (Figure 2). Geologically the mountains are part of the Permian Reef complex of Texas and New Mexico and are composed mainly of limestone, dolomite, and sandstone. The environmental and ecological variations that result from the extremes in elevation make this area unique. The high reef escarpment, rising from the scorched and desiccated desert, is penetrated by steep-sided canyons and supports a perennially green conifer forest.

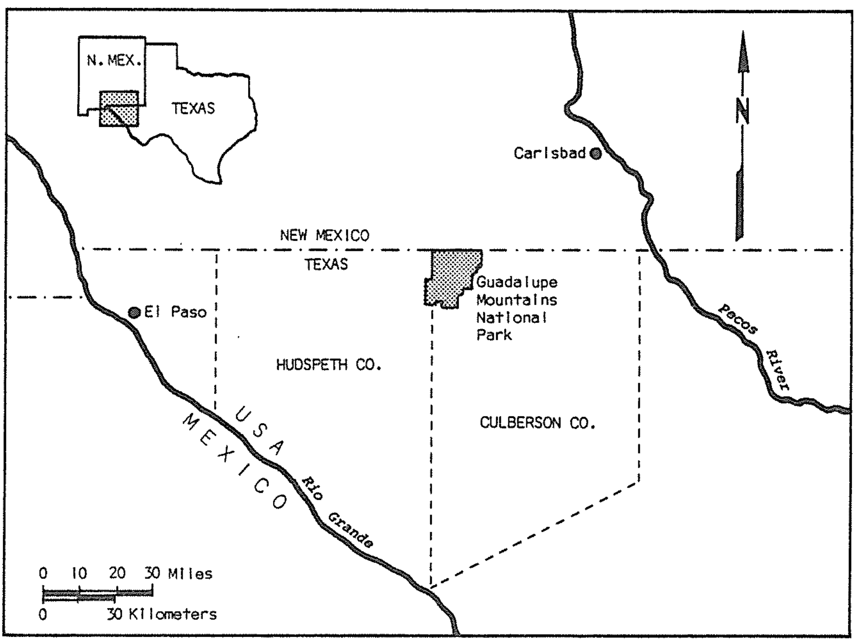

Figure 1. Map of part of Texas and New Mexico showing location of Guadalupe Mountains National Park.

Geology

The present-day nature of the Guadalupe Mountains region is the result of geologic processes. In the early part of the Permian period, the Delaware Basin developed in what is now Trans-Pecos Texas and southeastern New Mexico. On the margin of the basin a series of reefs—the Permian Reef complex—formed. Parts of this reef have survived essentially intact as the Glass, Apache, and, most notably, Guadalupe mountains.

The Guadalupe Mountains are a great wedge that protrudes southeastward into Texas from New Mexico, terminating abruptly at the spectacular promontory El Capitan. The mountains make up the northern half of an eastward-tilting block of the earth's crust that measures about 160 km (100 miles) from north to south by 80 km (50 miles) from east to west.

> The southeastward facing Reef Escarpment . . . extends diagonally across the tilted surface, following an ancient tectonic and stratigraphic axis, along which the limestones of the Guadalupe Mountains come to an end. . . . On the west side of the tilted block, the mountains break off in steep escarpments. . . . The escarpments slope toward the Salt Basin, a depression with no outlet to the sea, whose lower part stands at an altitude above 3,600 feet, or nearly a mile below the summit of Guadalupe Peak not far away. Extending westward from the lowest benches of the basin is a great alluvial apron composed of detritus washed down from the mountains. Rising from the alluvium in places are low rock ridges, such as the Patterson Hills southwest of El Capitan [King 1948:5].

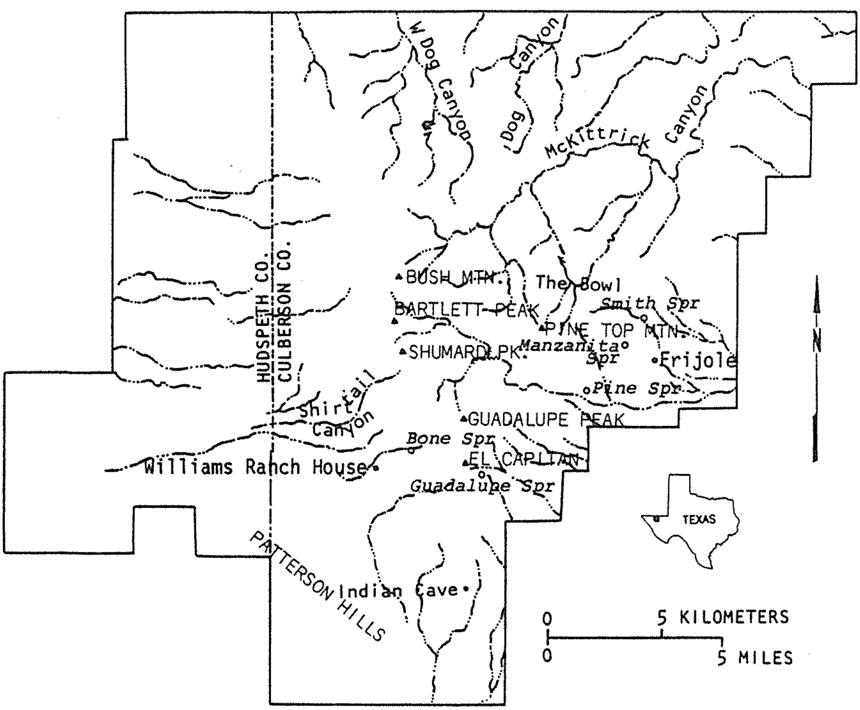

Figure 2. Map of Guadalupe Mountains National Park showing places referred to in this report.

The Guadalupe Mountains consist principally of limestone and sandstone and occasional shale formations. The thick, massive Capitan and Carlsbad limestones make up more than 90 percent of the Guadalupes and the Patterson Hills (Figure 2), which adjoin the mountains on the southwest. Underneath these limestones are other formations of interbedded limestones, sandstones, shales, and quartzites. These are found on the south and east edges of the Guadalupe Mountains and along the east side of the Patterson Hills. The few cherts that are found in the southern Guadalupes are in these rocks, principally on the eastern escarpment in the Manzanita Member of the Brushy Canyon Formation. The floors of Dog Canyon, West Dog Canyon, and the desert surrounding the mountains are of alluvium. These alluvial deposits vary from fine-grained bolson deposits and sand dunes west of the mountains to slope deposits and gravels on the flanks of the mountains and on the desert to the east.

A brief survey turned up poor-grade cherts cropping out in the Manzanita Member of the Brushy Canyon Formation and small nodules (about 10 cm in diameter) of higher quality cherts in the gravels below the southeast escarpment. Less than two days were spent in the attempt to locate sources of chippable stone in the region, so it is likely that further investigations might result in the discovery of deposits of higher quality chippable stone that would have been available to the prehistoric residents of the Guadalupes (see Boisvert 1980: Appendix 1 for a more detailed discussion of the geology of the park area).

Climate

The National Park Service describes the climate in the park as variable and often extreme.

> Summertime temperatures may be disagreeably hot at lower elevations while the highlands and moist canyons are cool by contrast. The western escarpment produces a reflector-oven effect on the west side lowlands which creates pleasant conditions during cool winter months. At the same time, the highlands can be bitterly cold and snowy [National Park Service 1974:34].

The officially recorded extremes of temperature at the 1524-meter (5,000 ft.) elevation are -20° C. (-6° F.) in January and 35° C. (96° F.) in July. Annual precipitation in the park is 56 cm (22.23 in.), but most of it falls in the higher elevations, especially above 2000 meters (7,000 ft.). High winds are common, especially from late fall to early spring, often reaching 95 to 130 kph (60-80 mph). The record high wind is 180 kph (110 mph) on January 25, 1967 (National Park Service 1974:34-35).

Life Zones

Four life zones are recognized in the park: the Lower Sonoran arid division of the Lower Austral zone, the Upper Sonoran arid division of the Upper Austral zone, the Transition zone, and the Canadian zone (Bailey 1928:16-18). The Lower and Upper Sonoran divisions and the Transition zone each cover about a third of the park, but the Canadian zone covers only a very small area at the highest elevations (Figure 3). The division between the Lower and Upper Sonoran zones is usually at the 1400 meter (4,500 ft.)

elevation, with variations resulting from local topography. The Upper Sonoran zone tends to extend down below 1400 meters (4,500 ft.) on eastward-facing canyons and slopes, and tends to retreat above 1400 meters (4,500 ft.) on westward-facing slopes. This difference is the result of the desiccating effect of the prevailing winds, which blow across the salt flats toward the mountains. The Upper Sonoran and Transition zones meet at about 2000 meters (7,000 ft.). The dividing line between the Transition and Canadian zones can be fixed at about 2600 meters (8,500 ft.), restricting the Canadian to the top of the highest mountains in the park (Burns 1967:8). Although there is an overlap in the life forms that inhabit these zones, each zone has its own floral and faunal assemblages.

Lower Sonoran Life Zone

The Lower Sonoran life zone covers the western and southern parts of the park, where it is interrupted only by the Patterson Hills (Figure 3). Most of the area is situated in the sand dune region between the salt flats and the western escarpment. The southern part of the zone is east of the Patterson Hills and has somewhat more relief where low sandstone ridges of the Brushy Canyon and Cherry Canyon formations protrude through the alluvial deposits.

A survey of the flora and fauna of the park was made by the TAS field school in conjunction with the archeological survey. The predominant plants recorded in the Lower Sonoran zone were creosote bush, mesquite (which were bearing many beans at the time), prickly pear and cholla cacti, sotol, agave, lechuguilla, and narrow leaf yuccas. Pincushion, barrel, bear, small spine, and Englemann's cacti also were seen, as were althorn, catclaw, grama grass, and a variety of other grasses and small plants, making up a typical xerophytic plant community.

The fauna recorded during the survey in the Lower Sonoran zone included jackrabbits, cottontails, various species of small rodents and lizards, mockingbird, and quail. In addition, a variety of snakes were recorded: four kinds of rattlesnakes, garter snakes, hognose snakes, and racers or whipsnakes (Gehlbach 1964:1-10). Skunks, roadrunners, orioles, cactus woodpeckers, Texas nighthawks, and white-necked ravens also are found in this area of the Chihuahuan Desert (Bailey 1928:11-12).

Upper Sonoran Life Zone

The Upper Sonoran zone occupies a broad belt along the western and southeastern escarpments of the Guadalupes. With few exceptions the zone is hilly, with steep-sided canyons cutting into the massif. The few level areas that do exist, between 1400 and 2000 meters (4,500 and 7,000 ft.) are dissected by numerous and often deep arroyos, which originate in the canyons above. Due to its higher elevation and proximity to the areas of higher rainfall in the mountain interior, this zone tends to be more moist than the Lower Sonoran zone. In addition, many springs are scattered along the front of the reef.

The flora recorded in the Upper Sonoran zone include all of the yuccas and cacti of the Lower Sonoran zone with the addition of pitaya and

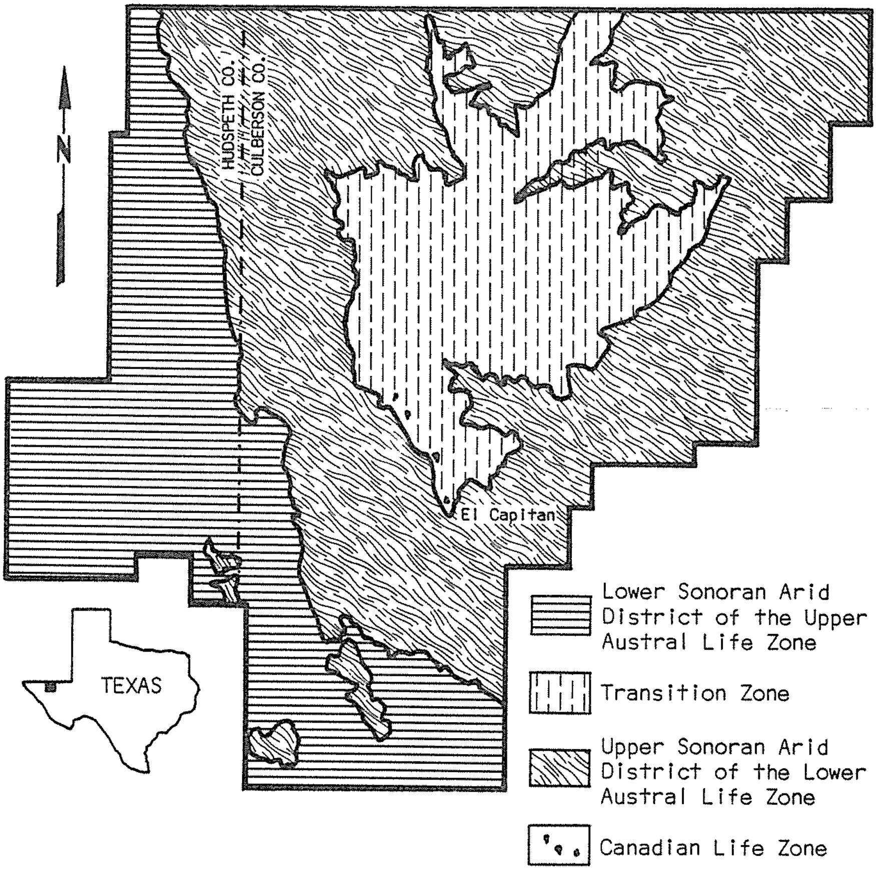

Figure 3. Map showing life zones in Guadalupe Mountains National Park. (Constructed from data of Bailey 1928.)

mammillaria cacti. Trees are more common in the Upper Sonoran, especially on the canyon floors and at the springs. Among the trees are bigtooth maple, five varieties of oak, juniper, spruce, mountain spout mahogany, ponderosa pine, and, occasionally, pinyon pine, Texas walnut, willow, and ironwood. Added to the small xerophytic plants and grasses of the Lower Sonoran that are duplicated here are such plants as *Nolina texana*, or basket grass.

The fauna supported in the Upper Sonoran zone are varied. Bailey (1928:16) reports "Texas mountain sheep, grey mule deer, rock squirrel, Rowles white footed mouse, white throated rat, gray fox, horned lark, raven" and many other birds. Also in the area are porcupines, jackrabbits, desert cottontails, kangaroo rats, wood rats, numerous small rodents, and owls (Lundelius 1979). Burns (1967:10) reports that reptiles occur less frequently here than in the Lower Sonoran.

Transition Life Zone

The Transition zone occupies the central and north central part of the park. The region is cut by canyons and is marked by high, rugged mountains, woods, and parklands, and a wide variety of trees and plants thrive. Surviving in the Bowl (Figure 2) is a mixed mesophytic Pleistocene relic forest, one of the unique ecological aspects of the park.

The TAS spent little survey time in the Transition zone, and no records were made on the flora and fauna, but the area has been described by Bailey.

> This zone is strongly marked by the yellow pine, with huge scaly trunks in wide stretches of beautiful open forest, clear, and grassy underneath. Douglas spruce, southern white pine, large-leaved maple, New Mexico oak and locust occupy secondary places in the forest. Extensive open parks or grassy glades appear. . . .
>
> The characteristic mammals are white-tailed and mule deer, two species of chipmunks, a small form of the thirteen-lined ground squirrel, the Colorado wood rat, Guadalupe meadow mouse, fulvous pocket gopher, mountain cottontail and brown bat [Bailey 1928:18].

The avifauna include Merriam's wild turkey, band-tailed pigeon, spotted owl, screech owl, woodpecker, scaled quail, dove, and a variety of smaller birds. Burns (1967) also reports that the red-tailed hawk and golden eagle are found. The faunal inventory includes the cottontail, squirrel, badger, fox, bobcat, coyote, and porcupine.

Canadian Life Zone

The Canadian zone is restricted to the summits of Brush Mountain, Bartlett Peak, Shumard Peak, and Guadalupe Peak (Figure 3). Bailey (1928:18) reports that the flora consists of spruce, fir, and aspen forests with many other Rocky Mountain plant species. Among the rare and endangered flora of the park is a stand of no more than a hundred quaking aspens on a hillside with a northeast exposure southeast of Brush Mountain. The stand is not reproducing and is steadily diminishing in size (National Park Service 1974:90).

The fauna once included the now extinct Merriam elk; mountain lion and big horn sheep, now very rare, were also present. This small zone is relatively unimportant today, except as an ecological isolate, but it was once much more widespread in the southern Guadalupes.

Summary

Environmentally, the Guadalupe Mountains National Park area is extremely diverse. Confined within its 200 square kilometers (120 square miles) are four major life zones that include isolated relics of a verdant Pleistocene forest, permanent flowing streams, and alkali flats. The elevation ranges between 1100 and 2700 meters (3,650 to 8,750 ft.) within a distance of 11 km (7 miles). Some areas are nearly level and are covered with sand dunes; others have deep arroyos with precipitous clifflike sides, the products of furious flash floods. At first glance the region seems barren and devoid of life, but upon further inspection even the burnt umber landscape of the desert discloses a wide range of plant and animal life.

ARCHEOLOGICAL AND ETHNOHISTORICAL BACKGROUND

Half a century has passed since publication of the first archeological field report from the Guadalupe Mountains. Investigations have been conducted intermittently there since that time, yet the region is by no means well known or understood. The four cultural-historical stages—Paleo-Indian, Archaic, Neo-American (also called Late Prehistoric), and Historic—of Suhm, Krieger, and Jelks (1954) are all recognized in the region. The information available for each of these stages from the southern Guadalupes is summarized below.

Paleo-Indian Stage

The Paleo-Indian stage, a late Pleistocene and early post-Pleistocene hunting and gathering adaptation, has at least two manifestations in North America, distinguished by both geographical and cultural factors. On one hand is the big-game-hunting Paleo-eastern tradition, and on the other, the gathering-oriented Paleo-western tradition (Wormington 1957:21). Paleo-eastern materials, generally found east of the Rocky Mountains, are typified by distinctive, often fluted, lanceolate projectile points. The well-known associations between these points and extinct Pleistocene fauna have been responsible for the identification of big game hunting as part of the culture pattern, but a paucity of excavated Paleo-Indian habitation sites (as opposed to kill sites) has made it difficult to assess the significance of the gathering and small-game-hunting aspects of Paleo-eastern subsistence. Although the evidence is meager, there is a consensus among investigators in the field that plant collecting played a significant role in the Paleo-eastern life-style (Irwin 1971:46).

The Paleo-western tradition is less clearly defined than is the Paleo-eastern. The rarity of associations between recognized western Paleo-Indian projectile points and Pleistocene fauna suggests that big game hunting was not especially important. Irwin (1971:58) has suggested that some big game hunting may have taken place early in the Paleo-western tradition, but it gave way to a more diverse gathering economy.

Archaic Stage

The term *Archaic stage* was first used by William Ritchie (1932) to describe adaptations in New York. The definition has been modified to include a large part of North America, including Texas (Suhm, Krieger, and Jelks 1954:18). The Archaic, which overlaps the Paleo-Indian, is a generalized hunting and gathering subsistence pattern that persisted for several millennia. There is ample evidence in terms of both tool kits and botanical remains that plant food collecting played a major role in Archaic stage subsistence. Pottery and indications of agriculture are absent, except during the final part of the stage, when they appear as either products of internal development or, more commonly, results of diffusion. In a broad sense, the Archaic stage can be equated with the Old World Mesolithic in that it exemplifies a broad-based hunting and gathering post-Pleistocene adaptation.

Neo-American Stage

According to the terminology of Suhm, Krieger, and Jelks (1954), the next prehistoric stage in Texas is the Neo-American. Subsistence in this stage includes agriculture, but the presence of the bow and arrow shows that hunting was still practiced. Ceramic technology is another hallmark of the Neo-American. Permanent settlements were larger; some even approached urban levels. However, Krieger reports that the two new traits—ceramics and agriculture—do not necessarily appear simultaneously; consequently, Neo-American is applied to any group that had two of the traits (Suhm, Krieger, and Jelks 1954:20).

Historic Stage

The Historic stage is defined as beginning when European artifacts are found associated with native American sites. At the time of contact between the Spanish and the native populations, groups having both Archaic and Neo-American lifeways were living in Trans-Pecos Texas. This was a dynamic period in which groups underwent rapid change and, in some cases, extinction. Records left by the early Spanish adventurers and chroniclers not only describe the fate of these people but also provide some information on their life-styles. For this reason the Historic stage is especially important in the interpretation of Trans-Pecos archeology.

Cultural-Historical Stages in the Park Area

The Guadalupe Mountains are on the southeastern periphery of the Rocky Mountains, with the southern Plains, including the Llano Estacado, on the east, and an arid basin and range system of the American Southwest on the west. South of the Guadalupes is the extensive Chihuahuan Desert, which stretches deep into Coahuila and Chihuahua, Mexico. Culturally, the Guadalupes are in the Northeastern district of the Trans-Pecos region as defined by Lehmer (1958:110). The other districts are El Paso at the western extreme of Texas, La Junta along the Rio Grande below El Paso, and Southeastern along the lower Pecos River (Figure 4).

This subdivision unfortunately belies the actual interrelationship of the Trans-Pecos to major culture areas. Lehmer's El Paso and, possibly, La Junta districts (at least during the first millennium A.D.) should be included in the Southwest culture area, and his Southeastern district is in the Northeastern Mexico culture area (Willey 1966:329). Lehmer's Northeastern district should be viewed as transitional between the Southwest, Plains, and Northeastern Mexico culture areas (Figure 4). Indeed the existence of the Trans-Pecos region is a result of modern investigators' attempts to fit that part of a modern geopolitical unit into an existing archeological framework. As work in the area progresses and relations are clearly established with other culture areas, it may become advisable to abandon Trans-Pecos as an archeological subdivision. However, until that happens, the Trans-Pecos is useful for identifying a geographical study area.

Following is a review of the cultural-historical stages within the Northeastern district of the Trans-Pecos of Texas, with emphasis on the southern Guadalupe Mountains and the relationship between this area and adjacent regions.

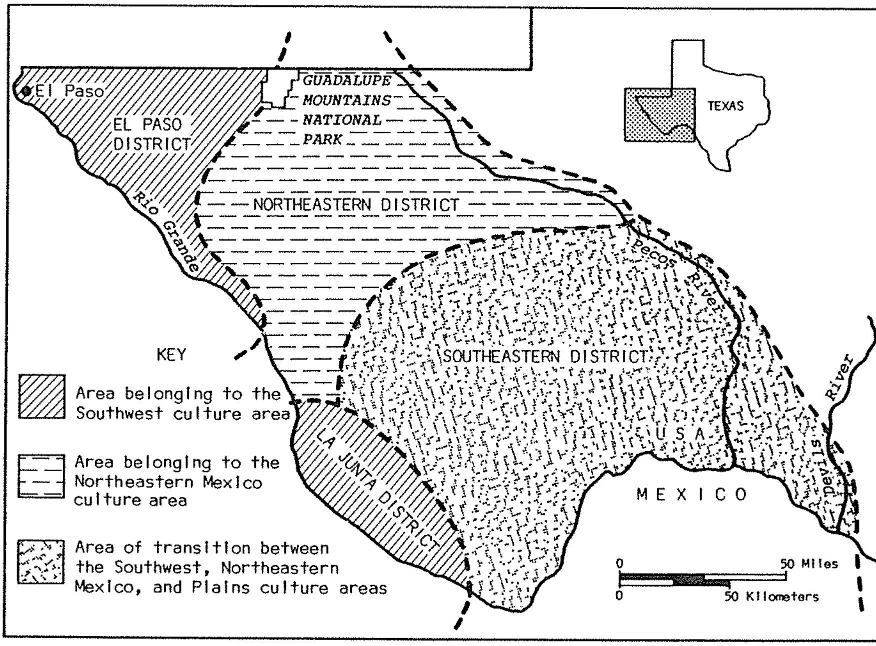

Figure 4. Map showing culture areas in the Trans-Pecos region of Texas. (After Lehmer 1958.)

Paleo-Indian Sites

The best evidence of Paleo-Indian occupation in the Guadalupe Mountains is outside the park in Burnet Cave, a dry cave in New Mexico about 30 km (20 miles) north of the Texas-New Mexico border and 50 km (30 miles) west of Carlsbad. There, in an essentially undisturbed deposit, E.B. Howard (1932) uncovered, at depths from 1 to 2.5 meters (3 to 8 ft.) below the surface, the remains of more than ten extinct animals or animal species that are no longer found in the region. The faunal inventory consisted of "an extinct four horned antelope (Tetrameryx), two extinct horses (Equus fraternus and E. complicatus), extinct bison (Bison alleni), extinct musk-ox (Bootherium sp), a large extinct camel, extinct California condor, and a number of other bird bones, including those of the wild turkey" (Howard 1932:15). Howard also found the remains of marmots (*Marmota falviventris*), which have been significant in the interpretation of the Paleo-environment (Murray 1957; Antevs 1954).

In addition to the faunal material, Howard (1932:13) also found a Clovis point: "The depth at which our spear-point was found was five feet seven inches below the surface and about four feet below the level of the Basket Maker burial. As I mentioned we had to move a large rock which was directly over the hearth, which contained the point." Howard proposed that the location of the hearth below the Basketmaker level and the quantity of broken horse, bison, and camel bones indicated that these animals were hunted by the makers of the Clovis point. He admitted that the fractured condition of the bones could be explained by roof fall, but at this time, with the benefit of hindsight, his suggestion that the animals were hunted by the makers of the Clovis point seems more likely to be the correct interpretation.

In the early 1950s a sample was taken from Burnet Cave materials for radiocarbon dating, and a date of 7432 ± 300 years B.P. was obtained (Wormington 1957:33). However, the composition of the faunal inventory and the much earlier dates for Clovis material in the Southwest have prompted Wormington (1957:33) to suggest that this date is too recent.

Within the park there have been several finds of Paleo-Indian projectile points. Paul and Susanna Katz (1974:54-55) report the base of a probable Plainview point from a site on a bench on the southeast reef front at the north end of the Patterson Hills, and the base of a probable Midland point from a ridge in the northwestern part of the park. They also found a biface fragment, which they attribute to the Paleo-Indian stage, at a site (41CU31) in Pine Spring Canyon (Figure 2). These artifacts are the only signs of Paleo-Indian occupation in the extreme southern part of the Guadalupe Mountains.

Joe Ben Wheat (n.d.) has studied extensive deposits of Paleo-Indian materials from a multicomponent site in the Van Horn area, 96 km (60 miles) south of the park. Occupation of the site extends from early Paleo-Indian through late Paleo-Indian, Archaic, and Neo-American stages; the site covers about 3 ha (9 acres) and was once probably stratified (Wheat n.d.), although most of the material is now on the surface. Wheat reports that the inventory of Folsom materials includes 100 Folsom points, 425 end scrapers, 400 side scrapers, 52 gravers, 11 burins, 16 notches, and 80 channel flakes. In addition, San Jon, Plainview, Agate Basin, and possibly Milnesand points have been recovered. The site is on a chain of late Pleistocene playa lakes and alkali flats in a setting that resembles the physiography to the west of the Guadalupes.

All of the Paleo-Indian materials that have been discovered thus far relate to the Paleo-eastern tradition; no Paleo-western (gathering-oriented) Paleo-Indian materials have been identified in the southern Guadalupes, although some may yet be found. Collins (1976) has proposed that such a gathering-oriented (Paleo-western) terminal Pleistocene adaptation existed on the lower Pecos River some 482 km (300 miles) to the southeast in Lehmer's Southeastern district (Figure 4). He has further proposed that there was no cultural continuity between the terminal Pleistocene big-game-hunting peoples and the earliest Archaic cultures (Collins 1976:22). This raises the question that there may be as yet unidentified non-big-game-hunting Paleo-Indian cultures in the Pecos River region and adjacent areas.

Archaic Sites

The Archaic of northeastern Trans-Pecos Texas is still poorly understood. Radiocarbon dates are rare because few excavations, especially of stratified sites, have been carried out since the introduction of the technique. Consequently, it is difficult to make precise statements about the nature and chronology of Archaic manifestations in the area. The presence of many Archaic stage projectile points and other coeval artifacts does suggest that a wide range of Archaic manifestations may be present.

Suhm, Krieger, and Jelks (1954:31) consider the Cochise culture, defined by Sayles and Antevs (1941), as the ultimate source for the Archaic cultures of the region. Cochise has considerable antiquity; its earliest phase has associations with now extinct Pleistocene fauna. Irwin-Williams (1967:454) reports some radiocarbon dates that range between 9300 and 8300 B.P. for the Sulphur Springs (earliest) phase. The San Pedro (latest) phase, dates between 4000 and 2000 B.P. The Cochise culture thus covers an immense span of time. Sayles and Antevs interpreted the Cochise as having a gathering-oriented subsistence base, with hunting playing only a minor part. Milling stones dominate the artifact assemblage, especially in the first two stages, with chipped stone becoming frequent only during the last stage. Most of the Cochise finds come from Arizona and New Mexico and may not have a direct application to the Trans-Pecos.

To the southeast, in the Lower Pecos region, is another cluster of sites that contain evidence of gathering-oriented Archaic cultures. Collins has synthesized data from 20 components in seven sites that range in time between 14,500 and 5000 B.P. On the basis of his analysis, "the beginnings of a long Archaic tradition of plant food gathering, fishing, and small game hunting occur around 9000 years ago" (Collins 1976:22). In the early part of the Archaic, from 9000 to 5500 B.P., rabbits and rodents were the basic animal foods; deer were hunted regularly only after 5500 B.P. Direct evidence for exploitation of plant food was not preserved in most cases, but the artifact inventory of bifaces, choppers, and grinding stones makes it reasonable to assume that plant foods were probably quite important.

The subsistence strategy for the early Archaic, and quite possibly for most of the Archaic, seems to be oriented more toward gathering than hunting. This is inferred from patterns of the Cochise culture to the west and the Lower Pecos River culture to the southeast. These patterns may not be applicable to the southern Guadalupes, but the environmental similarities and comparable artifact inventories from at least a few sites indicate that the analogy may in fact be appropriate.

There is a nearly total lack of information on the early Archaic in the vicinity of the southern Guadalupes, but there is not quite such a void on the later Archaic. Lehmer (1948) defines the Hueco phase as the precursor of the Jornada branch of the Mogollon, a Neo-American stage culture. The Hueco phase was originally described by Sayles (1935) as the Hueco Cave Dweller phase. The Hueco seems to have had a broader material culture than did the previous Cochise or Cochise-like culture and may represent some degree of specialization in subsistence. The Hueco phase has been summarized as having

> . . . unhafted choppers, leaf blades, drills, flake knives, several kinds of projectile points, core scrapers and grinding tools, including manos and metates, and mortars and pestles. Mortar holes are deep and cylindrical with rounded bottoms and are found in boulders and rock outcrops. Pestles are long and tapered to the top from a point just above the grinding surfaces which are flat or convex along the axis; occasionally wedge-shaped cross sections occur. . . . Metates have flat grinding areas or oval bowls. The trough variety is not known [Lehmer 1948:72].

The atlatl was in use, but apparently not the bow and arrow or ceramics, except in the very latest adaptations.

There are at least two excavated Hueco phase sites in the southern Guadalupes. Williams Cave (or Indian Cave) (41CU16), was excavated by Mary Youngman Ayer in the 1930s under the aegis of E.B. Howard. Although the site was quite deep, Ayer did not indicate whether it was stratified or even dug in arbitrary levels. She recovered an unspecified number of manos—both convex and wedge shaped—flat metates, scrapers, sotol-digging sticks, shafts and foreshafts (presumably of atlatl darts), at least three varieties of sandals, and a wide variety of other basketry and cordage. Under plant remains she reported "primitive flint corn, ears 1½-3 inches long, average 12 rows of kernels, mesquite beans, piñon cones, prickly pears, sotol seeds, bundles of grass (use problematical)" (Ayer 1936:604).

The fauna from the cave consisted of a variety of small rodents, three species of deer (including white-tailed deer), wapati, pronghorn antelope, bobcat, cougar, grizzly bear, and gray fox. A yellow-haired porcupine was noted, and Ayer commented that its natural habitat was in the Transition or Canadian zone. Extinct faunal remains from the cave included direwolf, horse, bighorn sheep, and ground sloth. All of the extinct faunal materials were recovered between 1 and 1.5 meters (4 to 5 feet) below the surface (Ayer 1936:604-617). With the exception of these faunal remains, Ayer does not furnish provenience for any of the faunal or artifactual materials excavated.

Three burials were excavated from the cave, a basket burial of two children and an adult, a cradle burial, and a bag burial of an adult. Ayer reports that the multiple burial was at a depth of 46 cm (18 in.) in the rear of the cave, and the cradle burial was near the innermost wall; no mention was made of the location and depth of the third burial. No evidence of occupation was found more than 1 meter (3 ft.) below the undisturbed surface (Ayer 1936:600-601).

The artifact inventory, nature of the burials, and lack of pottery corresponded to Sayle's Hueco Cave Dweller culture (Ayer 1936:604). Since there were no tabulations of artifact frequencies, faunal materials, or provenience, it is difficult to assess the significance of the site. Clearly, a hunting and gathering subsistence is indicated, probably with emphasis on gathering, since most of the faunal remains represent only one individual per species. Unfortunately, we have no idea how many milling stones or sotol digging sticks were recovered; this data might have given us a better indication of the subsistence emphasis. There is a suggestion of stratigraphic separation of the cultural materials and the Pleistocene fauna, appearing to rule out a late Paleo-Indian or early Archaic occupation. No dates have been suggested for this site, but it is conceivable that some of the organic cultural materials could be used for radiocarbon analysis.

Pratt Cave is on the northeast edge of the park, on the south side of McKittrick Canyon. In 1961 a cache of artifacts was discovered in the cave, and in 1965 excavations were initiated under the direction of Albert Schroeder (Katz and Katz 1974:7). The results of the archeological investigations have recently been published (Schroeder 1983), and the pollen analysis (Bryant 1983) and faunal analysis (Lundelius 1979) are available.

Two radiocarbon dates of perishables in the cache were: TX-1021—wood slab, 1420 ± 60 B.P. (ca. A.D. 530); and TX-1022—basketry, 1840 ± 60 B.P. (ca. A.D. 110) (Valastro et al. 1979:262). These dates indicate that the cache is probably late Hueco.

In addition to the excavations at Pratt Cave described above, H.P. Mera investigated 13 sites in the Guadalupes (Mera 1938). Originally he had planned to work only in caves because they were being destroyed at an alarming rate by relic collectors, but he decided to include some open campsites as well. Although his report contains a wealth of information, it includes neither descriptions of the excavation techniques nor the provenience of the materials recovered, except by site. It is apparent that many of the sites yielded artifacts from the Archaic stage, as well as some evidence of Neo-American occupations. In High Cave, now known as Higher Sloth Cave (Katz and Katz 1974:6), Mera excavated a midden ring, and from this and other excavations in the cave he recovered mescal quids, 46 sandals, a section of net, and a large hardwood projectile point, but no ceramics (Mera 1938:34-35). It is quite possible that this site may date to the Archaic.

Further documentation of Archaic occupations in the southern Guadalupes comes from the recent work of Paul and Suzanna Katz. In their survey of the park subsequent to the TAS survey, they compared many of their projectile points to those in a typology established by LeRoy Johnson (1967). They identified Johnson's C-, D-, and E-group points among ones they recovered from lithic and ceramic-and-lithic scatter sites in the Guadalupes. Johnson's chronology, which the Katzes tentatively adopted, dates these projectile points from 6000 B.C. to A.D. 1. The Transitional period, according to Johnson's scheme, dates from A.D. 1 to A.D. 800 and is represented by H- and I-group points. Transitional period sites are also characterized by brown ware ceramics (presumably Jornada Brown, El Paso Brown, and South-Pecos Brown, all of which are found in the park). The Texas Tech survey conducted by the Katzes, like the TAS survey, dealt only with surface collections; therefore, assignment of Archaic stage dates to their sites is by typological comparison only.

Although Archaic manifestations in the southern Guadalupes have been studied more thoroughly than have any other stages, our understanding of the Archaic is still rudimentary. The existence in the mountains of several caves with Archaic components, as well as many Archaic style points in open sites, indicates a substantial occupation during the Archaic, but there are no clear associations of Archaic materials with extinct fauna, leaving an early Archaic occupation an open question. The single set of radiocarbon dates for the southern Guadalupes confirms a late Archaic presence. The available floral and faunal inventories from the dry caves and shelters indicate that gathering was more important than hunting. It is apparent that there was some variety of generalized Archaic hunter-gatherer culture in the region. Typologically it seems to resemble the Hueco phase most closely.

Neo-American Sites

The Neo-American stage is represented in Trans-Pecos Texas by the Jornada branch of the Mogollon, defined by Donald H. Lehmer (1948). Since ceramics are an integral part of the Jornada inventory, it has been possible to define rather precisely the spatial and temporal limits of the various phases of the Jornada branch. Lehmer was able to date three phases on the basis of a series of Jornada ceramics and the association with them of various previously dated intrusive wares. Below is a brief description of sites in the Guadalupes and adjacent regions that have Jornada branch materials.

Lehmer believes that the Neo-American stage in the Trans-Pecos developed out of a blending of the Hueco culture with influences from the Mogollon pueblos of San Maricial. Since the subsistence pattern already focused on plant gathering, the shift to plant food production was not a drastic change. According to Lehmer (1948:73), "the transition from the earlier gathering economy to a horticultural one was apparently gradual and without marked disturbing effect on the rest of the pattern." The large projectile points of the Hueco continued to be used in the early phases of the Neo-American, especially in the more marginal (i.e., mountainous) areas (Lehmer 1948:38).

Lehmer (1948) defines the Jornada branch of the Mogollon as having northern and southern variants, each subdivided into three phases. The phases of the southern variant (Mesilla, Dona Ana, and El Paso), which are more pertinent to the Guadalupe Mountains, will be discussed here.

Briefly, the Mesilla phase lasted from about A.D. 900 to 1000. Both rectangular and circular pithouses were used during this time, and ceramics were introduced into the region, apparently derived from Alma Plain (Lehmer 1948:74). El Paso Brown is the only ceramic type associated with the Mesilla phase. The subsistence base included some agriculture—probably maize and squash—but hunting and gathering continued to play a significant role (Lehmer 1948:75-78).

The Dona Ana phase (A.D. 1000-1200) is a transitional phase between the Mesilla and El Paso phases. The use of pithouses continued, but Pueblo-style houses also appeared. El Paso Polychrome was added to the El Paso Brown ware already in use. There was probably no significant change in the subsistence pattern (Lehmer 1948:78-80).

The El Paso phase (A.D. 1200-1400) had the most sophisticated development of the Jornada branch. The people lived in pueblos that were often arranged either in simple rows or in squares with interior plazas. Both El Paso Brown and El Paso Polychrome ceramics continued to be used, although the brown wares declined in relative frequency. Also at this time, intrusive potteries, most commonly Chupadero Black on White, became more frequent than at any other time. By this time agriculture had become more important, displacing hunting (Lehmer 1948:30-84).

There are several reported Neo-American sites in the Guadalupe Mountains. Mera (1938) discovered two caves, Goat Cave and Wild Horse Cave, with Neo-American components. In Goat Cave he found a burial, a great deal of vegetable matter, wooden projectile points, dart foreshafts, cane shafts, rabbit sticks (small hardwood sticks presumably used to kill rabbits), a fragment of rabbit-skin robe, and El Paso Polychrome and Chupadero Black on White pottery. His report does not indicate whether all of the materials from the cave came from the same archeological component, or whether they came from stratified deposits. At Wild Horse Cave, Mera found bits of weaving, a scraper, a knife, and 10 potsherds (nine Jornada Brown and a single sherd of Chupadero Black on White), and a midden circle was close by. Mera also commented that in all of the caves where he found vegetable material there were many mescal quids and occasional remains of opuntia fruits (tunas), but he found no mesqite beans or corn.

Another cave in the park with a Neo-American component is Hermit's Cave, excavated by Edwin Ferdon, Jr. (1946). The site had three levels, of which only the uppermost had ceramics. The pottery consisted of Chupadero Black on White, Lincoln Black on Red, and Classic Pueblo, or Pueblo III. Ferdon noted that changes in projectile point types indicated a shift from the use of atlatls in the lower levels to bows and arrows in the upper level. He did not find evidence of agriculture (Ferdon 1946:24-28). The ceramics at the site suggest a date of about A.D. 1350 (Breternitz 1966:72, 82).

About 160 km (100 miles) northeast of the park is the Merchant site, an open site excavated by the Lea County Archeological Society (LCAS) (Leslie 1965). The site was on the edge of a ridge overlooking a dry lake bed. Fourteen permanent structures were found there, including two pitrooms and twelve surface houses. Corely and Leslie report that the walls of the pitrooms were independent of the pit sides (Lehmer 1948:128). However, Collins suggests that they were indeed semisubterranean pithouses. The surface structures were made of caliche stones mortared with clay. An impressive number of projectile points—some 7,000—were recovered from the site (Leslie 1965:28). A few were Archaic dart points, but most were small arrow points. More than 7,000 sherds were recovered, 98 percent of which were made locally; the other 2 percent were intrusive decorated wares. On the basis of the intrusive types, an occupation date of about A.D. 1400 was established (Leslie 1965:29). The subsistence base seems to have been hunting, as "many large and small animal and fowl bones appeared in most all trash and refuse" (Leslie 1965:28). No evidence of agriculture was found, and the investigators suggested that acorns, which were found in small quantities at the site, were substituted for maize in the diet.

The El Paso Archaeological Society has reported on the excavation of a single-room house at the Hot Well site (Shultz 1966) in the Hueco Bolson west of the park. The excavators recovered 388 potsherds from the structure, 95 percent of which were local El Paso Polychrome. The identifiable intrusives from the house were Chupadero Black on White and Lincoln Black on Red. The overlap of the approximate time spans of the wares (Breternitz 1966:72, 74, 82) suggests an occupation date of about A.D. 1350. Stone artifacts were rare at this site; they consisted of a minor amount of chippage, one limestone chopper or hoe, and a hammerstone or anvil. The Hot Well site was an open site with little potential for the preservation of perishables, so no vegetable materials were recovered. No positive evidence for the subsistence base was found, but cultigens were probably a significant factor in the diet.

The nature of the Neo-American occupation of the southern Guadalupes is still poorly known. We know little more than that the region was indeed occupied during that time period. Data on subsistence orientation and possible cultural affinities to nearby regions are totally lacking.

Historic Accounts

The brief Historic stage in the Guadalupes was the final episode of aboriginal occupation. Our knowledge of this era is derived not so much from the study of historic sites as from the study of historic documents, although there are few ethnohistoric accounts concerning residents of the southern Guadalupes (Hammond and Rey 1966). None of the early Spanish expeditions actually entered the mountains; rather, they passed nearby (Figure 5). Nowhere in the historic documents is there any report of agriculture in or near the Guadalupe Mountains. The groups mentioned in the ethnohistories of the area seemed intent upon hunting and gathering, supplementing their needs and wants by trade or raiding. It is the raiding that eventually brought about the final defeat and subjugation of the last Indian residents of the Guadalupes.

At the time of contact with the Spanish, the Trans-Pecos region was an area of great cultural diversity, with representatives of three different cultural adaptations existing in rather close proximity. The Cabris Indians, including the Rayas and Conchos, were representative of the hunter-gatherers who occupied the northeastern region of Texas. They were organized in fairly small bands and apparently subsisted on small game and wild plants. Pueblo influence was manifested in the form of the sedentary villages in the La Junta area, which were described by the Spaniards as pueblos. These people, such as the Patarabueye, cultivated large amounts of maize, beans, and squashes. There were Plains Indians collectively identified as Jumanas or Jumanos. They too were hunter-gatherers, but they focused on large game—bison, deer, and antelope. There was certainly contact between these groups, and some northeastern Mexicans were cultivating a few crops, apparently diffused south from the Pueblo region. The settled Patarabueyes carried on a lively intercourse with the Jumanos and obtained from them bison hides and sturdy Plains bows. In return the Jumanos probably received corn, other foods, and cotton cloth.

Given the environmental and geographical situation of the Guadalupe Mountains, it is likely that all three life-styles—simple hunter-gatherer, Plains hunter-gatherer, and sedentary agriculturalist—played roles in the cultural history of the region.

During the seventeenth century, the Apachean groups became established in this area and put heavy pressure on the southernmost Pueblo towns. During this time groups like the Mansos, Sumas, and Jumanos faded from the records, absorbed or replaced by the Apaches (Schroeder 1974). From this time until their final subjugation late in the 19th century, Apachean groups under a variety of names—Siete Rios, Natage, and Mescalero (Schroeder 1974)—inhabited the mountainous areas between the Pecos River and the Rio Grande, with the Sacramento and Guadalupe Mountains as their heartland. They raided the Spanish and Anglos for livestock and captives during this period. Unfortunately, most accounts of this later period are also meager, limited to short descriptions of military actions taken against the Apachean groups. When these groups were expelled in the nineteenth century, more than 10,000 years of aboriginal occupation in the southern Guadalupe Mountains was abruptly ended.

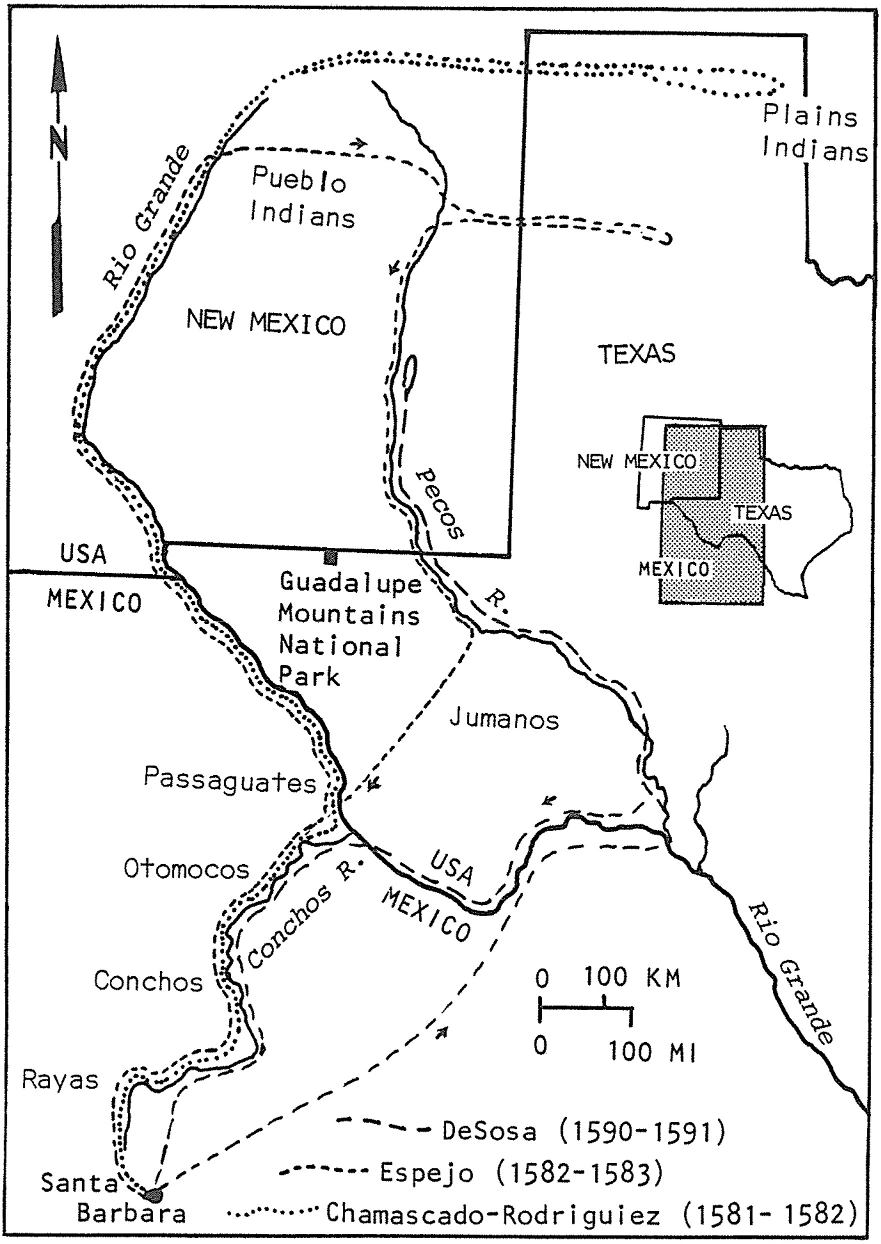

Figure 5. Map showing relation of routes of early Spanish explorers to the Guadalupe Mountains National Park area. The names and general locations of reported Indian groups also are shown. (After Hammond and Rey 1966.)

Although ethnohistorical accounts are limited, the documents that are available do provide information on the life-styles practiced in the area. The diversity of life-styles observed indicates that the southern Guadalupes were an area of cultural transition.

THE DATA BASE

Presented here are descriptions of the survey methodology of the TAS, the kinds of data collected by the survey, and a discussion of the inherent limitations of the data. Following this are descriptions of the artifact categories that were established and used for the analysis, with particular attention to the projectile points, since they constitute the bulk of the culturally and temporally diagnostic artifacts recovered. The flake forms are described, and the process used to define and select them is explained.

The archeological survey conducted by the TAS in 1970 gathered data with the objective of providing solutions to two problems. The first was to establish a relative chronology and to outline the culture history of the park area; the second was to ascertain, if possible, the distribution of various archeological materials with respect to the ecological zones in the park (Shafer 1971:11). The survey focused on the southern and western parts of the park. National Park Service officials requested that the survey be initiated there because they expected these areas to suffer the greatest immediate impact from development and use of the park (Roger Reich, National Park Service, personal communication).

The survey was carried out by about 200 members of the TAS consisting of school children, high school and college students, graduate students in anthropology, and avocational archeologists. Participants in the survey were organized into crews, each under the supervision of a crew chief who had had previous training or experience in archeological field work. The crews alternated a day in the field with a day in camp, cleaning, sorting, and cataloging the materials collected on the previous day.

The surveying was done on foot, and about 10 percent (19 sq km, or 12 square miles) of the park was covered. The survey methodology was designed to ensure recovery of a representative sample of materials from each site visited.

> Collecting techniques allowed for adequate artifact samples from most sites. Crews were discouraged from wandering about the sites looking only for projectile points and pottery. Rather, intensive collection from one or more areas of the site was encouraged with an emphasis on getting a sample of all kinds of artifacts [Shafer 1971:16].

The survey directors attempted to standardize the collecting techniques and to a great extent, but not entirely, they were successful. Some site notes were accompanied by detailed maps of collecting loci, but others gave only the site locations. For example, one site (41CU31) was surveyed by means of a controlled surface collection, a deviation from the standard methodology. Although the crew chiefs occasionally deviated from the prescribed survey approach in order to adapt to the particular conditions at various sites, the actual collection of samples from the sites was generally adequate and comparable from site to site. In most cases there is reasonable assurance that a representative collection of material was taken and the rest left in place for further work. A total of 146 sites were surveyed, including two historic sites. (A description of each is included in Boisvert 1980:Appendix 2.)

Before artifacts were analyzed, they were sorted into typological categories. The organization and construction of a typology must be appropriate to the purposes for which it is intended. One eminent archeologist has stated that "the major goal of classification in most present-day archaeological studies is to use type as a measurement of culture history in time and space" (Ford 1949:44), but an equally eminent one subscribes to other views:

> The artifact type is here viewed as a group of artifacts exhibiting a consistent assemblage of attributes whose combined properties give a characteristic pattern. This implies that, even within a context of quite similar artifacts, classification into types is a process of discovery of combinations of attributes favored by the makers of the artifacts, not an arbitrary procedure of the classifier [Spaulding 1953:305].

This report encompasses both kinds of problems, i.e., descriptions of cultural-historical phenomena and the elucidation of behavioral patterns. To this end the artifact typology is a construct of the author, whose avowed goal was to create the most meaningful and succinct means of describing and defining the artifacts found by the TAS survey. Once categorizing was accomplished, the artifacts were analyzed by various means in order to provide solutions to the stated problems.

The artifacts were classified primarily on a morphological basis, by dividing and subdividing them into increasingly smaller and less heterogeneous groups. The criteria for making these divisions were largely subjective, but in general follow the conventional typological procedures of American archeology. The objective was to arrive at artifact categories defined by morphological attributes, without reference to functional qualities. In several cases, however, functional names were used when morphological attributes coincided with artifact categories such as drills, projectile points, and chopping tools, to which functional significance is attached by most American archeologists. The artifact categories used to describe the survey collection from the park are (1) ground and pecked stone; (2) chipped stone, which is subdivided into the basic categories, cores, flakes, unifaces, and bifaces; and (3) miscellaneous artifacts. Special typological consideration has been given to the projectile points (26 types) and flakes (29 attribute combinations or types). (Boisvert 1980:Appendix 2 contains a site-by-site distribution of materials recovered by the survey.)

Ground and Pecked Stone

Battered Stone

These stones, primarily chert and quartzite, have one or more battered areas that indicate, from placement and quality, that the battering was not naturally derived. The stones have functioned as hammerstones, pounders, or anvils for stoneworking, for plant or pigment processing, or for some other process.

Flat Manos

Flat manos show evidence on one or both planar surfaces of use as grinding stones. All complete specimens in the collection can be held and used with one hand, although a few could have been used with two hands. Their size and shape are identical to artifacts normally termed manos in the Southwest.

Convex Manos

The convex manos are similar to the flat manos, except that the ground surfaces are distinctively convex.

Metates

Metates are slablike stones that have flat or slightly concave ground surfaces. They are thinner than manos and have broad grinding areas that cover most of their surface areas. No complete metates were recovered by the survey, but large metate fragments were collected. As with the manos, the term by which they are most commonly recognized in the Southwest has been adopted for use in this study.

Chipped Stone

Amorphous Cores

Amorphous cores are pieces of chippable stone from which flakes have been removed in seemingly random patterns. They tend to be globular, and apparently they have not been specifically shaped for use as tools or for the production of specialized flakes.

Single Platform Cores

Single platform cores are cores with a number of flakes removed from a single surface or facet. They are prismatic or cone shaped, and at least some are the sources of blades (flakes with prismatic cross section and parallel sides, which are at least twice as long as they are wide).

Flakes

Flakes are the by-product of chipped stone tool manufacture and are collectively termed chippage. Crabtree's succinct definition is followed in this report: "Any piece of stone removed from a larger mass by the application of force—either intentional, accidental or by nature. A portion of isotropic material having a platform and bulb of force at the proximal end (end at which the force was applied)" (Crabtree 1972:64). Included in this category are both fragmentary and complete flakes.

Core Fragments

Core fragments are small, angular pieces of stone similar to flakes, but whose identifying characteristics, platforms and bulbs of force, are missing.

They tend to be larger and, especially, thicker than most flakes, but they are too small to be used as cores. They are artifacts that show evidence of modification by man but that cannot be classed as flakes, cores, or implements. It is probable that they are the remains of shattered cores.

Utilized Flakes

Utilized flakes are flakes modified by use and exhibiting polish, use retouch, or striations on one or more edges. All artifacts identified as utilized flakes in this study were examined under a binocular microscope before being so classified.

Unifaces

Unifaces are flakes or cores that have a planar surface; they have been modified by the removal of a series of flakes at one or more places along the edge of one surface only. A wide variety of shapes can result from such unifacial flaking; some unifaces may have been purposely shaped for specific uses. Listed below are the types of unifaces, defined on the basis of morphology.

Type I unifaces are semicircular, with trimming only along the curbed edges.

Type II unifaces have a semicircular notch on an edge. The notch is produced by unifacial flaking, and parts of the remaining edge may or may not be flaked as well. Artifacts of this type have been called spokeshaves.

Type IIIa unifaces are flaked only along the short axis of the parent flake or core, the worked edge of which is incurvate.

Type IIIb unifaces are flaked only along the short axis of the parent flake or core, the worked edge of which is straight.

Type IIIc unifaces are flaked only along the short axis of the parent flake or core, the worked edge of which is excurvate.

Type IVa unifaces are flaked only along the long axis of the parent flake or core, the worked edge of which is incurvate.

Type IVb unifaces are flaked only along the long axis of the parent flake or core, the worked edge of which is straight.

Type IVc unifaces are flaked only along the long axis of the parent flake or core, the worked edge of which is excurvate.

Type V unifaces are artifacts on which the flaking is not restricted to a particular long or short axis, nor is the shape of the flaked edge readily classifiable as being straight or curved. They are best described as unshaped (amorphous) unifaces.

Type VI unifaces are flakes with minute unifacial retouch along one or more edges. The flake scars are rarely more than 2 mm long. Such flaking could result from use as an implement (intentional retouch) or from unintentional retouch prehistorically (ground wear) or during contemporary times (bag retouch).

Uniface fragments are the broken parts of any of the unifaces described above. Their typically small size, in addition to their fragmentary nature, precludes further classification.

Bifaces

Biface-Uniface Composites

Biface-uniface composite artifacts are any flakes or cores with both unifacially and bifacially flaked edges.

Bifaces

Bifaces are flakes or cores that have been flaked along one or more edges by blows originating from opposing directions, resulting in edges that are formed by the intersection of two planes or surfaces, both bearing negative flake scars.

Unhafted Bifaces

Unhafted bifaces are bifaces with no evidence of modification for the attachment of handles or shafts. This does not necessarily mean that none of these artifacts were ever hafted, but only that they lack hafting modifications. Four specimens that very closely resemble recognized projectile point types are not included in this part of the typology, but are listed with the projectile points.

Marginal bifaces are flakes with retouch similar to Type VI unifaces, except that the retouch is bifacial. Marginal bifaces typically have limited areas of small, irregular bifacial retouch.

Single-edge heavily retouched bifaces are cores or large flakes that have been flaked by percussion along only one edge, thus producing a single crude sinuous edge.

Chopping tools are similar to the single-edge heavily retouched bifaces described above except that they are made exclusively on large pebbles, and the flaked edges are made by removing broader, somewhat flatter flakes. The term *chopping tools* has been adopted because of the similarity between these artifacts and those Old World artifacts called chopping tools (see Bordes 1968:242, 243).

Ovate bifaces are bifacial implements, oval or slightly rectangular, with well-rounded corners, biconvex in cross section. The artifacts are flaked all the way around, generally a result of soft hammer percussion, with some secondary retouch.

Tabular bifaces (Figure 6), made from naturally tabular material, have percussion-flaked edges. They are usually shaped like right triangles with the longest sides usually excurvate and the shorter sides straight and untrimmed. They are relatively large artifacts, measuring from 76 to 221 mm in length, from 54 to 116 mm in width, and from 8 to 20 mm in thickness. All of the specimens collected by the survey were of limestone.

Planoconvex bifaces are defined on the basis of their cross sections, which, as the name indicates, are planoconvex. Most specimens resemble Type IIIc and IVc unifaces and may in fact be rejuvenated versions of the same.

Preforms, or blanks, are unfinished bifacially worked artifacts that have been subjected to primary trimming and shaping but have not yet received the final shaping and such finishing touches as modifications for hafting. They

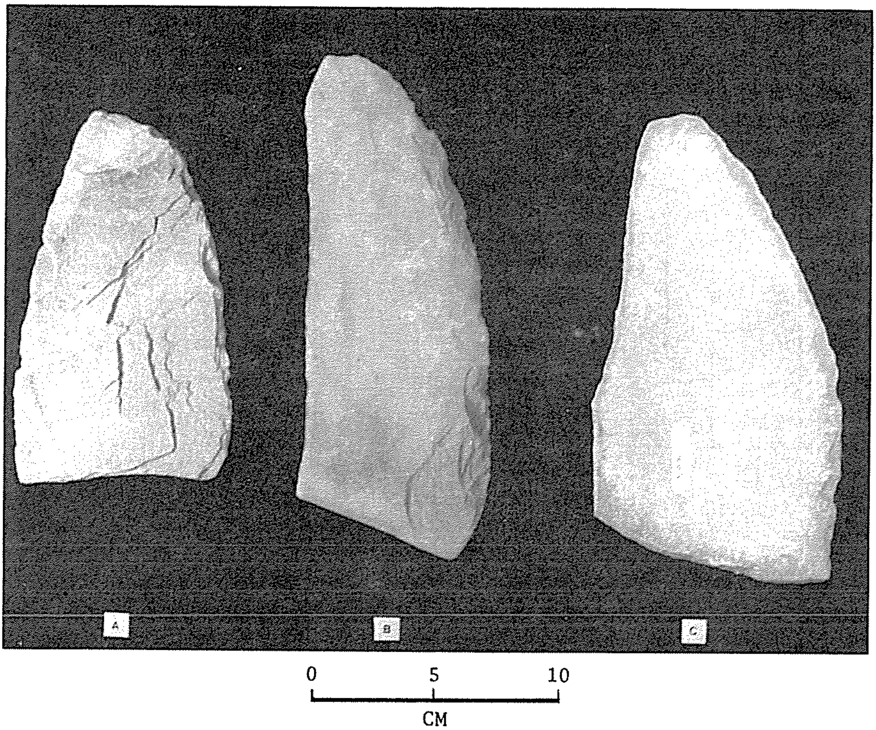

Figure 6. Tabular bifaces.

are usually oval or roughly triangular in outline, with relatively thick cross sections. Percussion flaking is evident on the artifacts, but pressure flaking is not.

Snap fragment bifaces are fragments of bifaces for which the specific cause of breakage could not be determined. All biface fragments except those with hafting modifications fall into this category; it includes tips, large edge sections, midsections, and squared or rounded bases.

Transverse fractured bifaces are similar to the snap fragment bifaces described above, except that the breakage could be related to the manufacturing process. A bulb of percussion, either positive or negative, and radial shatter lines can be seen originating at one of the bifacial edges and continuing across the exposed transverse section of the biface. The particular location of the break is usually associated with other flaking problems such as knots or collapsed edges from unsuccessful shaping.

Hafted Bifaces

All hafted bifaces except drills are considered projectile points. This interpretation is made with the realization that some of the artifacts may have been used as knives, but since many have been found in dry caves or rockshelters hafted to projectile shafts or foreshafts, in most cases their

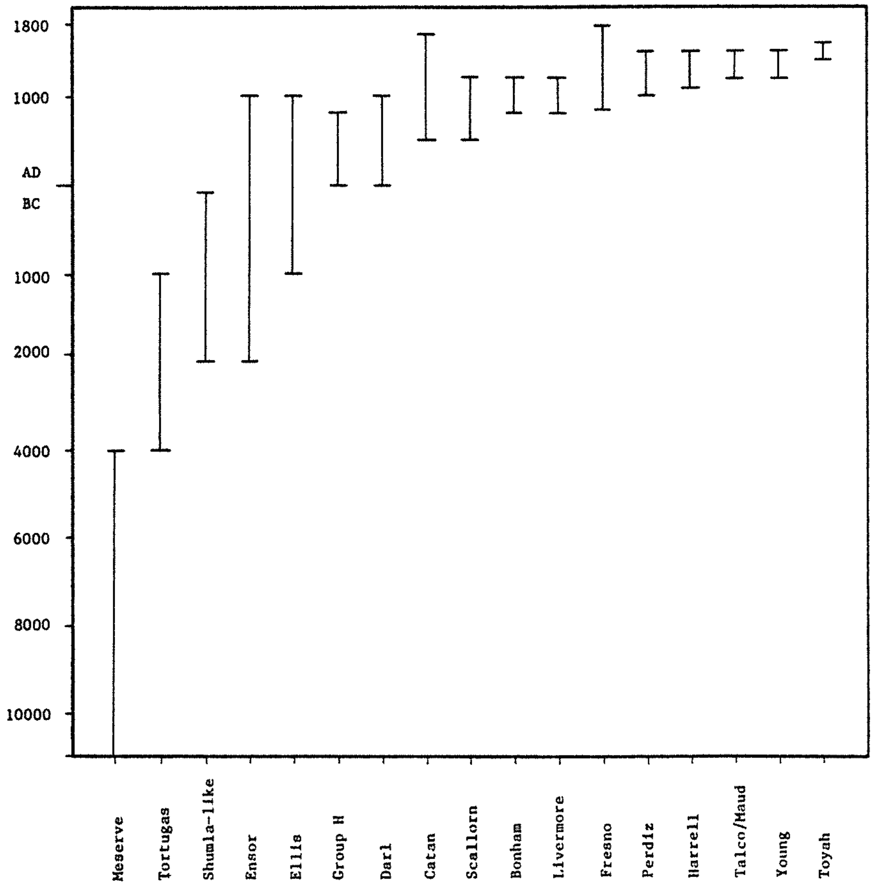

Figure 7. Time spans of identifiable projectile points.

identification as projectile points is probably accurate. The types of projectile points recovered by the survey are described below. Comparisons with previously defined types are made and cultural-temporal affiliations are indicated when possible (Figure 7). Table 1 shows the distribution of the points by site; Table 2 shows the range of metric attributes.

Projectile Points

Type 1—Livermore points (Figure 8, A-D); narrow, spikelike blades with wide shoulders that are more than double the blade width; expanded stems, and rounded bases that may be as wide as the shoulders; made from thin flakes that often retain the original curvature of the flake. They conform well to the type description provided by Suhm and Jelks (1962:279-280), except that in some cases the bases of the points in the survey collection are wider.

Table 1. Distribution of Projectile Points

SITE	TYPE																										TOTALS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
CU14		1																									1
CU18	1				1							1													1		4
CU19	3			1	2	1		1	1			1				1					1						12
CU25															1												1
CU27																			1								1
CU29																										1	1
CU31							1	1	3									1									6
CU43										1																	1
CU56													1														1
CU67									1		1						1										3
CU68												1															1
CU75							1																				1
CU80						1		1	1				1														4
CU89								1																			1
CU90													1														1
CU96	1					1		1	1	1				1						1							7
CU98									1																		1
CU108											1																1
CL110																2						1					3
HZ30								1																			1
HZ32									1															1	1		3
HZ36								1																			1
HZ39								1	1																		2
HZ40																	1										1
HZ43										1																	1
HZ47														1													1
HZ50															1												1
HZ51																							1				1
HZ52	2						1																				3
HZ61								1	1																		2
HZ68	3		2													1	1										7
HZ78				1								1															2
Random sf		1							1	1	1				1												5
TOTALS	10	2	2	2	3	3	3	9	12	4	3	4	3	2	3	4	3	1	1	1	1	1	1	1	2	1	82

Table 2. Metric Attributes of the Projectile Points
(Measurements in Millimeters)

Name	Type	Length	Width	Thickness	Total
Livermore	1	39*	12-14	3.0 - 4.5	10
Perdiz	2	23*	18-15	3.0 - 4.0	2
Bonham?	3	20	14-15	3.0 - 4.0	2
	4	21-31	13-14	4.0 - 5.0	2
Ellis?	5	23-31	20-21	4.5 - 5.0	3
	6	32*	13-17	5.0 - 6.0	3
Darl?	7	32**	24-25	5.0 - 7.0	3
	8	32-40≠	20-27	5.0 - 7.0	9
	9	35*	(29)	4.0 - 8.0	12
Shumla	10	50*	35*	5.5 - 6.0	4
	11	31-45**	17-19	6.0	3
	12	42**≠	19-26	5.0 - 9.0	4
	13	28**≠	25-27	4.0 - 6.0	3
	14	29-31	15-16	5.0 - 6.0	2
	15	42-50	25-38	7.0 -10.0	3
Ensor	16	42*	20.5-23	6.0 - 7.0	4
	17	27-36	36*	4.0 - 5.0	3
Meserve	18	29	17	5.0	1
Talco/Maud	19		14	4.0	1
Scallorn	20	28	15.5	3.0	1
Fresno	21	21	14	3.0	1
Harrell	22	19	15	4.0	1
Toyah	23	20	12	3.0	1
Young	24	33	24	5.0	1
Catan	25	39-44	29-30	7.0	2
Tortugas	26	56	31	10.0	1
TOTAL					82

*One specimen only.
**Measurement taken on largest of fragmentary specimens.
≠Measurement estimated from fragmentary specimen.

Type 2—Perdiz points (Figure 8, E, F); triangular blades with nearly straight sides; shoulders are straight, making the blade shape very nearly an equilateral triangle; stems are slightly contracted, and bases are rounded. Compared to the shoulders, the stems are fairly narrow, about one-third of the total width.

Type 3—Thin, triangular blades, nearly twice as long as they are wide (Figure 8, G, H); thin and finely serrated edges; shoulders are barbed asymmetrically; stems are parallel sided, with slightly rounded bases. These points resemble Bonham points (Suhm and Jelks 1962:267-268), except that stems are not as straight sided and straight based as the type specimens.

Type 4—Small points (Figure 9, A, B), somewhat crudely made compared to other points of similar size in the survey collection; thick relative to their length and width; triangular blades with asymmetrically barbed shoulders; expanded stems; excurvate bases.

Type 5—Triangular blades, as long as they are wide (Figure 9, C-E); blade edges are excurvate or slightly recurvate; stems are broad, almost as wide as the shoulders; expanded stems and slightly barbed shoulders formed by shallow corner notching; basal edges are excurvate; closely resemble Ellis points (Suhm and Jelks 1962:187-188), but are consistently shorter.

Type 6—Triangular blades, slightly longer than they are wide (Figure 9, F,G); blade edges are excurvate; shoulders taper down into the stems, which are relatively broad, over half the width of the point, and have rounded bases.

Type 7—Fairly large (the tips are missing from all specimens) with slightly asymmetrical shoulders (Figure 10, A-C); parallel-sided stems with incurvate bases; resemble Darls (Suhm and Jelks 1962:179-180), but, since all specimens are fragmentary, they are not confidently identified as such.

Type 8—Medium-to-large points with triangular bases nearly as wide as they are long (Figure 10, D-F); blade edges are straight to slightly excurvate and may be slightly serrated; shoulders are usually barbed, but in some cases are rounded yet prominent; stems are expanded and make up about one-fourth of total length. They are also broad, nearly three-fourths of the width at the shoulder; bases are excurvate. Both Type 8 and Type 9, described below, are identical to some of the Group H points in Johnson's typology (1967). Katz and Katz (1974) use Johnson's typology and illustrate points of this type that were recovered in the park during their survey for Texas Tech University.

Type 9—Similar to Type 8 points except that the shoulders are not usually barbed, although they are quite prominent (Figure 10, G-J); blade forms are similar, but serrations are less common; stems are expanded and bases are straight, rather than excurvate.

Type 10—Larger than most other points recovered in the survey (Figure 11, A-D); triangular blades with straight or nearly straight edges; bases have been notched, producing straight or nearly straight stems, and long barbs are either curved or straight. Type 10 corresponds to the Shumla as defined by Suhm and Jelks (1962:247-248). Dibble (1967:35) has subdivided the type on the basis of the shape of the barbs; at Arenosa Shelter the straight-barbed Shumla-like points occur earlier in the stratigraphic sequence than do the curved-barbed Shumlas. Figure 11 C resembles the Shumla-like variety.

Type 11—Elongated blades as much as twice the width (Figure 11, E-G); blade edges are excurvate; shoulders are rounded; stems are rounded and make up about one-fourth of the total length.

Type 12—One of the largest points in the assemblage (Figure 11, H-K); stems are long (13 to 17 mm) and stem sides are incurvate with excurvate bases; shoulders are rounded or slightly barbed; blade edges near the shoulders are often triangular or nearly parallel. There are no complete specimens in the collection.

Type 13—Basal fragments only (Figure 12, A-C); blade edges are serrated and essentially straight where observable; points are broadly side notched, resulting in moderately barbed or rounded shoulders; stems are expanded, with rounded corners that are as wide as the maximum width of the shoulders; bases are slightly incurvate.

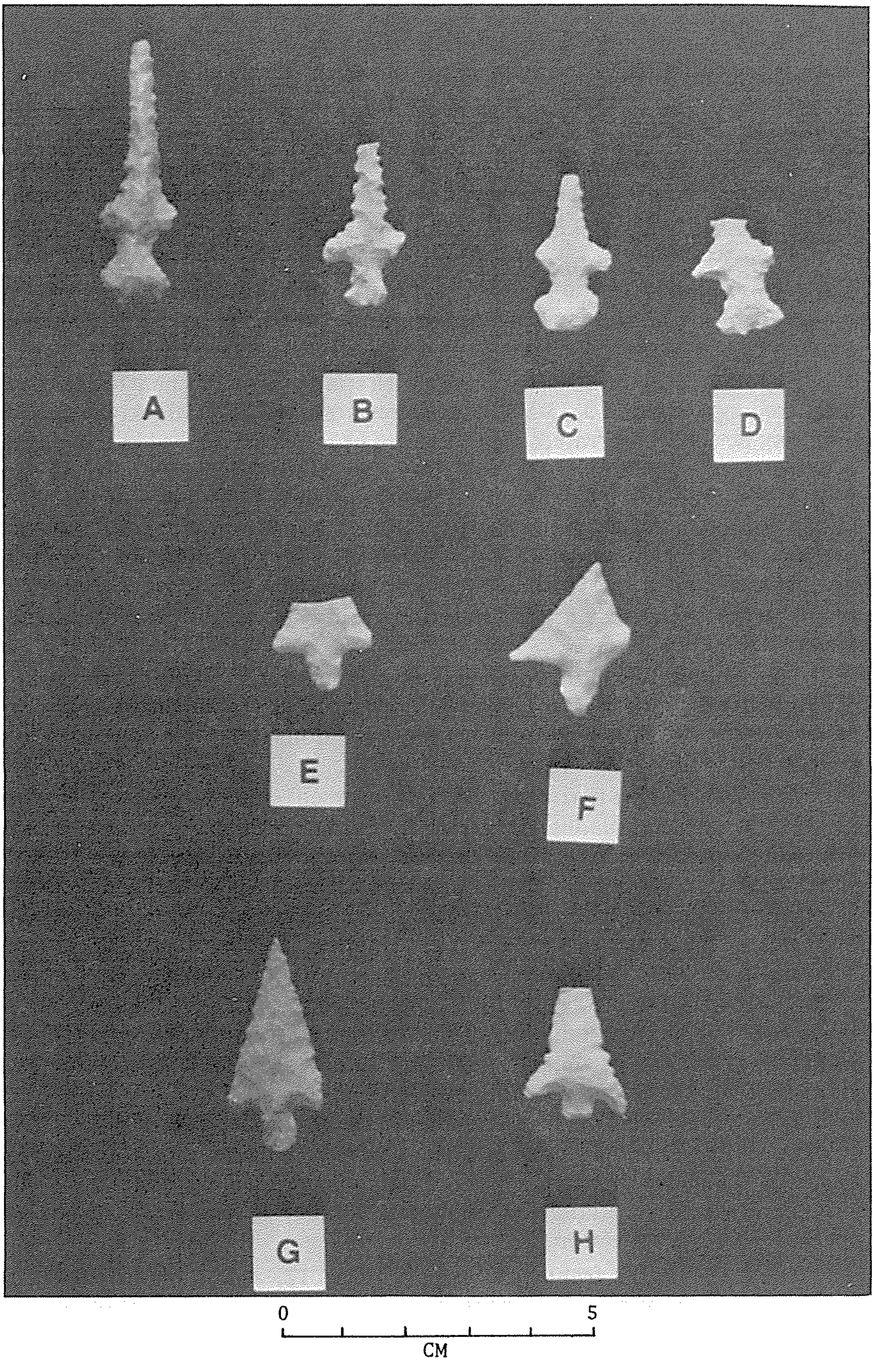

Figure 8. Projectile points: (A-D) Type 1; (E,F) Type 2; (G,H) Type 3.

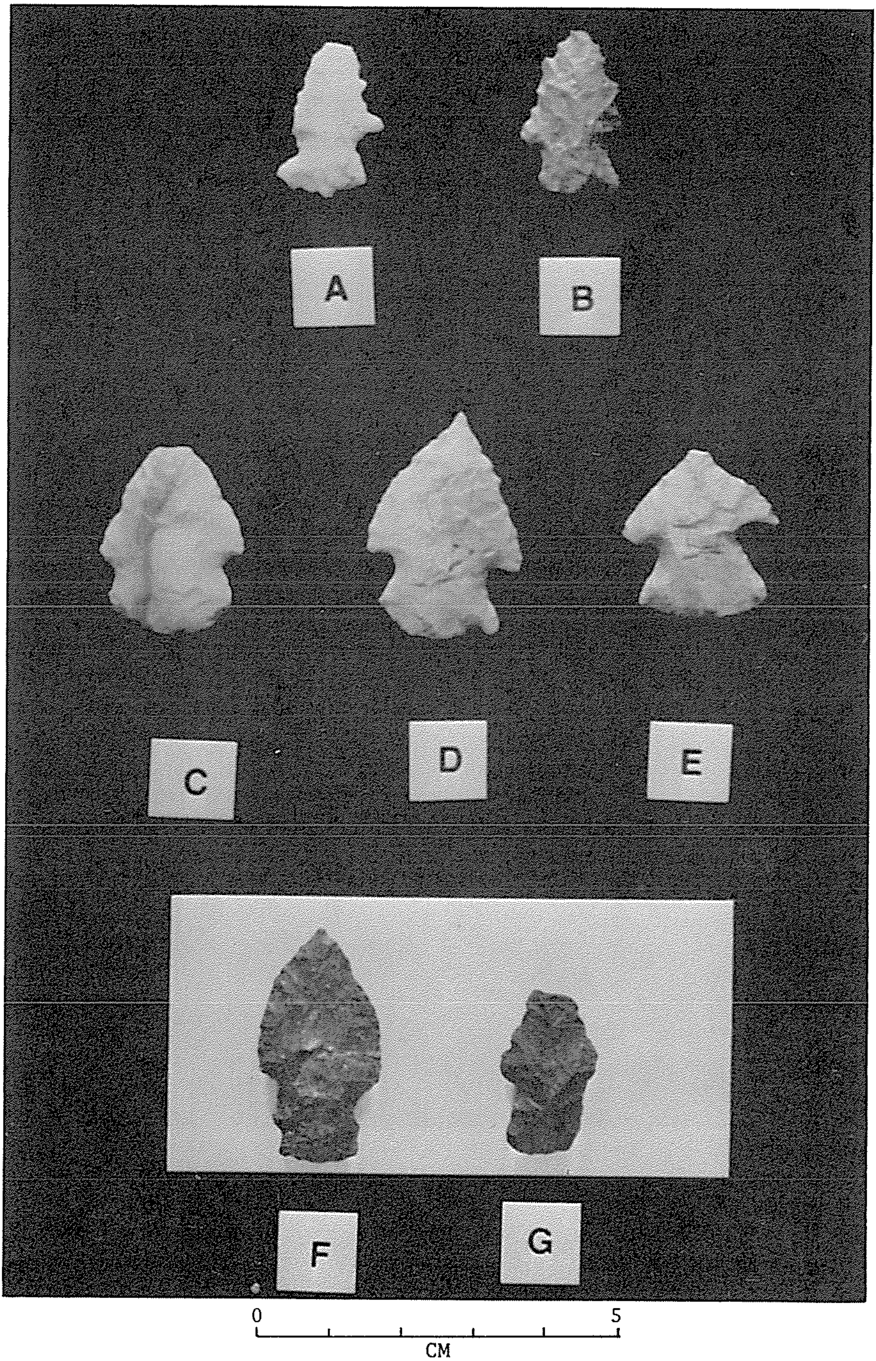

Figure 9. Projectile points: (A-B) Type 4; (C-E) Type 5; (F, G) Type 6.

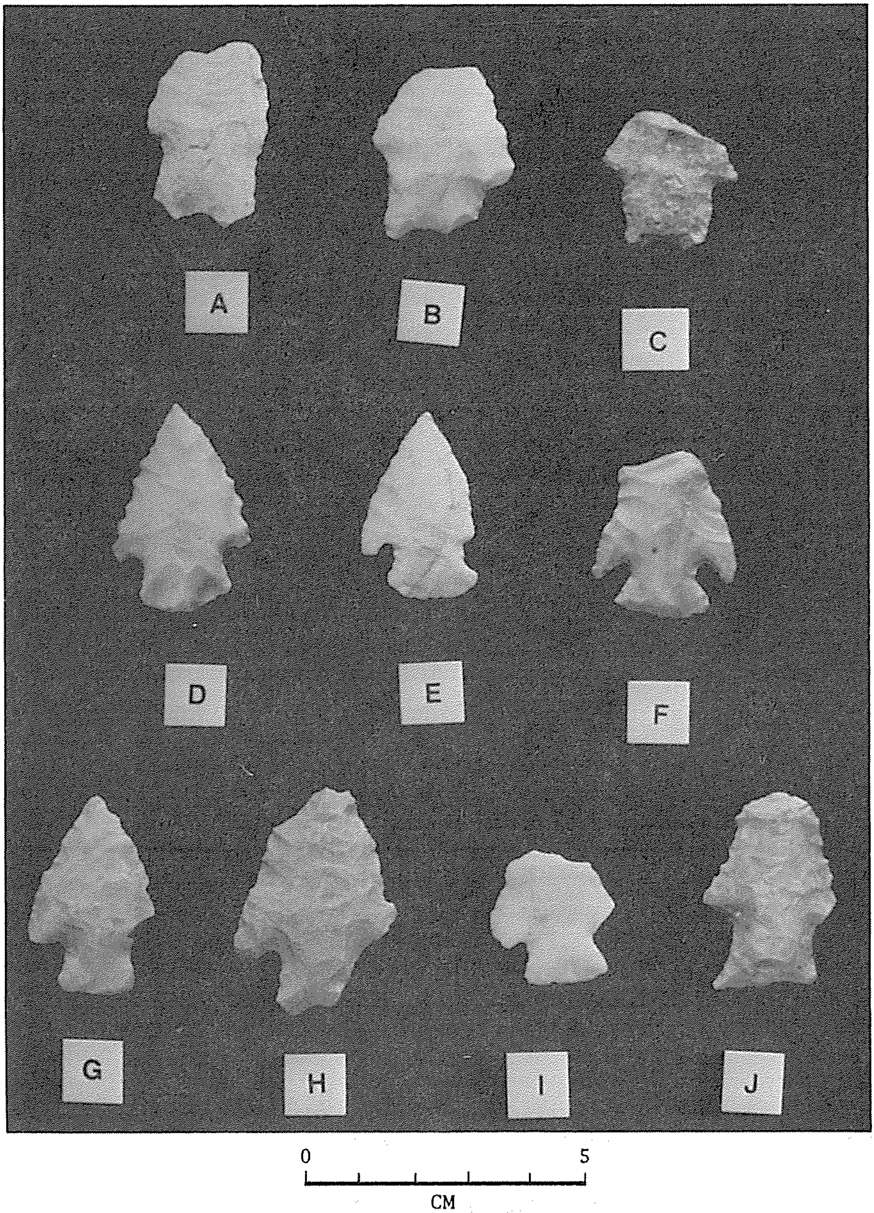

Figure 10. Projectile points: (A-C) Type 7; (D-F) Type 8; (G-J) Type 9.

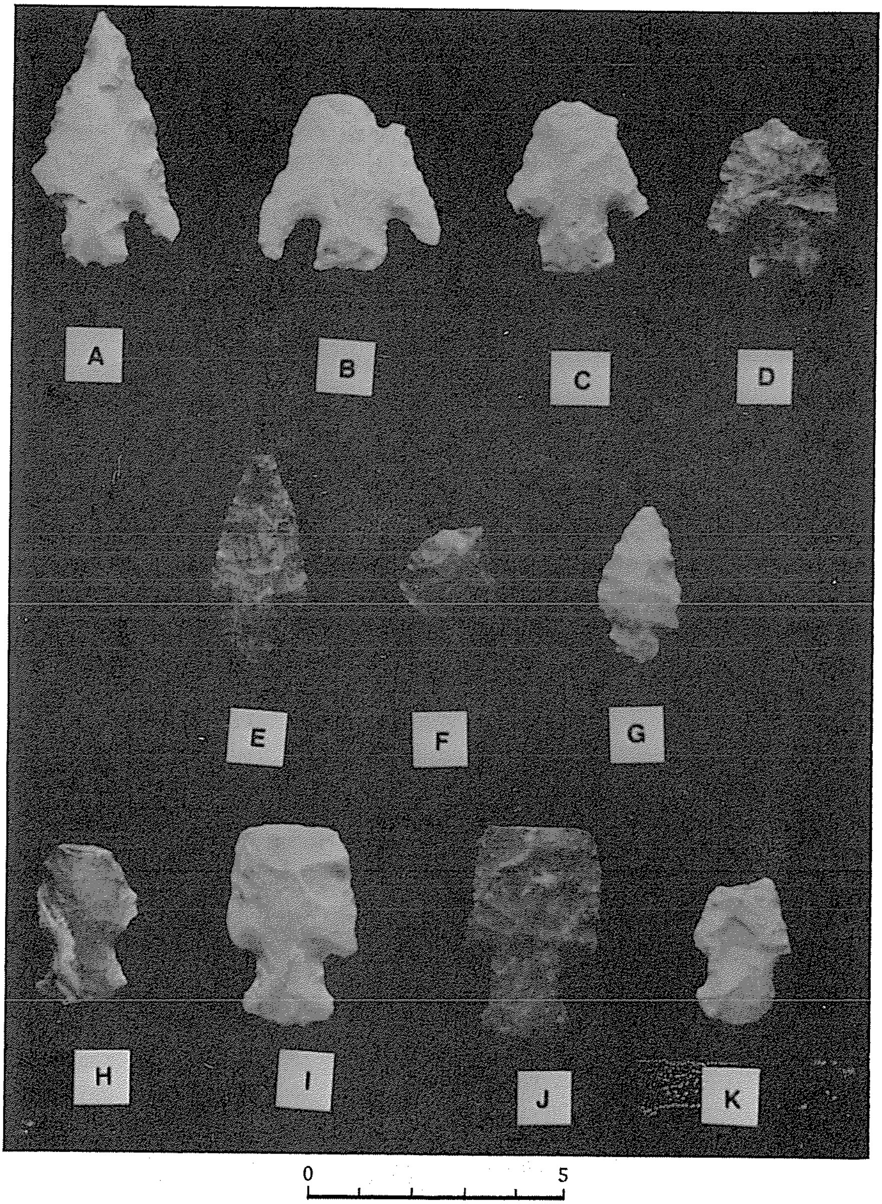

Figure 11. Projectile points: (A-D) Type 10; (E-G) Type 11; (H-K) Type 12.

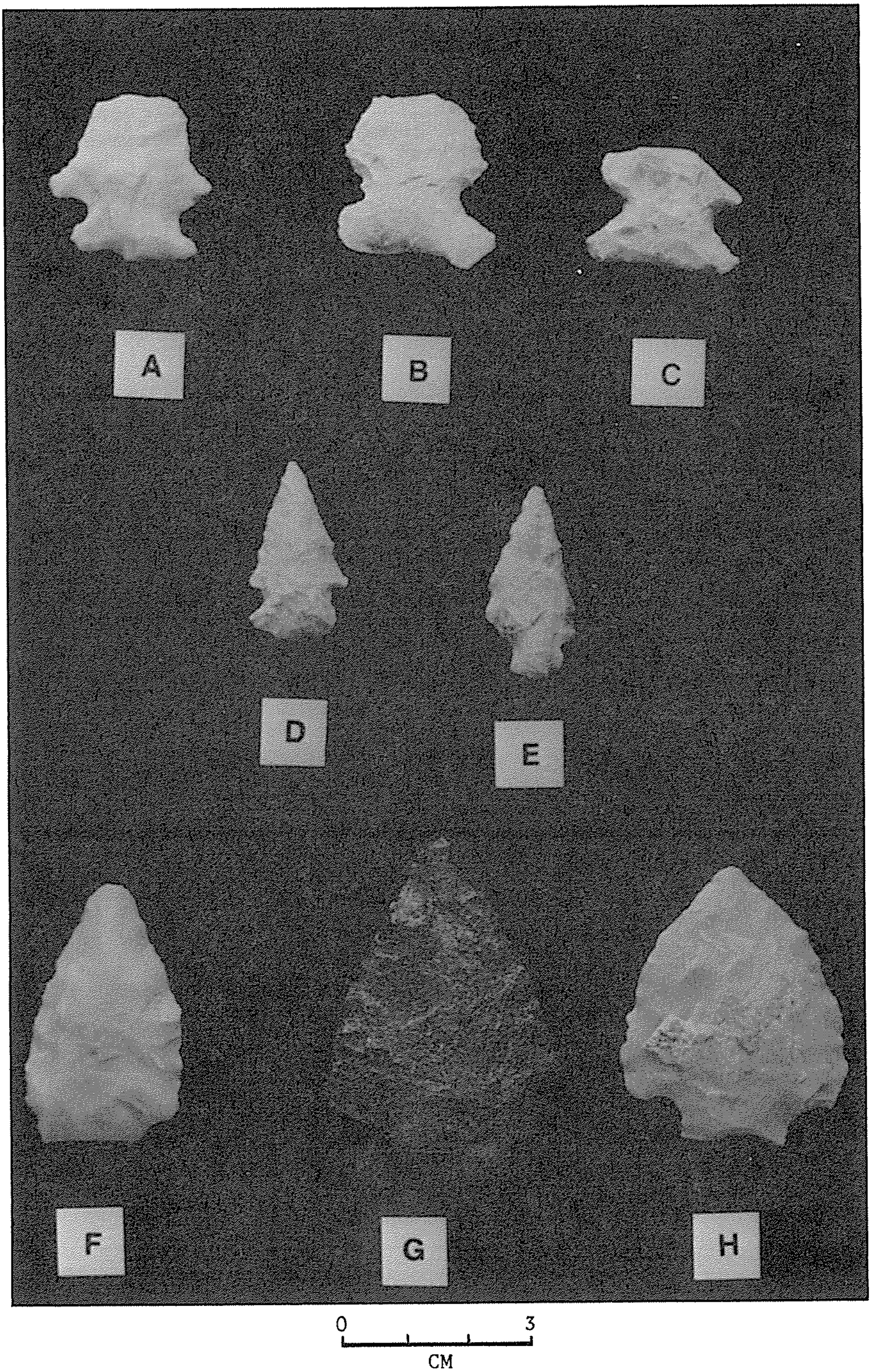

Figure 12. Projectile points: (A-C) Type 13; (D,E) Type 14; (F-H) Type 15.

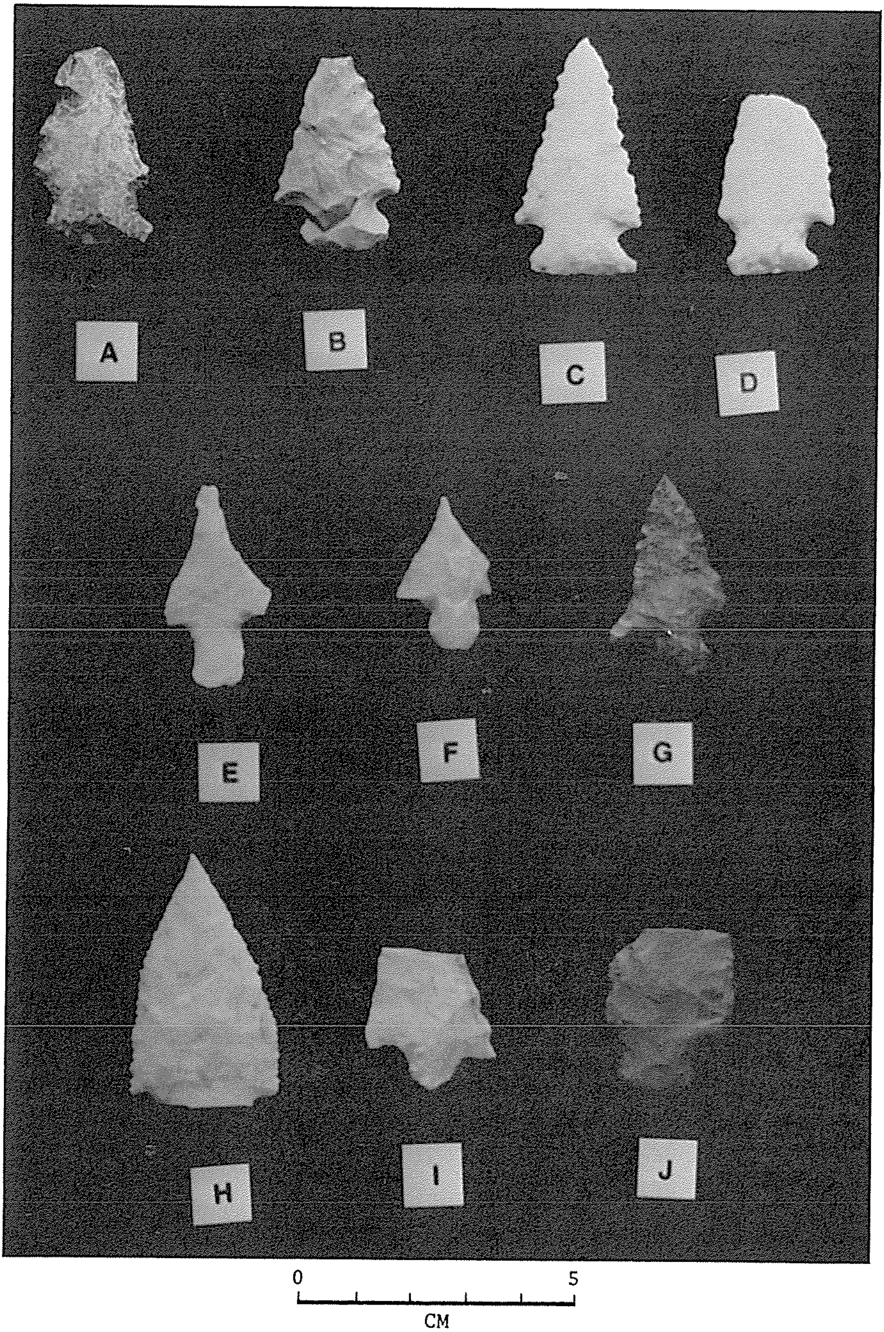

Figure 13. Projectile points: (A-D) Type 16; (E-G) Type 17; (H-J) fragments.

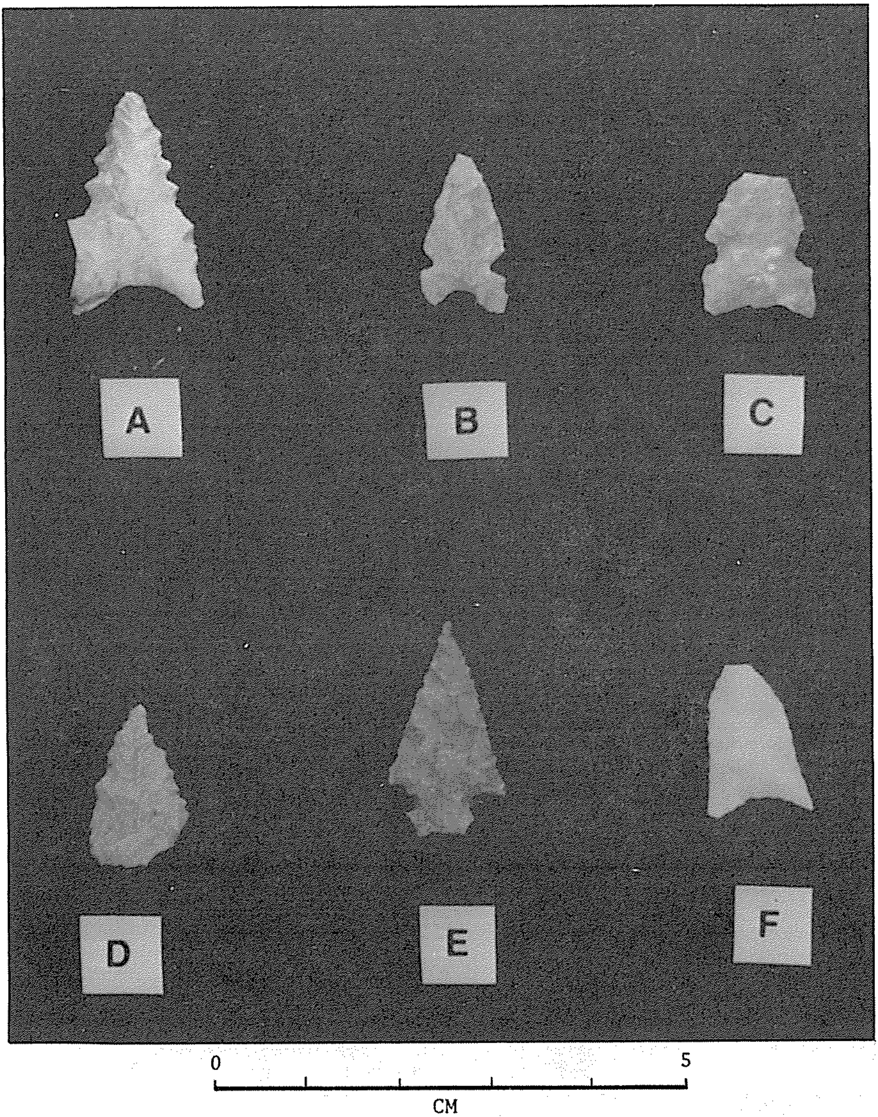

Figure 14. Projectile points: (A) Type 18; (F) Type 19; (E) Type 20; (D) Type 21; (C) Type 22; (B) Type 23.

Type 14—Blade outlines are triangular with rather acute tips (Figure 12, D, E); bases are weakly side notched to straight, with rounded shoulders and expanded stems; somewhat crudely flaked compared to the rest of the collection.

Type 15—Large, broad, triangular points (Figure 12, F-H) with excurvate sides; corners have been removed, forming very short, broad stems with straight or slightly contracting sides and straight bases. All of the points in this type are made of quartzite.

Type 16—Ensor points (Figure 13, A-D); lateral notches, shoulder forms, and blade outlines conform to the type description provided by Suhm and Jelks 1962:189, 190).

Type 17—Relatively thin, small points (Figure 13, E-G); recurvate blade outlines may be the result of some reworking; shoulders are straight or barbed; both stems and bases are straight or slightly excurvate. The points are made on thin flakes, and the original curvature of the flake is still evident on some specimens.

Type 18—A single point (Figure 14, A) closely resembling the Meserve point (Suhm and Jelks 1962; 217, 218); rather small (28.7 mm long, 17.1 mm wide at the base, and as much as 4.7 mm thick at the midsection); serrated triangular blade; base is broader than the blade at its widest part; sides are slightly incurvate; base too is incurvate, having been produced by short flakes—but not fluting flakes—running parallel to the long axis of the point; point has secondary retouch, which enhances the incurvate nature of the base; point is ground at the sides and bottom of the base. It is an exceptionally small example of a Meserve point.

Type 19—A single point (Figure 14, F) that has similarities with both Maud and Talco (Suhm and Jelks 1962:281, 282, 289-293) points; tip of point is broken and blade outline was almost surely recurvate, making it more like Talco; length of the broken point is 2 cm, and the estimated length of the complete point is 3 or 4 mm longer; base is slightly flared and incurvate. Since this point is fragmentary, it is difficult to assess its similarity to the established point types; however, it is likely a variant of either the Talco or the Maud type, both of which have similar temporal and spatial ranges.

Type 20—Small, fairly well-made point (Figure 14, E) closely resembling the Scallorn point (Suhm and Jelks 1962:285-286); made from a flake; blade edges are essentially straight and evenly pressure flaked; blade edges extend to the notches to form slight barbs. The corners of the base have been broken, making an assessment of the hafting morphology difficult; however, it appears to have been diagonally notched, producing an expanded stem.

Type 21—Closely resembles the Fresno point (Figure 14, D) (Suhm and Jelks 1962:273-274); slightly more than 2 cm long and may have measured 1.5 cm in width (exact width cannot be determined because one corner is broken); point was made from a flake and has a smooth interior surface that has been modified by a series of small, relatively crude retouch flakes; opposite surface of point has several small retouch flakes and has evidence that several flakes were removed from the core prior to the removal of the flake from which the point was made; base is essentially straight, with a series of small nibbling flakes along its margin (these flakes could have been produced quite easily by superficial grinding or rasping with an abrader); point is planoconvex in cross section.

Type 22—Triangular blade with straight sides, side-notched with a short, relatively wide, straight stem; base is incurvate and slightly thinned on one face; point is biconvex in cross section, finely pressure flaked on both surfaces, and made from a mottled, honey-colored, jasperlike (probably nonlocal) material (Figure 14, C); assigned to the Harrell type (Suhm and Jelks 1962:275-276); length is estimated at 2.2 cm, well within the Harrell range, and the width at the base is 1.5 cm; maximum thickness is 0.4 cm.

Type 23—Toyah, the only example of a very late prehistoric, possibly protohistoric, point (Suhm and Jelks 1962:289-290); small (Figure 14, B), basically triangular, with excurvate blade edges; point is both side and basal notched, so the hafting area resembles two constricted lobes protruding from the blade area; point is biconvex and finely pressure flaked.

Type 24—Conforms to the description of the Young point (Suhm and Jelks 1962:295-296); essentially triangular with excurvate blade outline and slightly incurvate base (Figure 15, B); made from a flake of banded cherty limestone; multifaceted striking platform is plainly visible on one corner of the point, with a moderate lip overhanging the bulb; nearly half of exterior part of point is covered by flake scars made prior to removal of the flake from the core; rest of chipping is light retouch, apparently for shaping point. This point bears a remarkable resemblance to the specimen pictured in Suhm and Jelks (1962:Plate 148 H).

Type 25—Two bifaces (Figure 15, C, D) resemble the Catan point (Suhm and Jelks 1962:175-176), which lacks specific hafting modifications; triangular (teardrop shaped), with excurvate blade edges and rounded bases.

Type 26—Biface (Figure 15, A) resembling a Tortugas point (Suhm and Jelks 1962:294-295); triangular bordering on pentagonal, as the lower blade edges are nearly parallel; one edge roughly excurvate; the other has a slight angle; one face fairly flat and may retain part of unmodified interior face of a large flake; opposite side beveled, with many flake scars; made from a very grainy purple quartzite, which accounts for its rather crude outline and surface treatment; straight base with no evidence of grinding.

Projectile Point Fragments

As the name implies, these are the pieces of broken projectile points. Usually some part of the hafting area is identifiable, but in most cases there is no possibility of identifying the point type (Figure 13, H-J).

Drills

These artifacts are hafted bifaces with slender spikelike blades. In cross section the blades are either rhomboidal or nearly circular. The bases are generally broad, occasionally shouldered, and typically resemble straight-stemmed or expanding-stemmed projectile points. In some cases they may have been recycled from broken projectile points. The functional term *drill* has been adopted for use in this typology, since these forms are inevitably identified as drills or perforators in the literature of North American archeology.

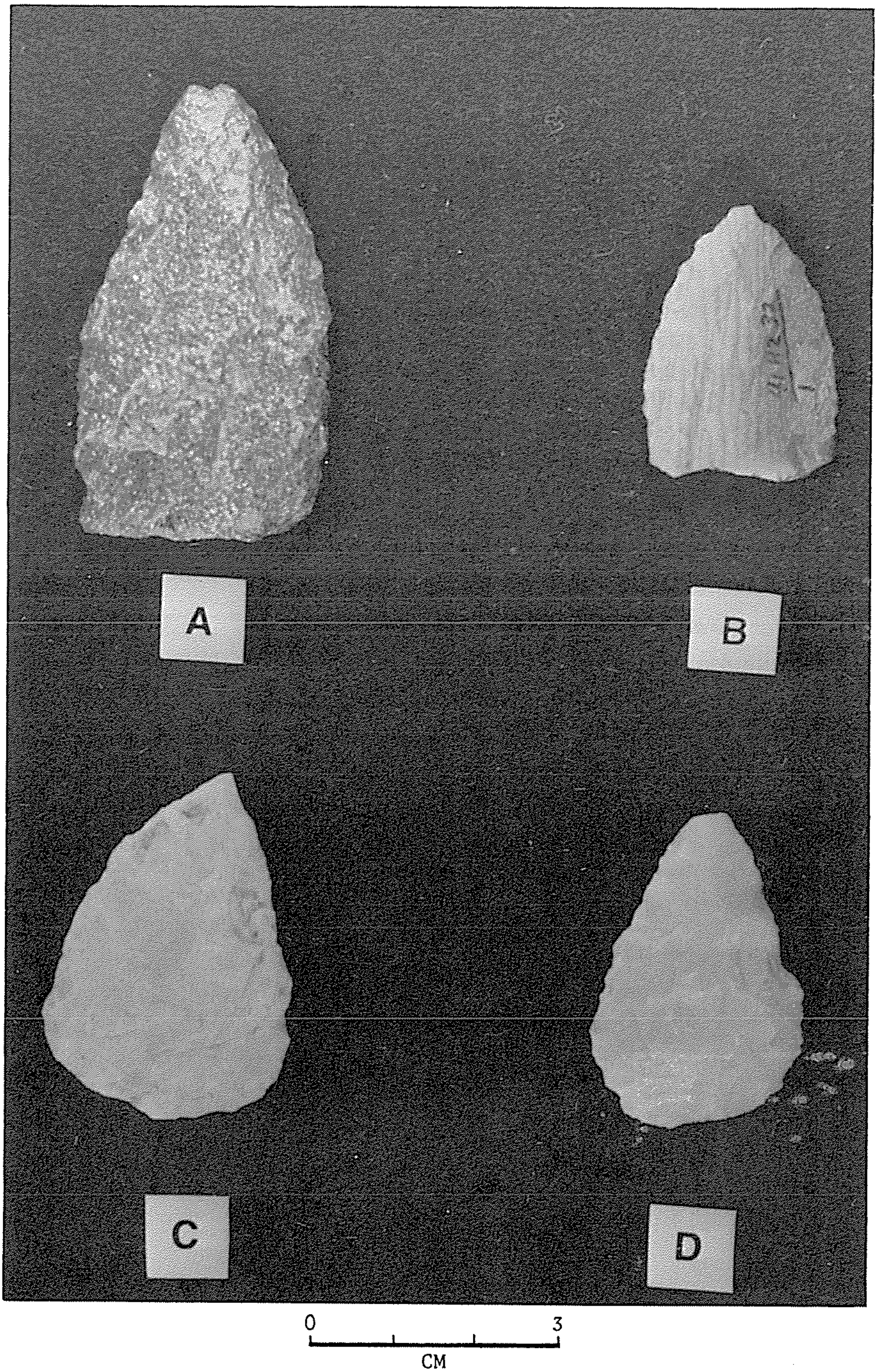

Figure 15. Projectile points: (B) Type 24; (C,D) Type 25; (A) Type 26.

Miscellaneous Artifacts

Some of the artifacts and items collected by the TAS survey do not fit into the lithic artifact typology described above; they are presented here, but they have not been included in the computer-assisted analyses because they are dubious artifacts (i.e., there is some doubt that they were man made) or are so unique in shape, function, or occurrence that no meaningful comparisons could be made. Table 3 shows the distribution of these artifacts, which are described below.

Parallel-sided Bifaces

Parallel-sided bifaces are essentially pentagonal, relatively long and narrow, with essentially parallel sides and biconvex cross sections. This artifact type and the two directly below are similar in some respects to some projectile points; however, no satisfactory comparisons could be made between any of these specimens and point types described in the archeological literature.

Triangular Rounded-base Bifaces

Triangular rounded-base bifaces are biconvex in cross section, with excurvate edges, the bases being defined as the shortest of the three edges.

Triangular Straight-base Bifaces

Triangular straight-base bifaces are similar to the rounded-base bifaces, differing in that the shortest edges are straight rather than rounded or excurvate.

Amorphous Bifaces

Amorphous bifaces constitute a troublesome category. Their crude, irregular shapes defy description or explanation. Some specimens could be abandoned cores, aborted bifacial tools, or even finished implements whose form and function could not be surmised. Rather than adding these artifacts to one of the existing categories, it was decided to leave them out of the analysis altogether.

Hematite

Four specimens of hematite were collected in the survey. Two are ground and gouged and were possibly a source of pigment.

Burins

In the collection are two burins, one from CU19 and one from CU25, both made on broken bifaces. The working edges of the burins were made by removing flakes from the broken surfaces parallel to the bifacial edges.

Hafted Scraper

This scraper was probably made from a broken projectile point. The scraping edge was made by beveling the fracture plane. The hafting area consists of a straight stem with parallel sides and a slightly excurvate base.

Table 3. Distribution of Miscellaneous Artifacts

Artifact	Site																Total
	CU18	CU19	CU25	CU27	CU31	CU33	CU43	CU52	CU53	CU68	CU75	CU85	CU96	HZ32	HZ52	RS2	
Paral lei-sided bifaces						1	1			1							3
Triangular rounded-base bifaces	1													2			3
Triangular straight-base bifaces													1				1
Amorphous bifaces				1	1		1	1									4
Hematite					1		1					1	1				4
Burins		1	1														2
Hafted scrapers														1			1
Beveled knives												2					2
Pick											1						1
Large triangular biface					1												1
Tabular limestone biface		1						1	1								3
Limestone bar																1	1
Engraved limestone															1		1
Polished stone					1												1
TOTAL	1	2	1	1	4	1	3	2	1	1	1	3	2	3	1	1	28

Beveled Knives

Two bifaces have been identified as alternately beveled knives. The pointed ends of the bifaces were produced by flaking along one edge of each side to produce a bevel on each edge. One knife is made from a local gray quartzite and measures 78 mm long, 29 mm wide, ad 9 mm thick. The other is made from honey-colored chert and is 64 mm long, 31 mm wide, and 9 mm thick.

Pick

A long, nearly cylindrical limestone rock in the collection may be a pick. The removal of several flakes from one end is interpreted as an attempt to make a working point. However, the flakes were crudely removed and could also have been fortuitous. The specimen measures 23 cm in length and 5 cm in diameter.

Large Triangular Biface

This specimen is 6 cm wide at the base, 10 cm long, and approximately 9 mm thick, and is probably a knife. The long edges are excurvate and slightly asymmetrical; the base is slightly incurvate. The biface is exceptionally well flaked and is made from local limestone. It is the largest and best-flaked limestone biface in the collection.

Tabular Limestone Unifaces

These are thin limestone slabs from which series of flakes have been removed at one or more places on an edge. They may be unifacial versions of the tabular limestone bifaces also collected on the survey. However, the unifacial flaking may be fortuitous. These specimens cannot confidently be identified as artifacts.

Limestone Bar

Another limestone artifact in the collection is from an area designated as Random Surface #2, in Hudspeth County. The exact location is not specified in the field notes, but it is presumed to have come from the sand dune area of the western part of the park, where most of the Hudspeth County sites are located. It is a narrow, bar-shaped, tabular limestone artifact. It is about 48 cm long, 5.5 cm wide, and 3 cm thick. The corners come to right angles, and the broadest surface has been ground smooth. It may have functioned as a kiva bell, for if it were supported by a leather thong and struck with a stick, it would produce a musical tone. Or, it may be a modern whetstone fashioned by a contemporary rancher from local material. Since its precise provenience is not known and there are no known associations of this artifact with prehistoric materials, theories as to its age and function are speculative.

Engraved Stone

The only work of art recovered by the survey is an engraved limestone tablet (Figure 16), 7.4 cm long, 3.9 cm wide, 0.9 cm thick, and rectangular in shape with nearly square corners. A geometric pattern is engraved on one side. The central part of the design is linear and runs nearly the length of the

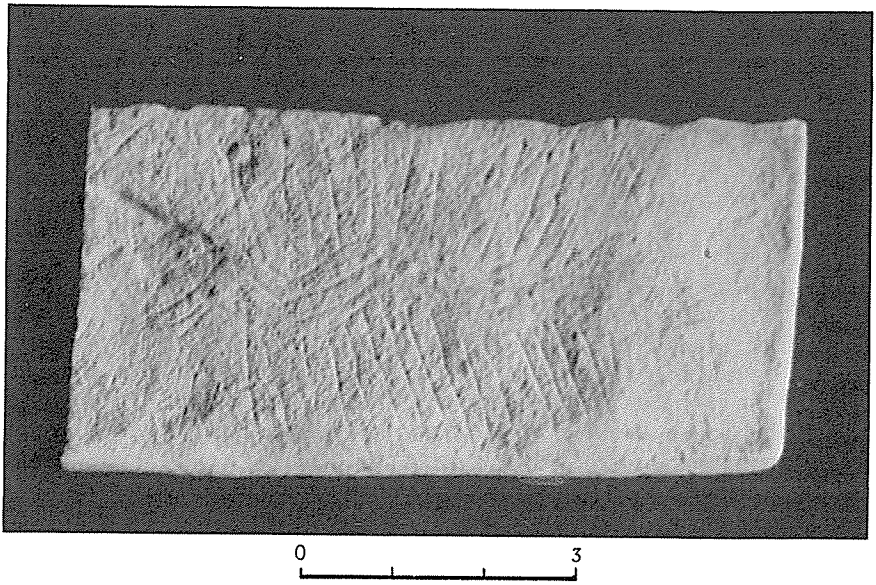

Figure 16. Engraved tablet.

tablet. It is a centipedelike design consisting of four zigzag parallel lines between two series of short lines that are perpendicular to the long axis of the tablet.

Flake Typology

The typology of the artifacts presented above follows the Ford (1949) approach and is useful as a means of defining cultural and temporal limits. However, the analysis of chippage and biface fragments necessitates further subdivision. A description of these two data categories and a discussion of the manner in which they have been manipulated follows.

Analysis of the flakes necessitated construction of a typology. The methods employed here have been taken in large part from the work of M.B. Collins, who has emphasized the isolation of specific attributes of chipping debris obtained from replicative experiments and the observation of their combinations and distribution in archeological assemblages (Collins 1974).

The first step in this flake analysis was to separate the chippage from the rest of the collection while maintaining site-by-site provenience. Pieces of nonartifactual material and occasional tools or tool fragments also were culled. Once the chippage was isolated, observations were made on each flake. All complete flakes and broken flakes that retained at least part of ther platform ends were subjected to further analysis. Once the culled flake fragments (i.e., those parts of flakes without platform ends) were counted and their material types were recorded, they were given no further attention. These fragments were not included in the complete analysis for three reasons: (1) although each flake has only one platform (except in the rarest circumstances), a single flake may consist of many fragments; (2) statistically, assuming that there are no significant sampling errors, any information available from the fragments (such as presence or absence of cortex, flake thickness, and nature of the bulb of percussion) should have been acquired already from the sample; and (3) the breakage might have occurred under circumstances totally unrelated to, and possibly long after, the removal of the flake from the core.

A total of 2,897 flakes from 103 sites (i.e., all sites with flakes) were analyzed. Frequency of flakes per site ranged between 1 and 383. An analysis using research methods similar to those employed in this report (Goodell 1973) has already been conducted on part of the flake assemblage from Guadalupe Mountains National Park. However, the results of this work could not be used in this study for both methodological and practical reasons. Goodell used some different observational criteria, so it would be difficult to adjust his findings to the ones based on this system. In addition, the flakes studied were remixed with the unanalyzed flakes,creating a curatorial problem of immense magnitude. It was more efficient and consistent to analyze all of the flakes by one process. About a third of the analysis was done by an experienced student and the remainder was done by the writer. To minimize bias, the collections were not analyzed in a predetermined order, nor were specific blocks of sites assigned to either analyst. Many collections from the larger sites consisted of several lots, and each of these lots was treated separately. Consequently, the skewing due to differences between observers or changes in judgment of either of the observers over time was minimized.

Table 4 presents five sets of attribute observations made on each flake: platform, bulb, body, size, and material. Each set is independent—i.e., mutually exclusive in its definitional characteristics—from all other sets. The Appendix has a description of each of the attributes in the categories.

Once the flakes were analyzed and the attributes for each of the categories were recorded and coded, the data were keypunched. The keypunched data were then used as the raw data for further analyses, using an IBM 370-165/II computer.

The analyais of the flake morphology is a modified version of the one made by M.B. Collins and uses the IFREQ program written by J. Watts (Collins 1975). IFREQ is a sorting program that allows the investigator to identify and count the number of flake types (attribute state combinations) in a sample. Both expanded and abbreviated versions of the program were used, but these variations did not change the basic operations; rather, they lent more flexibility of analysis by permitting greater or lesser numbers of variables to be sorted and counted.

The number of possible combinations of the 46 attributes observed formed a five-dimensional matrix of 21,600 cells, each one constituting a unique combination of attribute states. Of this number, 760 were actually represented in the collection in frequencies ranging between 1 and 115. The extremely low frequency of most combinations forced a reduction in the number of attributes to be analyzed. Therefore, the size and material categories were deleted from the clustering analysis of the flake morphology, and the resulting abbreviated set of attributes, which emphasizes flake shape,

Table 4. Flake Attributes

Platform	Code No.	Bulb	Code No.	Body	Code No.	Size	Code No.	Material	Code No.
Cortex		Normal	1	Primary cortex		Very small			
straight	1			thin	1	(< 1 cm)	1	Greenstone	1
sequent	2	Exuberant	2	medium	2				
X	3			thick	3	Small		Quartzite	2
		Flated		angular	4	(1-2.5 cm)	2		
Single		(lipped)	3					Cherty lime-	
straight	4			Secondary cortex		Medium		stone	3
sequent	5			thin	5	(2.5-5 cm)	3		
X	6			medium	6			Limestone	5
				thick	7	Large			
Double				angular	8	(5-10 cm)	4	Chert	6
straight	7								
sequent	8			Secondary edge		Very large		Other	7
X	9			cortex		(> 10 cm)	5		
				thin	9				
Multiple				medium	10				
straight	10			thick	11				
sequent	11			angular	12				
X	12								
				Noncortex					
Shattered	13			thin	13				
				medium	14				
Broken	14			thick	15				
				angular	16				
Ground	15								

was used. The platform, bulb, and body attributes totaled 34 and rendered a three-dimensional matrix of 720 possible combinations of attributes. Of these, 147 were present in the collection in frequencies varying from 1 to 254. This number of flake forms was also considered too great for the purposes of cluster analyses, not only because it made it difficult to establish a cognitive framework in which to conceptualize the data, but also because it exceeded the capacity of the clustering program and the computer. Furthermore, a large number of attribute combinations occurred only at very low frequencies, suggesting that they were aberrant flakes and their interpretation would contribute little to a study aimed at eliciting overall patterns of knapping behavior.

Eighty-seven of the recorded combinations occurred only once or twice in the entire collection; that is, 57 percent of the variation in flake types occurred in slightly less than 3 percent of the actual flakes.

For more meaningful analysis of the flake morphology, a smaller number of attribute combinations had to be selected, so a companion program to IFREQ, IFREQ 3 PCT, was written. This program expresses the occurrence of flakes by attribute combinations in terms of their relative percentages in the sample, as well as in terms of their raw frequencies (Table 5). The final number of flake forms was determined by selecting those attribute combinations that accounted for at least 0.76 percent of the flakes in the collection. Using this program, 29 flake types were established, totaling 2,194 flakes; that is, slightly less than 20 percent of the morphological variability accounted for over 75 percent of the flakes.

STONE TYPE ANALYSIS

The production of stone tools begins with the selection and acquisition of suitable materials. Consequently, a comprehensive analysis of lithic technology takes into account the raw materials from which the artifacts have been fashioned. This section investigates the relation between the raw materials used and the forms into which these materials were processed by the prehistoric residents of the southern Guadalupes.

Six raw material categories have been identified in the survey collection. They are greenstone, quartzite, cherty limestone, limestone, chert, and miscellaneous materials; a description of each is presented below. (The geology of the park, with special emphasis on chert, is described in Boisvert 1980:Appendix 1.)

Greenstone is conspicuous but not abundant in the collection. It is bright apple green, although it may weather to a bluish slate gray. It is found in several geologic strata in the Guadalupe Mountains, primarily in the Manzanita Limestone and other members of the Cherry Canyon Formation. It is volcanic ash that has settled into still waters, forming bentonite, a clayey rock that is normally quite friable and has the ability to absorb water, swelling when it is wet. In the Guadalupes this rock has been metamorphosed into greenstone, a chertlike rock with conchoidal fracture. Its structure is platy to blocky, and it occurs in chunks varying from walnut-sized pebbles to blocks of several cubic meters. It erodes out of the southeast escarpment from the Pine Springs area northeastward toward the Texas-New Mexico border (King 1948:37), and in all likelihood it occurs in other areas of the mountains.

Table 5. Flake Forms Selected for Cluster Analysis, with Codes, Frequencies, and Percentages

Code	Platform	Bulb	Body	Freq.	Percent
1 1 14	St cortex	normal	noncortex, medium	29	1.00
1 1 15	St cortex	normal	noncortex, thick	22	0.76
4 1 7	St single	normal	sec cortex, thin	28	0.97
4 1 13	St single	normal	noncortex, thin	45	1.55
4 1 14	St single	normal	noncortex, medium	254	8.76
4 1 15	St single	normal	noncortex, thick	200	6.89
4 2 14	St single	exuber-ant	noncortex, medium	36	1.24
4 2 15	St single	exuber-ant	noncortex, thick	26	0.90
4 3 6	St single	flat	sec cortex, medium	26	0.90
4 3 7	St single	flat	sec cortex, thick	33	1.14
4 3 13	St single	flat	noncortex, thin	59	2.03
4 3 14	St single	flat	noncortex, medium	277	9.55
4 3 15	St single	flat	noncortex, thick	139	4.79
5 1 14	Seq single	normal	noncortex, thick	23	0.79
5 3 14	Seq single	flat	noncortex, thick	26	0.90
7 1 14	St double	normal	noncortex, medium	45	1.55
7 1 15	St double	normal	noncortex, thick	22	0.76
7 3 14	St double	flat	noncortex, medium	37	1.28
10 1 13	St multiple	normal	noncortex, thin	45	1.55
10 1 14	St multiple	normal	noncortex, medium	143	4.93
10 1 15	St multiple	normal	noncortex, thick	53	1.83
10 3 6	St multiple	flat	sec cortex, medium	24	0.83
10 3 13	St multiple	flat	noncortex, thin	111	3.83
10 3 14	St multiple	flat	noncortex, medium	228	7.86
10 3 15	St multiple	flat	noncortex, thick	57	1.96
13 1 13	Shattered	normal	noncortex, thin	51	1.76
13 1 14	Shattered	normal	noncortex, medium	91	3.14
14 1 14	Broken	normal	noncortex, medium	39	1.34
14 1 15	Broken	normal	noncortex, thick	24	0.83

St=Straight Seq=Sequent sec=secondary

Quartzite is extremely common in the Guadalupe Mountains and constitutes major outcrops in the Cherry Canyon and Bell Canyon formations. It varies in color from light tan through buff to reddish brown and sometimes has a greenish tinge. The texture varies from coarse and somewhat friable to sugary and dense to fine grained and quite dense. It is found in the park along the southern periphery of the mountains from below Shumla Peak to the northeast corner of the park (Figure 2). It constitutes the bulk of the Delaware Mountains and the southeast parts of the Patterson Hills (King 1948:Plate 3). Large exposures of quartzite can be seen, and great quantities of boulders, cobbles, and fragments litter the ground in many areas. Quartzite is second only to limestone in abundance in the region.

Cherty limestone was isolated as a separate material after several frustrating attempts to identify it as chert or as limestone. Some specimens made from cherty limestone have very glossy surfaces, are extremely fine grained, and are comparable to what is usually called chert by archeologists and lithic technologists. However, the material grades into a much duller substance that is coarse grained and more closely resembles limestone. It is generally dark, ranging from brownish black to light brown, often with light-and dark-brown banding. Such grading of quality from one end of the spectrum to the other can be found in several samples. Instead of arbitrarily dividing the material into chert and limestone, it was deemed more appropriate to recognize it as having qualities of both and to put it into a separate category. The geologic distribution of the cherty limestone is not precisely known at this time; according to regional experts, it is common in the area from El Paso to Van Horn and into New Mexico (John Hedrick, personal communication), and an outcrop may exist within the park.

Limestone is ubiquitous in the Guadalupe Mountains. Indeed, in most areas it *is* the Guadalupe Mountains. It ranges from white, platy, friable stone in the Capitan Formation to a dark, hard, fine-grained material in the Bone Spring Formation. With the exception of the mainly quartzite south and southeast reef escarpments, as noted above, virtually all of the exposed rock in the Guadalupes is limestone. Boulders, cobbles, pebbles, and fragments of every size litter the canyons, arroyos, and flats. Its quality is highly variable, but significant supplies of material suitable for flaking are available. Limestone is second only to chert in the amount of chippage recovered.

Chert is the material most frequently used by the aboriginal knappers in the southern Guadalupes. It is a very fine-grained cryptocrystalline material, composed for the most part of silica and variable amounts of impurities. Its most notable and desirable quality, from the standpoint of the knapper, is its conchoidal fracture. An attempt was made to identify the varieties of chert used on the basis of macroscopic sorting, but the task proved to be too complex and subject to error, since there were no available comparative collections of cherts from the park or the southern Guadalupes. For the purpose of analysis, all varieties of chert were treated alike, and no attempt was made to distinguish between them.

The miscellaneous category comprises a group of rocks that do not belong in any of the other groups. Some of these materials are specific nonchert stones such as obsidian. Others are cryptocrystalline silicates such as chalcedony and jasper. They are of extremely high quality and in thin sections are translucent to transparent. The high quality, low frequency (26 in the entire collection), and lack of similarity to most of the cherts in the collection suggests that they were obtained outside the park region, as certainly must be true for the obsidian. The chalcedony and jasper artifacts are the smallest of the six groups and account for less than 1 percent of the sample. Included in the miscellaneous category is a white quartzite material that differs significantly in color and texture from the quartzites known to exist in the park region. This quartzite is found only in the metate artifact category.

Artifact Classes and Raw Material Type

Methodology

In order to provide explanations for the selection of particular kinds of stone for the various kinds of artifacts, a methodology was developed that included a statistical test to determine the degree of nonrandom distribution of material types in the artifact classes. First, the frequency of all the artifacts was tabulated by material type and artifact class. Then a Chi Square Goodness of Fit Test was run on each artifact category; this was accomplished by using a WATFIV program written for testing these data.

Data

The data used for the analysis consist of a distribution matrix of the artifact classes and material types. The artifact classes correspond to the typological categories defined above in the section describing the data base, with the exception of two categories, worked hematite and miscellaneous artifacts. Worked hematite was deleted because the artifact was defined in terms of its material type, and miscellaneous artifacts were excluded because the category is not a type of artifact.

Analysis

The tabulated data were keypunched and processed with the Chi Square program. The initial test was based on an analysis of the distribution of all six material types. A preliminary inspection of the output suggested that the very low frequency of greenstone and miscellaneous stone had caused an upward skew in the significance values generated by the test. Consequently, an additional test was run that eliminated the scarce material types from consideration and compared only quartzite, cherty limestone, limestone, and chert.

Results and Interpretation

Table 6 presents the significance values generated by both the Chi Square tests and the distributional data. As expected, there were some changes in the probabilities of nonrandom distribution when greenstone and miscellaneous stone were removed from consideration. In two cases, Type IIIa and Type IVa unifaces, the change in probability that the material type selection was nonrandom changed from less than an .01 to a greater than .05 confidence level. In four other cases—Type I and Type IIIb unifaces, marginal bifaces,

Table 6. Artifact Categories* by Stone Type Chi-Square Goodness of Fit Tests

Artifact Category	Stone Type: Greenstone	Quartzite	Cherty Limestone	Limestone	Chert	Miscellaneous	TOTAL	Probability of Random Distribution: All Types .05	.05	.01	Four Types .05	.05	.01
1 Battered stone	1	4	3	15			23			X			X
2 Amorphous cores	9	49	67	156	94	5	280			X			X
3 Single platform cores	4	7	1	10	7		29			X			X
4 Chippage	83	163	404	719	1501	26	2986			X			X
5 Utilized flakes	1	33	1	4	10		49			X			X
6 Unifaces, Type I		3	6	1	3		13		X		X		
7 Unifaces, Type II		2	3		1		6	X			X		
8 Unifaces, Type IIIa		4	3	11	9		27			X	X		
9 Unifaces, Type IIIb		4	2	2	6		14		X		X		
10 Unifaces, Type IIIc		2			3		5	X			X		
11 Unifaces, Type IVa		14	5	14	13		46			X	X		
12 Unifaces, Type IVb	2	8	3	14	22	3	52			X			X
13 Unifaces, Type IVc	2	3	5	8	20		38			X			X
14 Unifaces, Type V	2	24	26	44	48		144			X			X
15 Unifaces, Type VI	1	24	33	46	64		168			X			X
16 Uniface fragments		3	4		61		68			X			X
17 Biface-uniface composites		2	2	2	5		11	X			X		
18 Marginal bifaces			5	1	6		12			X		X	
19 Single-edge heavily retouched bifaces		2					2	X			X		
20 Chopping tools				5			5			X			X
21 Ovate bifaces		2		7		1	10			X			X
22 Tabular bifaces				27			27			X			X
23 Parallel-sided bifaces					3		3		X			X	
24 Triangular biface, round base					3		3		X			X	
25 Triangular biface, straight base		1			1		2	X			X		
26 Planoconvex biface		1	4	3	5	1	14	X			X		
27 Preforms	3	3	44	52	60	4	155			X			X
28 Drills			2		4		6		X		X		
29 Biface fragments, snap fractures		8	18	25	182	6	239			X			X
30 Biface fragments, transverse		5	16	5	40	1	68			X			X
31 Manos, flat		18		7			25			X			X
32 Manos, convex		13		5			18			X			X
33 Metate fragments		10		1		9	20			X			X
34 Core fragments				1	20		21			X			X
36-52 Projectile points (all types)		2		1	27		60			X			X
53 Projectile point fragments					23		23			X			X
54 Miscellaneous projectile points					15		15			X			X

*Artifact Category 35 was not included, since it consisted of hematite lumps.

and drills—there was a similar change in probability that the material type selection was nonrandom, from an .01 to a less than .05 confidence level.

Interpretations of the test results show that although greenstone of chippable quality occurs within the park area and is conspicuous where it is found, it was never extensively utilized. Isolated cores and flakes constitute the bulk of the greenstone artifacts, with only seven finished tools—all unifaces—and four unfinished tools—three preforms and a biface broken during manufacture. The greatest amount of greenstone occurs at site CH31, adjacent to an outcrop of the material, where 39 flakes, a core, and three unifaces were collected. The use of greenstone may represent opportunistic exploitation of a convenient but inferior resource.

In contrast to greenstone, quartzite was locally available and was frequently used by the prehistoric residents of the southern Guadalupes. Cores are common in the quartzite assemblage, and in numbers rank second only to flakes. However, the ratio of flakes to cores—slightly less than three to one—is the lowest for any material type. This may represent a sampling bias in the data-collecting process. Since quartzite is native to the region and abundant in some areas, many flakes, particularly the smaller ones, could be easily overlooked or dismissed by the field collectors as natural spalls, especially since flake features such as bulbs and ripple marks are almost indiscernible in quartzite.

Four artifact categories have statistically significant numbers of quartzite artifacts, consisting of utilized flakes, both varieties of manos, and metates. The utilized flakes are mainly large to very large, and 20 of the 33 can be described as blades. They are long, relatively thin, often narrow flakes, with relatively straight edges and prismoidal cross sections. Although blades are found at only one site—CU19—there is no indication that prismoidal cores were being systematically fabricated and maintained for the production of blades. Examination of these artifacts indicates that the knappers were exploiting the natural shape of the quartzite, which occurs in blocks, making it a simple matter for the knappers to produce big, long flakes by following the natural ridges on the stone. The flakes were sequentially removed, thus producing blades. Areas of cortex on the flakes are common, and some have cortex covering not only their exterior sides but also their platforms and terminal ends. A blade-core technology is not evident in the Guadalupes, since the only tools made on blades were utilized flakes. There were no projectile points, unifaces, or burins made on blades.

Microscopic examination of the utilized flakes indicated that they were probably used for cutting purposes, since the edges are rounded and the polish extends up both sides. Some flakes have massive amounts of polish, which could have occurred only as a result of long or hard use.

Quartzite was also the favored material for grinding stones. Flat and convex manos and metates are mainly of quartzite. In three cases an apparently nonlocal quartzite was used for the grinding slab, and because the material—a rather coarse white quartzite—bears no resemblance to the known local varieties, it is tabulated under the miscellaneous heading. Limestone was also used, but not as extensively as quartzite.

Quartzite also would have been an ideal choice for hammerstones, but the battered stone artifact category has only four possible examples. In all likelihood, quartzite pebbles were used as hammerstones; their abundance in the area suggests that they may not have been retained and used repeatedly. Furthermore, it would be extremely difficult to discriminate between quartzite hammerstones and natural pebbles in the field, especially if the hammerstone was not used extensively.

Cherty limestone is common in the collection, constituting nearly 13 percent of the chippage and 19 percent of the other artifacts. However, it is the predominant material in only one artifact category—Type I unifaces. It occurs in relatively high proportions in Types V and VI unifaces as well as in preforms and both varieties of biface fragments. With one significant exception—projectile points—cherty limestone generally parallels the distribution of chert artifacts. Only two points, a Type 7 point recovered from a random surface and a Type 24 (Young) point, were made from cherty limestone. The relatively large numbers of artifacts in the preform category is perplexing, in view of the fact that so few finished bifaces of cherty limestone are reported. It is possible that some of the cherty limestone preforms may be finished implements, ones for which no secondary trimming was intended, but no satisfactory explanation for this situation can be found.

Limestone artifacts are common on sites in the Guadalupes, reflecting the abundance of the material in the area. Although second to chert in most artifact categories, it is predominant in several. It accounts for 41 percent of the amorphous cores—16 percent more than chert. This figure may be too low considering that many limestone cores and flakes may not have been collected due to their resemblance to natural pebbles and spalls. Many pebbles and spalls were collected as artifacts during the survey, a fact that attests to the difficulty in discriminating between artifacts and nonartifacts in the field. Indeed, this is often a difficult task even under more favorable laboratory conditions.

Limestone and chert are the dominant material type for Type V and VI unifaces. These are the most generalized forms of unifaces, and little cultural or temporal significance can be attached to them. Examination of the collection shows that virtually any material was used for these artifacts, and that limestone was used nearly as often as chert.

Limestone is significant in the manufacture of three other kinds of artifacts. Two, the chopping tool and the ovate bifaces made from rather large pebbles, are quite similar. Limestone pebbles occur in sizes and shapes convenient for the manufacture of these implements; the only other material that consistently has these characteristics is quartzite. The preference for limestone over quartzite might be explained by the overall suitability of limestone to flaking. Limestone is softer and lighter than quartzite; consequently it would be easier to flake with the quartzite hammerstone. Replicative experiments using materials native to the Guadalupes might confirm this hypothesis or suggest other avenues of explanation. At this point, however, it is not possible to explain further the preference for limestone over quartzite for the production of the large bifaces. The third artifact category in which the use of limestone is significant is tabular bifaces. The use of limestone to produce the tabular bifaces is environmentally determined, since limestone is the only material available that naturally occurs in thin sheets. Manufacture of implements from this material is simple and requires only an appropriate source and virtually any kind of percussor. The stone knappers of the Guadalupes exploited the tabular limestone to produce tools with exceptionally long (some as much as 20.8 cm) bifacial edges.

Chert was the most widely used chippable stone in the Guadalupe Mountains. It was the preferred material for four varieties of unifaces—Types IVb, IVc, V, and VI—and for the production of small bifaces, especially projectile points. The preference for chert in the production of thinned bifaces can be viewed as an interplay between the inherent qualities of the material and the desired attributes of the implement. Very hard, sharp edges can be fashioned in chert, and these are qualities desirable in tools designed for piercing, cutting, and scraping. The cryptocrystalline quality of chert is eminently suited to the removal of the thin, flat flakes that are required in the final stages of reduction and shaping of most bifaces. Such final stages of reduction produce relatively large quantities of flakes, especially in proportion to the mass of material involved; this would explain the high number of chert flakes compared to flakes of other materials.

In general, the use of stone for tool manufacture in the Guadalupes can be described as follows. Very specialized chipped stone tools, such as projectile points, were made almost exclusively from chert. Grinding tools were made mainly from quartzite, but occasionally from limestone. Tools with large mass or cutting or scraping edges were commonly made from limestone. Most unifaces were made from chert or limestone, although all kinds of materials were used. Flake knives were usually made from quartzite or, to a lesser degree, chert. The miscellaneous category is made up of high-quality silicates such as obsidian, jasper, and chalcedony. These materials are presumably exotic in origin, and their usage tends to parallel that of chert.

Flake Size and Material Type

This section deals with the interrelations between the material types and the chippage. It has been implicitly assumed that the use of different kinds of raw material in the manufacture of different kinds of artifacts will result in patterned distributions of different flake sizes. The validity of the assumption was tested by flake-size analysis.

The Data

The data selected for the study of this problem were based on all of the flakes in the survey collection, and derived through observations of flake size and material type, which were encoded together with platform, bulb, and body states. Frequencies for each combination of flake size and material type were obtained.

Methodology

The method of analysis entailed arranging the frequency data in matrix form and comparing the relative frequencies of the sizes and raw material types of the flakes. The objective of this inductive approach was to describe and quantify the patterns of flake size and material type. The interpretations of this information were then compared to findings concerning the raw materials available and the forms into which these materials were processed (Figures 17, 18).

	Small	Very Small	Medium	Large	Very Large	Total
Chert	61* 4.0 91.3	1034 68.8 76.4	396 262 33.1	11 .7 4.1	- - -	1502
Cherty Limestone	3 0.7 4.8	143 35.4 10.5	233 57.7 19.5	25 5.1 9.2	- - -	404
Limestone	2 0.2 3.2	102 14.2 7.5	434 60.3 36.2	173 24.0 64.8	8 1.1 623	719
Quartzite	- - -	27 16.5 2.0	78 47.8 6.5	53 32.5 200	5 3.1 37.7	163
Greenstones	1 1.1 1.6	40 48.2 2.9	39 47.0 3.2	3 3.6 1.1	- - -	83
Misc.	- - -	8 30,1 0.5	16 61.5 1.3	2 7.7 0.8	- - -	26
Total	67	1353	1196	267	13	2897

*61 Raw Frequency

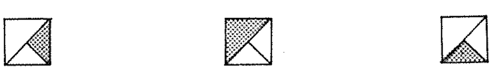

Figure 17. Distribution of flake sizes and material types

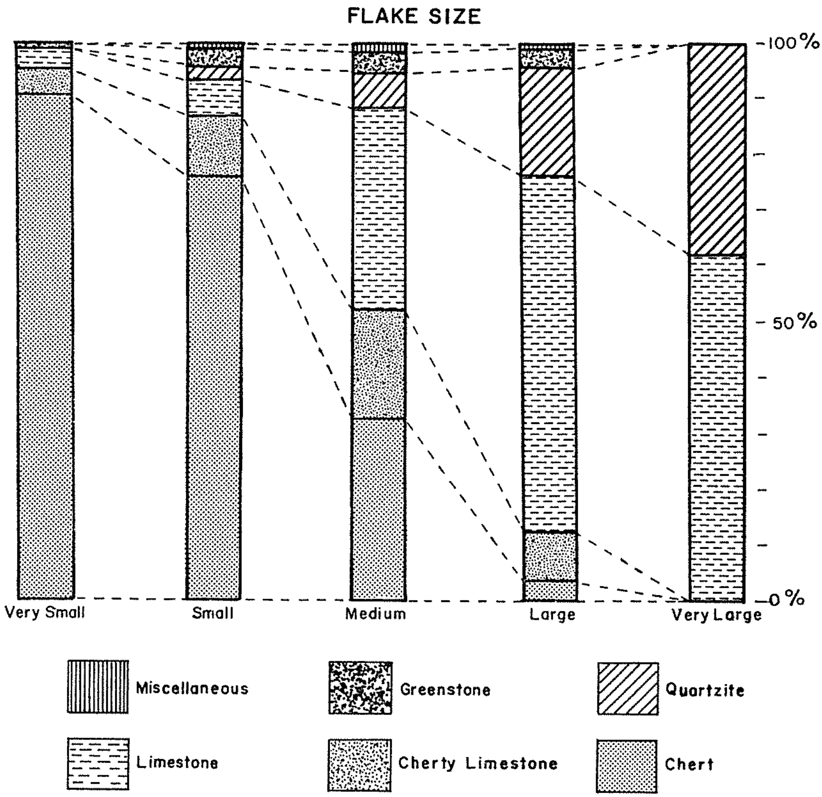

Figure 18. Relative frequency of flakes of size and material type.

The frequency of the flake sizes for each of the material types and the relative percentages are presented in Figure 17. The raw count for each category is in the upper left part of the cell, the raw percentage is in the right side of the cell, and the column percentage is at the bottom of the cell. For example, the raw frequency for small chert flakes is 61, which constitutes 4 percent of all chert flakes and 91.3 percent of all small flakes. Figure 18 presents the same data in a cumulative histogram.

Analysis and Interpretations

It is apparent from the distributions that there is a consistent trend in flake sizes according to material types. The chert flakes are consistently small; greenstone flakes are almost equally divided between small and medium; cherty limestone flakes are consistently medium to small; limestone flakes fall into the medium category, although nearly a quarter of them are large; and quartzite flakes are the largest. Flakes of miscellaneous materials tend to be medium to small, but they are so few in number that size comparisons to flakes of other material types may not be valid.

The interpretation of these distributions incorporates several factors, one of which is sampling error. Limestone and quartzite flakes probably were not recognized in the field as frequently and consistently as were chert and cherty limestone. The escarpment and foothill areas are littered with boulders, cobbles, and spalls of both quartzite and limestone, and their abundance probably masked the presence of the culturally derived quartzite and limestone debitage. Flakes of those materials are probably under-represented in the collection, especially in the smaller-sized specimens. Another factor in the distribution of the samples is the size of the raw materials as they occur in nature. Cherts have not been found, and greenstone has been found only rarely, in the Guadalupes in large blocks. However, large cobbles or boulders of limestone and quartzite are commonly found. Thus, certain parameters are imposed on the flake sizes by the form in which the raw materials naturally occur.

Other factors that would bias the distribution of flake sizes are the method of flaking and the definite preferences for certain materials for the manufacture of specific artifact types. Logically, the manufacture of small bifaces, which were made from chert, would entail the production of small flakes, and the manufacture of large bifaces, which were made from limestone, would probably entail the production of a large number of medium-to-large flakes. Furthermore, an important factor in the choice of material for the manufacture of a given tool is its potential for producing certain kinds of flakes. The cryptocrystalline silicates are much more likely to produce small, thin flakes than are the coarser, less glassy, limestones and quartzites.

The distribution of flake sizes and material types results not from any one variable, but from the interplay of several variables. The size and quality of the raw material, the forms into which it was processed, and the techniques utilized in that process all contribute to the distribution of flakes of different sizes and materials. The tool makers in the Guadalupes clearly recognized the limiting factors of their lithic resources and adapted their tool-making behavior accordingly.

Flake Form and Material Type

A logical next step after the flake-size and material-type analysis is consideration of the relations between flake forms and materials. Because specific interrelations exist among material types, artifact forms, and flake sizes within the assemblages analyzed, patterns of distribution of flake forms in the various material can be expected. Analysis of the flake forms should therefore provide some degree of confirmation of the findings presented above, and it is hoped that it will also provide some unique insights into the flaking of the different material types.

Methodology

The 29 flake morphologies that have been described above were subjected to a hierarchical clustering analysis in order to determine the most frequently co-occurring groups of flake forms. One interpretation of these clusters resulted in the ordering of the flake forms along one axis of a cumulative percentage graph, which was used to compare the frequencies of the flake forms for the various material types.

The percentage of each form was computed for each material type, and from a cumulative total of these percentages a cumulative line graph (Figure 19) was prepared for the flake forms of the five material types. Using these data, the percentages, and the graphic display, correlations of material types with flake forms could be made.

Analysis and Interpretations

From Table 7 and Figure 19 it can be seen that some overall patterns are evident for the flakes as a whole and for particular aspects of certain types of materials.

Certain attribute combinations are more common in some material types than in others. Limestone flakes have more single-faceted platforms with thick to angular decorticated bodies. Chert flakes are much more likely to have complex, or multifaceted, platforms with thin-to-medium noncortex bodies. Cherty limestone falls between limestone and chert, with substantially fewer angular body flakes than limestone and somewhat fewer thin-to-medium noncortex body flakes than chert. Quartzite also falls between limestone and chert but diverges from their distributions, with a greater percentage of flakes with cortex and a decidedly smaller percentage of complex-platformed flakes, especially when compared with chert. The greenstone flake sample is much smaller than the other raw material samples

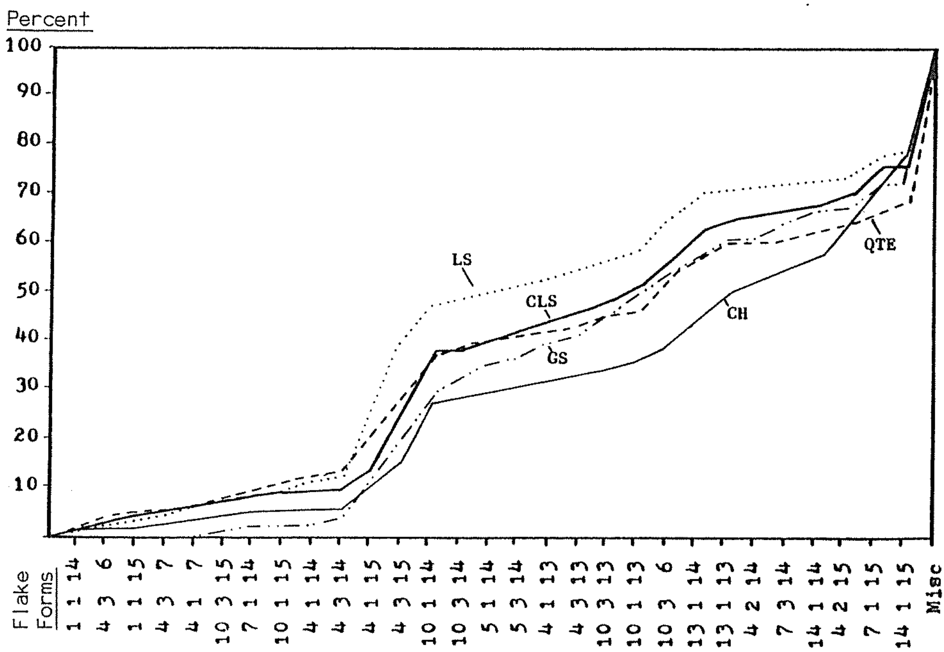

Figure 19. Relative frequency of flake forms by material types. CH, chert; CLS, cherty limestone; LS, limestone; QTE, quartzite; GS, greenstone.

Table 7. Frequency and Relative Percentages of Selected Flake Forms by Material Types

Flake Attribute Combinations	Greenstone			Quartzite			Cherty Limestone			Limestone			Chert		
	#	%	Com %	#	%	Com %	#	%	Com %	#	%	Com %	#	%	Com %
1 1 14			0.0	4	2.45	2.45	5	1.24	1.24	4	.56	0.56	16	1.07	1.07
1 1 15			0.0	3	1.84	4.29	4	.99	2.23	11	1.53	2.09	4	.27	1.34
4 7 7			0.0	1	0.61	4.90	7	1.73	3.96	14	1.95	4.04	5	.33	1.67
4 3 6			0.0	1	0.61	5.51	7	1.73	5.96	1	.14	4.18	17	1.13	2.80
7 1 15			0.0	1	0.61	6.12	3	0.74	6.43	13	1.81	5.99	5	.33	3.13
4 3 7	1	1.20	1.20	3	1.84	7.96	5	1.24	7.67	11	1.53	7.52	12	.80	3.93
10 3 6	1	1.20	2.40	2	1.23	7.19	3	0.74	8.41			7.52	13	1.20	5.13
4 2 15			2.40	3	1.84	11.03	3	0.74	9.15	13	1.81	9.33	7	.47	5.60
5 1 14			2.40	2	1.23	12.26	2	0.50	9.64	13	1.81	11.14	5	.33	5.93
5 3 14	2	2.41	4.81	2	1.23	13.49	1	0.25	9.90	6	0.83	11.97	15	1.00	6.93
4 1 15	5	6.02	10.83	13	7.98	21.47	23	5.69	15.59	116	16.13	28.10	42	2.80	9.73
4 1 14	6	7.23	18.06	11	6.75	28.22	48	11.88	27.47	87	12.10	40.20	99	6.59	16.32
4 3 14	7	8.43	26.49	14	8.59	36.81	41	10.15	37.62	48	6.68	45.88	164	10.93	27.24
14 1 15	5	6.02	32.51	3	1.84	38.65	1	0.25	37.87	9	1.25	48.13	6	0.40	27.64
14 1 14	2	2.41	34.91	1	0.61	39.26	7	1.73	39.60	10	1.39	49.52	19	1.26	28.90
4 2 14	1	1.20	36.12	1	0.61	39.87	9	2.23	41.83	9	1.25	50.77	16	1.07	29.97
7 1 14	3	3.61	39.73	3	1.84	41.71	8	1.98	43.81	16	2.23	53.00	15	1.00	30.97
7 3 14	1	1.20	40.93	1	0.81	42.32	7	1.73	45.54	5	0.70	53.70	23	1.53	32.50
10 1 15	3	3.61	44.54	4	2.45	44.77	7	1.73	47.27	21	2.92	56.62	17	1.13	33.63
10 3 15	3	3.61	48.15	1	0.61	45.38	12	2.97	50.24	11	1.53	58.15	30	2.00	35.63
4 3 15	4	4.52	52.97	12	7.36	52.74	26	6.44	56.68	47	6.54	64.69	50	3.33	38.96
10 1 14	2	2.41	55.38	6	3.68	56.42	23	5.69	62.37	32	4.45	69.14	77	5.13	44.09
13 1 14	4	4.82	60.20	4	2.45	58.87	9	2.23	64.60	8	1.11	70.25	64	4.26	48.35
13 1 13			60.20			58.87	2	0.50	65.10	3	0.42	70.67	45	3.00	51.35
4 1 13	5	3.61	63.81	1	0.61	59.48	2	0.50	65.60	5	0.70	71.37	34	2.26	53.61
4 3 13	2	2.41	66.22	3	1.84	61.32	4	0.99	66.59	7	0.97	72.34	42	2.80	56.41
10 1 13			66.24	2	1.23	62.55	6	1.49	68.08	3	0.42	72.76	34	2.20	58.67
10 3 14	4	4.82	71.04	6	3.68	66.23	25	6.19	74.27	30	4.17	76.98	161	10.72	69.39
10 3 13			71.04	2	1.23	67.46	2	0.50	74.77	2	0.28	77.21	103	6.86	76.25

but is notable for the relatively large proportion of flakes with shattered and broken platforms. Newell et al. (1953:64) report that the siliceous content of greenstone is low—51 to 61 percent—and that the clay content is fairly high—20 to 24 percent. The green color is the result of finely disseminated grains of minerals of the chlorite group, alteration products of volcanic ash (Newell et al. 1953:64), which apparently cause the material to lack the hardness and strength of chert. This weakness may account for the high proportion of greenstone flakes with broken platforms (8.41 percent) compared to flakes of limestone (1.98 percent), and chert (1.66 percent). The generally low silica content, together with the decomposed nature of the original ash structures, may explain the preponderance of broken platforms on the greenstone flakes.

Quartzite is also a local material, but its pattern of flake-form frequencies and distributions differs from greenstone. Not only are cortical areas frequent, but quartzite seems to be an exceptionally strong material. Shattered and broken platforms are relatively rare, a fact which, together with the low frequency of complex platforms, strengthens the premise that the material was selected for the production of cutting blades because of its naturally large size, availability, and overall strength and durability.

The dominant feature of the chert flake forms is their large proportion of multifaceted, flat, medium-to-thin, noncortex flakes. In addition, similar flakes with straight platforms are also quite common. This particular distribution attests to the fact that chert was the material most frequently selected for the manufacture of small, morphologically complex bifaces. Two of the flake forms—thin and medium noncortex flakes that are multifaceted and thin bulbed—are usually interpreted as typical flakes associated with final trimming and maintenance of bifaces. This interpretation is supported by the fact that in cherty limestone, which has a low frequence of bifaces, there is a very low percentage of such flakes.

Summary and Conclusions

The analysis of flake forms based on material type tends to confirm the interpretations developed from the analyses correlating material type with artifact type and flake size with material type. Chippage associated with the production and maintenance of bifaces and other morphologically complex artifacts tends to be chert. Chipped stone artifacts that require long, durable edges are made from quartzite, and the nature of the quartzite chippage affirms the contention that it is indeed a strong and durable material. Limestone is a ubiquitous material in the region, and its distribution in both the artifacts and flake assemblages suggests that it was most suitable for the manufacture of simple tools such as unifaces or large tools that would have required large cores. The distribution of cherty limestone chippage and artifacts parallels that of limestone, with the exception of large bifaces. One might speculate for that reason that large pieces of cherty limestone do not occur in nature. Greenstone was not a popular material of the prehistoric knappers of the Guadalupes, as the flake study suggests, because its platforms have a tendency to break, although it appears to be suitable at first glance. The sample of miscellaneous material is both too diverse and too small to warrant any detailed analysis.

DEBITAGE ANALYSIS

For the purposes of this report, debitage includes not only waste flakes, but also implements broken prehistorically by use, during manufacture, or by accident, and subsequently abandoned or discarded. Also included in debitage are implements abandoned during manufacture because of problems such as failure to thin, excessive hinge fracturing, and edge collapse. Not included in debitage are implements that were broken intentionally or broken by farm equipment or by excavators after they had been committed to the archeological record as completed tools. The study of debitage, rather than complete implements, is the focus of this report for two reasons. First, the finished products usually reflect only the final stages of manufacture, whereas the debitage reflects all stages. Second, the completed implements in the survey collection constitute a very small sample when compared to the debitage. The analysis of the debitage is divided into two parts: first, a hierarchical clustering analysis of the chippage, the purpose of which is to provide an empirical definition of flake types and to explain from a technological standpoint the relative distribution of different flake forms; and second, an analysis of the broken and unfinished implements. The analysis of broken and unfinished implements provides some insights into the modes of chipped stone tool manufacture and tool use in the southern Guadalupes. In other words, two questions are considered: "What can the site collections tell us about flake assemblages?" and "What can flake assemblages tell us about the sites?" It has been important throughout this analysis to maintain the distinction between these two questions in order to avoid a tautology.

Hierarchical Clustering of Flake Attribute Combinations

The first step in the cluster analysis was to determine the natural groupings of flake forms found on the sites, then to use the same data base to determine which sites have the most similar flake assemblages. The eventual goal was to elucidate at least some facets of tool-making behavior.

The Data

The flake clustering analysis used flake morphology data drawn from the output of IFREQ 3 PCT as described in the section on Flake Typology. Each case was defined as one of the 29 attribute combinations (see Table 5). The variables were defined as the distribution of the frequencies of the flake forms at each site (Table 8).

The sites selected for analysis had to satisfy certain criteria. They had to have at least 20 analyzable flakes. The total number of flakes on the site, regardless of whether or not they were included in the 29 flake forms selected for analysis, was used. Another criterion was that the collection of artifacts at the sites, as could be determined from the field notes, was not overly biased. The field notes for some sites indicated that chippage was generally ignored or that no attempt was made to gather representative samples. For that reason, sites were reviewed individually before being included in the analysis.

Table 8. Distribution of Selected Flake Forms by Site

Flake Attribute Combinations	Sites																																	
	CU18	CU19	CU20	CU27	CU31	CU33	CU34	CU38	CU43	CU52	CU67	CU68	CU69	CU83	CU85	CU88	CU91	CU96	CU99	CU108	CU110	HZ29	HZ32	HZ33	HZ39	HZ42	HZ43	HZ44	HZ45	HZ46	HZ52	HZ53	HZ68	HZ71	HZ73
1 1 14	0	1	0	0	1	0	1	0	0	1	0	1	0	2	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	6	1	2	0	0
1 1 15	0	2	0	1	3	2	1	1	2	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0
4 1 71	2	1	0	0	3	1	1	0	2	0	0	1	0	2	1	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	2	2	1	0	0
4 1 13	0	3	0	0	6	0	0	0	0	0	0	0	0	1	3	0	1	2	0	1	0	5	0	1	0	0	0	0	1	2	3	9	3	0	0
4 1 14	22	6	2	2	28	7	0	1	6	2	5	3	0	14	2	3	1	11	5	2	2	4	2	4	2	4	0	1	5	0	39	19	14	6	0
4 1 15	20	8	3	10	38	5	1	2	6	1	4	1	1	13	2	4	0	0	5	3	1	3	2	5	2	2	1	3	0	2	14	6	3	3	2
4 2 14	0	0	0	0	2	1	0	0	0	0	2	1	1	3	0	1	1	1	0	0	0	0	2	4	0	0	0	1	3	0	2	1	6	1	0
4 2 15	3	1	0	1	1	0	0	1	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	1	0	0	0	1	0	0	2	0	2	1	1
4 3 6	0	0	0	1	1	0	0	0	0	2	0	1	0	2	1	0	0	0	0	0	0	1	0	1	1	0	1	0	0	1	4	0	1	0	0
4 2 7	2	3	1	0	2	5	0	2	1	0	0	1	0	0	0	0	0	3	0	0	1	3	0	0	0	0	0	0	0	1	2	1	1	0	0
4 3 13	1	2	1	0	8	2	1	0	2	0	2	0	0	0	1	0	0	3	0	1	0	6	1	0	2	0	0	1	2	2	8	9	0	0	0
4 3 14	9	13	2	2	28	4	1	3	10	1	1	0	1	19	5	2	1	7	3	5	2	8	1	2	2	4	0	2	1	5	48	25	12	2	4
4 3 15	10	8	2	1	12	4	0	3	3	0	1	1	1	6	1	1	0	1	1	6	3	3	2	3	1	2	4	0	2	2	9	10	9	1	1
5 1 14	2	0	0	2	3	2	0	0	1	0	0	0	0	0	0	0	0	2	0	1	0	1	2	1	0	0	0	0	0	0	2	1	0	0	0
5 3 14	2	1	2	2	5	0	0	0	0	0	0	0	0	0	2	0	0	2	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1
7 1 14	2	2	1	0	4	2	0	0	4	0	0	0	1	0	0	0	1	0	3	4	0	0	0	0	1	0	0	1	1	1	7	3	2	0	1
7 1 15	2	3	0	0	3	1	1	0	1	1	0	0	0	0	0	1	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
7 3 14	1	1	0	0	0	3	0	0	0	0	2	0	1	0	1	0	0	0	0	1	0	1	0	2	2	0	1	0	3	0	4	3	2	0	0
10 1 13	1	1	0	1	3	0	0	0	2	0	2	0	0	1	0	0	0	3	1	1	0	5	2	0	0	0	0	0	1	0	5	7	6	0	0
10 1 14	4	2	1	0	10	0	0	1	5	0	1	1	3	5	3	2	1	6	4	6	0	5	3	0	4	2	0	0	5	0	14	15	17	2	2
10 1 15	3	3	0	1	4	0	1	0	6	0	1	0	0	5	2	0	1	2	0	1	2	1	0	0	0	0	0	0	1	0	10	2	0	0	2
10 3 6	1	0	1	0	2	0	0	0	0	0	0	0	0	3	3	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	6	3	0	0	0
10 3 13	2	0	2	1	7	3	0	2	1	0	1	0	0	2	9	1	3	11	0	1	0	13	1	0	3	2	2	3	2	3	10	12	4	0	0
10 3 14	3	6	4	0	9	3	0	6	6	2	2	0	1	1	5	0	3	8	1	4	3	9	4	1	4	3	2	1	8	2	46	20	13	0	1
10 3 15	2	5	3	1	5	0	0	0	2	0	2	0	1	4	1	0	0	0	0	2	3	1	0	1	1	1	0	0	0	0	5	2	5	0	2
13 1 13	2	1	4	0	1	0	0	0	0	0	0	2	0	0	3	0	0	2	2	0	0	8	0	0	0	1	0	0	0	0	15	6	2	0	0
13 1 14	0	4	5	0	5	0	0	2	1	2	0	1	0	4	3	0	0	4	1	1	0	5	0	1	1	0	0	0	0	1	24	4	3	1	1
14 1 14	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	2	0	0	0	4	0	0	0	0	0	0	1	2	2	0	15	1	5	1	0
14 1 15	0	2	0	0	6	0	0	0	0	0	0	0	2	0	0	1	0	0	1	1	0	0	0	0	1	0	0	1	3	0	2	0	0	0	0

Methodology

The cluster analysis used MATRIX, HCLUS, and PLINK computer programs gathered together and articulated by Don W. Graybill (1975). Clustering programs available from the Bimed series (BMDP 2M) (Dixon 1975:323-330) and the H Group clustering program described by Veldman (1967:308-319) were also tested.

The Bimed and Veldman cluster programs were used to verify the results of the HCLUS program. All three programs produced essentially the same results, but with slightly different output displays. The HCLUS version was chosen because it not only displayed the clusters in the form of more clearly understood dendrograms, but it also printed the correlation matrix of all possible comparisons between cases that allowed for specific case-by-case comparisons.

The HCLUS program offers eight options with which to perform clustering operations, and a choice of two kinds of matrices, each of which can be derived from one of four possible combinations of standardizations of the data. The options for performing the clustering are

1) Nearest Neighbor
2) Furthest Neighbor, complete linkage
3) Weighted Pair group arithmetic averages
4) Unweighted Pair group arithmetic averages
5) Median, weighted centroid
6) Centroid, unweighted centroid
7) Lance Williams Flexible Method
8) Ward's Method

The distance similarities matrix is offered as appropriate for methods 1 through 4 and the correlation similarities matrix is recommended for methods 5 through 8. Standardization options are offered for both columns (variables) and rows (cases to be clustered).

Following the work done by Graybill (1975), Ward's method was chosen for analysis. Briefly, the program creates the clusters by calculating a distance that expresses the degree of similarity between any two cases in the sample. It then merges the two cases that are most similar and treats them as one case from then on. It then selects the next two cases that are most similar and merges them. This procedure is continued until all cases are merged into one. The end result is displayed as a dendrogram with N-1 mergings when N equals the number of cases.

In all tests, standardization by column (variables) was applied. This was accomplished by expressing the frequencies in terms of percentage rather than raw count. This operation has the effect of giving each variable equal weight of significance, thus preventing abundantly represented variables from obscuring relatively rare variables. Each cluster analysis was run both with and without the option for standardization by row (cases). This operation would have the same kind of effect as standardization by column. The applicability of these options is discussed and evaluated for each of the cluster analyses in the section to follow. In all, four clusterings were generated, two clusterings of flake forms using site flake assemblages as variables (standardized and nonstandardized) and two clusterings of the site flake assemblages with the flake forms as variables (again, standardized and nonstandardized).

Analysis and Interpretation, Cases Not Standardized

The clustering of the flake forms without the standardization by case is presented in dendrogram form (Figure 20). It indicates that there are two distinct blocks within the flake sample. A comparison with Figure 17 reveals that Cluster II contains the seven most abundant flake forms, accounting for 70.99 percent of all flakes in the sample. The rest of the sample accounts for 29.01 percent of the flakes chosen for analysis. Raw frequency is the determining factor in differentiating between these two groups of flakes. However, within each cluster, the size of each case (i.e., frequency of each flake form) does not seem to be significant.

The clusters can be viewed as two separate, though similar, dendrograms. Cluster I is composed of six subclusters. Cluster Ia reflects activities involved

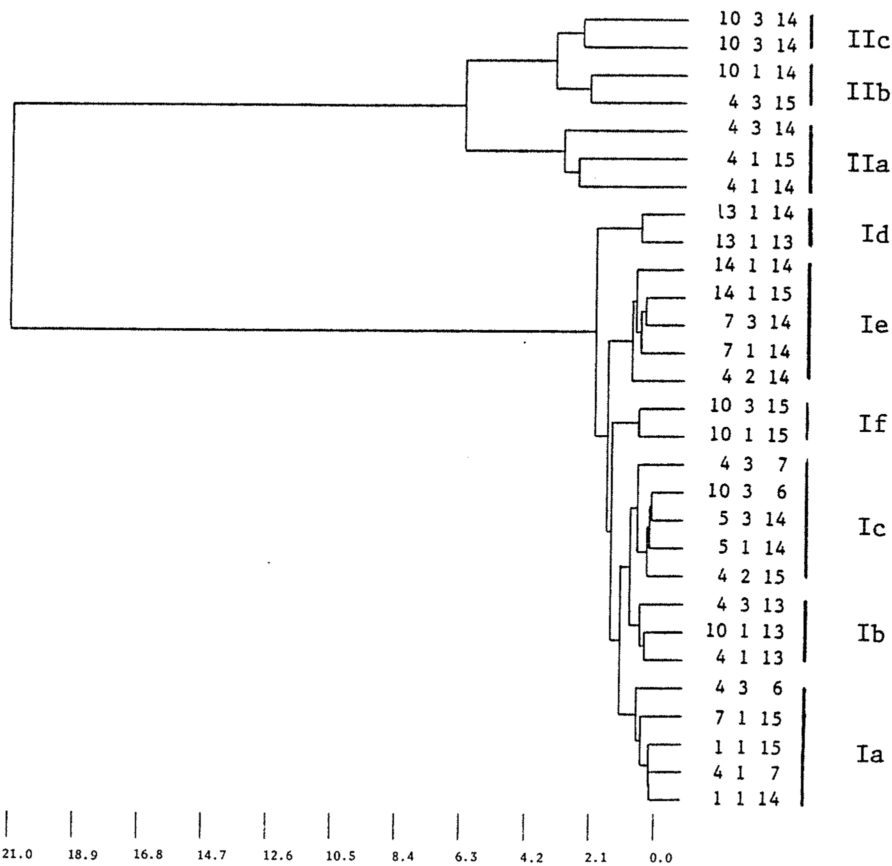

Figure 20. Flake clusters, not standardized by site.

with the initial reduction of cores. It contains four of the six flake forms that have cortical areas either on their platforms or bodies. The fifth case has no cortex, but it does have a double-faceted platform and a thick body, suggesting vigorous percussion flaking with the intention of removing a large flake. Experimental studies suggest that double platforms are especially strong and resist shattering. Otherwise the platforms are simple and the bodies are medium to thick in cross section.

Cluster Ib probably relates to the thinning or rejuvenation of bifaces. The flakes are uniformly thin, with normal and flat bulbs and straight and multifaceted platforms. The exteriors of the flake bodies lack any evidence of cortex.

Cluster Ic contains five flake forms that are commonly produced by the secondary reduction of cores. The remaining two varieties of flakes with cortical areas are included in the group, together with both examples of sequent flakes and a flake with a straight platform, exuberant bulb, and thick cross section. The exuberant bulb suggests hard hammer percussion, or at least vigorous soft hammer percussion. The sequent flakes indicate that at least some flakes have already been removed from the core.

Cluster Id contains only two varieties of flakes, flakes with normal bulbs and flakes with flat bulbs. Both have complex (multifaceted) platforms and thick noncortical bodies. The combination of multifaceted platforms and thick cross sections suggests that these flakes were produced by soft hammer shaping of partially finished bifaces.

Cluster Ie contains flakes that are predominantly of medium thickness. Both varieties of flakes with broken platforms are in this group, as are two of the three kinds of flakes with double-faceted platforms. The third form is one of the two exuberant-bulbed flakes and has a straight platform. This cluster shows evidence of having been produced either by hard hammer or vigorous soft hammer flaking which often produces bulbs and broken platforms.

Cluster If consists exclusively of flakes with shattered platforms. These flakes usually result from poor platform preparation or selection, or from inappropriately delivered blows. Their thin-to-medium thickness and normal bulbs suggest that they are products of soft hammer percussion, possibly in the thinning of bifaces or the manufacture of unifaces.

Cluster II is represented by only seven flake forms, each of which is quite numerous in the collection. Cluster IIa consists of three flake forms, each of which has a straight single-facet platform with normal-to-flat bulb and medium-to-thick body. These flakes would be by-products of core preparation or initial biface reduction done prior to fracture. In either case, they are not the result of bifacial shaping, as the platforms are not multifaceted. The thickness of the flakes and the nature of bulbs suggest fairly strong soft hammer percussion.

Cluster IIb is composed of two flake forms. One has a complex platform, normal bulb, and medium thickness; the other has a simple platform, flat bulb, and thick cross section. Both lack cortex on their bodies. This cluster may represent the result of further soft hammer core reduction with the beginnings of bifacial shaping.

Cluster IIc also is composed of two flake forms, both of which have multifaceted platforms and flat bulbs. They differ in the presence of medium-to-thin noncortical body states. These varieties of flakes are typical results of the final stages of bifacial manufacture and trimming, and of biface rejuvenation.

These nine attribute clusters can be interpreted as representing the by-products of chipped stone tool manufacture. This process may be conceptualized as containing several steps, each with characteristic products and by-products. The scheme illustrated below is an attempt to isolate several activity sets, some of which are optional in the manufacture of chipped stone tools. This is presented in the full realization that such behavior actually constitutes a continuum and that divisions between activities are in large part arbitrary. However, since chipped stone tool manufacture is of necessity a reductive process in which the tool becomes smaller as the process continues, it is legitimate to assume that certain activities must precede others. A biface cannot be rejuvenated until it has been finished, and the secondary trimming of an implement, if it occurs at all, must follow the primary trimming.

Figure 21 presents an outline of the steps or activity sets that have been defined by Collins (1975:25) in the overall process of chipped stone implement

Table 9. Association of Flake-type Clusters and Product Groups

Product Group	Products and By-Products	Clusters (Flake Forms)
i	Unaltered raw material	
ii	Amorphous and prepared cores, primary and secondary cortex flakes, core fragments	Ia
iii	Secondary and edge cortex flakes, large noncortex flakes, preforms, unfinished implements, fragments	Ia, Ic, Ie, IIa
iv	Noncortex flakes, preforms, unfinished implements, fragments	Ib, Id, Ie, If, IIb
v	Finished implements, trimming and retouching flakes, unaltered flake implements*	Ib, If, IIc
vi	Reworked implements, resharpened implements, implement fragments, retouching flakes	Ib, If, IIc
vii	Grave furniture, specialists' caches, ritual offerings	

*Hypothetically any flake could be chosen. Flake clusters presented are mainly those derived from the other artifact categories in product group v.

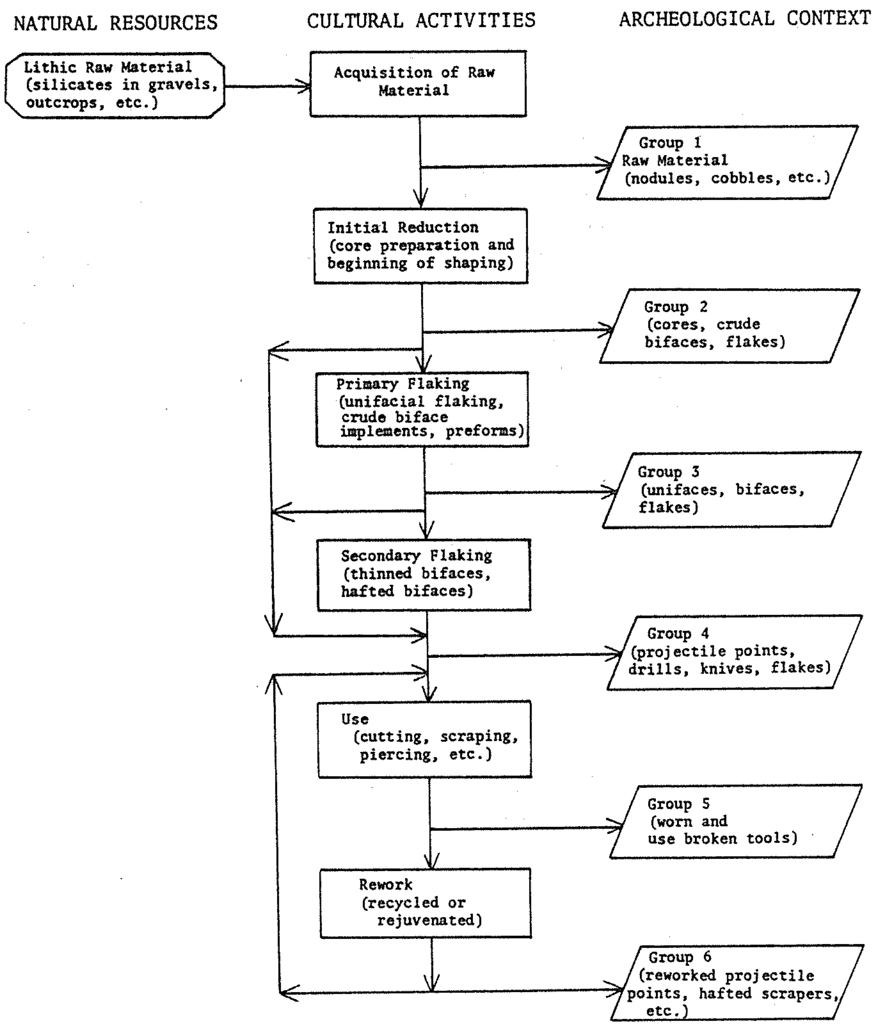

Figure 21. The lithic reduction process. (After Collins 1975.)

manufacture. Table 9 presents the relationship between the flake clusters and the product groups. Some categories, such as preforms, are general categories and are found in more than one product group. In a sense, a piece of raw material that fortuitously resembles a finished or near-finished tool is also a preform. However, for the purposes of this study a preform is a generalized bifacial form that is produced after the initiation of chipping and before the final shaping and thinning of the tool.

Some flake clusters crosscut product groups. This is due in part to the lumping nature of the clustering program; however, activities associated with different stages of chipped stone tool manufacture do produce similar flakes.

Product groups iii through vi are well represented in the collection in terms of both raw frequency and variety of flake clusters. Product group i does not usually have flakes associated with it; consequently, no clusters would be associated with it. Product group ii has only Cluster Ia assigned to it. Although 5 of the 29 attribute combinations make up this cluster, its total frequency is quite low. This may be due to three factors: (1) sampling error, (2) low production of such flakes in the normal sequence of lithic reduction, or (3) the infrequent incidence of behavior that would result in the production of flakes that form this cluster. In addition, the relative frequency of the major component of this cluster, flakes with cortical platforms or bodies, would be influenced by the nature of the raw material. Essentially identical activities by the same knappers with different materials would result in entirely different ratios of cortex- to noncortex-bearing flakes. These data indicate that the acquisition and initial reduction of cores was not a major activity on the sites surveyed.

Product group vii is not represented at all in the survey collection, since such materials would come only from excavated site contexts.

The relationship of the clusters of flake forms to the product groups is incorporated into the arrangements of the cumulative percentage graphs in Figures 25 through 31.

The flake forms are organized according to their clusters (Figure 22) which are arranged in the order of the assigned product groups. The forms associated with the earliest stage (product group ii) are at the lower end of the scale, and those associated with the final stages (product groups v and vi) are at the top. The part of the horizontal axis of the graph specific to each subcluster is shown, indicating the overlap between product groups.

Analysis and Interpretations, Standardized Data

Analyzing the same data but applying standardization by rows (sites) produces a dendrogram that is different, although it is somewhat similar (Figure 23) to the one generated without the row percentages. Three major blocks of clusters are recognizable. Cluster I consists of either very rare flake types or flakes that are best described as fragmentary, such as flakes with missing platforms. Cluster II contains a variety of flakes that tend to be thinner than the rest of the sample. Cluster III is composed of flakes similar to those in Cluster II, but thicker than average.

The organization of the standardized flake clusters could also suggest that there are two modes of flaking within the samples, in addition to a group of rare or essentially unclassifiable flake forms that have little relevance to either of the apparent activities.

Cluster I contains six flake forms, all of which are merged at a relatively high order, indicating dissimilar distributions in the sample (i.e., sites). They include both varieties of flakes with broken platforms, both examples of flakes with exuberant bulbs, and two of the three flake forms with straight double platforms. Both medium and thick forms are represented in the cluster, with indications of an internal differentiation between the two. This cluster reflects hard hammer percussion. Large bulbs of percussion and broken platforms are phenomena usually, although not exclusively, associated with hard hammers. Replicative experiments also suggest that double-faceted

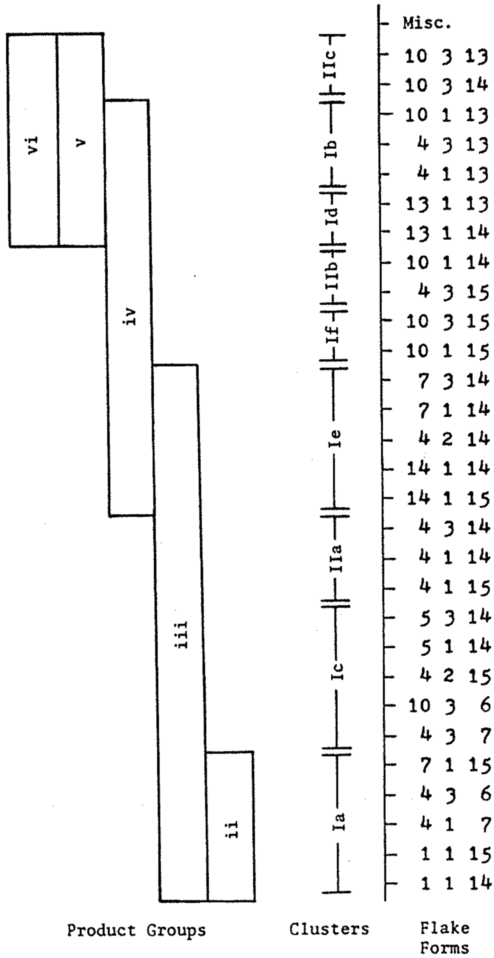

Figure 22. Flake clusters ordered by stages of reduction (product groups).

platforms are significantly stronger than simple platforms and are less likely to break, crush, or shatter when percussion flaking is applied. Significantly, no flake forms with cortical areas are included in this cluster, which suggests that these flaking activities are not related to the acquisition of raw materials or the preparation of the cores (product group i or ii). In addition, there are in this cluster no flakes with thin cross sections and complex platforms. The inference is that these flakes are the result of the primary trimming of cores (product group iii). Cluster I, the final merging accomplished in the clustering process, is distinct from the two other major clusters, suggesting that the flakes were produced at sites different from the ones where the materials were acquired and processed.

Cluster II can be subdivided into at least two subclusters. Cluster IIa comprises thin flakes with either flat or medium bulbs and either single or multifaceted platforms. Cluster IIb contains flakes with shattered platforms and a multifaceted flat flake with secondary cortex body. Six of the seven flake forms of the cluster are thin, all of the bulbs are either flat or medium, and only two of the seven forms have single-faceted platforms. Therefore, these two clusters are believed to represent the secondary trimming and final shaping of thin bifaces, probably by soft hammer percussion and possibly by pressure flaking. The occurrence of a flake form with cortex on part of its body is somewhat anomalous, although certainly not unexpectable. This form is rare in the assemblage, accounting for only 24 specimens (0.83 percent) in the total sample, and 22 specimens in the sample from sites selected for clustering. The nature of the present sample makes it impossible to explain this situation adequately.

Cluster III is subdivided into three or possibly four subclusters. Cluster IIIa consists of the six forms that occur most frequently in the typology. Two multifaceted forms merge at a low order and are then joined by four forms

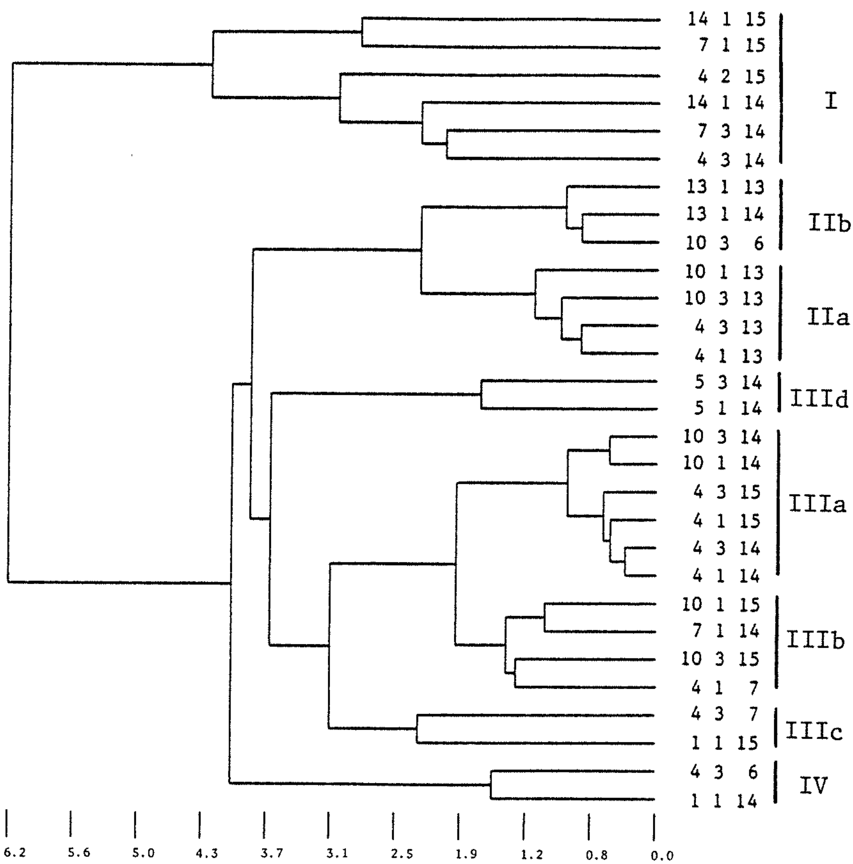

Figure 23. Flake clusters standardized by site.

with simple platforms that are also merged at a low order. Most of the body states are medium, but two are thick noncortical types. Medium and flat bulbs are evenly distributed.

Cluster IIIb is composed of four flake forms. Two are multifaceted, thick noncortical flakes, one is double-faceted medium, and one is single-faceted secondary cortical. The constituents of the subcluster are more diverse than those of IIIa and do not form as tight a cluster.

Cluster IIIc comprises only two forms, both of which are thick and have cortex either on their bodies or on their platforms, which are essentially simple and unmodified. These atributes seem to relate them to the earlier stages of either reduction.

Cluster IIId also is composed of only two forms. This subcluster contains the only flake forms with sequent platforms. They differ only in the bulb attributes, which are either flat or normal. This subcluster combines with the rest of Cluster III at a very high order. Since flakes of this subcluster represent less than 1.7 percent of the total sample, their association with the rest of the flakes in Cluster II may not be significant. The nature of the sample and its size is the source of the uncertainty.

Cluster IV is formed of only two flake forms and by default is defined as a separate cluster. It is quite distinct from the other clusters and is one of the final mergings accomplished in the hierarchical grouping. Both flake forms are rare and number more than two at only one site, HZ52, the site with the largest assemblages of chippage.

Cluster IIc can be interpreted as the result of initial reduction of cores. The thick bodies and cortical areas on the flakes are an argument for assigning this cluster to product group ii. Cluster IIIa probably relates mainly to the primary trimming of cores, with some suggestion that the forms with multifaceted platforms may be the products of secondary trimming.

Both Clusters IIa and IIb seem to be derived from activities associated with the secondary trimming processes, with a suggestion of some primary trimming related to Cluster IIb. The chippage is thin, with a preponderance of complex and shattered platforms. The trend toward flatness of the bulbs and the thin flakes suggest soft hammer percussion.

One interpretation of the pattern of clustering derived from this analysis is that there are two distinct flaking activity sets represented in the sample. Clusters I, IV, and IIIc stand essentially isolated from the rest of the clusters. They represent the earliest stages of flaking—basically core preparation and the primary shaping of the core. All of the flake forms from these clusters are relatively scarce in the sample, casting some doubt on their exact relationship to the rest of the flake forms. However, it is apparent that they do stand apart from the main constituents of Clusters II and III.

Cluster III contains subclusters that represent flaking activities from core preparation (IIIb) through primary trimming (IIIa) and possibly some secondary trimming (the multifaceted forms of IIIa). These activities may reflect the production and maintenance of unifacial and, possibly, bifacial scrapers. The dominance of thick flakes and a large proportion of straight platforms tend to confirm this interpretation. Straight platforms reasonably would be associated with uniface manufacture and maintenance. Thick flakes are more likely to occur as a result of primary trimming than secondary.

Cluster II contains flake forms in its subclusters which seem to relate most consistently to the secondary flaking and maintenance of bifacial implements. It is possible that partially finished forms were imported to sites and then finished, or that completed tools were being resharpened or recycled. This is not to suggest that these are the only activities concerning biface production that were carried out on the sites included in the sample. Since the manufacture of bifaces also included those stages necessary for the production of unifaces, it is reasonable to assume that in some cases chippage associated with Cluster III resulted from the production of bifaces as well.

The two methods of treating the flake data—standardizing or not standardizing by cases—have produced two interpretations. The first attempt at clustering without standardization generated a dendrogram that defined two major groups subdivided into nine subclusters. The composition of these subclusters coincides closely to flake forms that might be expected to occur during various stages in the process of lithic reduction.

The second attempt at clustering utilized the option to standardize the data by case. This meant that the clustering of flakes would be less sensitive to the number of flakes in each case. This clustering produced a dendrogram with three major clusters and one minor cluster. The three major clusters were subdivided into eight subclusters, which have been interpreted as representing two different varieties of flaking: one oriented toward the manufacture of unifaces, the other toward the manufacture and maintenance of bifacial implements.

Hierarchical Clustering of Sites

The application of hierarchical clustering techniques in order to delineate the clusters of sites that are most alike on the basis of their flake assemblages uses the same data and methodology but inverts the data matrix so as to render the sites as cases and the flake forms as variables.

Analysis and Interpretations, Cases Not Standardized

The cluster analysis of sites, derived from the flake data, used options for both standardizing and not standardizing the cases (sites). Cluster analysis using the data nonstandardized by case yielded inconclusive results, since the dendrogram that was generated simply merged sites on the basis of their sample size only. For the purpose of interpreting the site clusters, the standardized data is considered to be more appropriate.

Analysis and Interpretations, Cases Standardized

The dendrogram for the site clustering analysis of standardized cases reveals four major divisions, which have been termed Clusters I, II, III, and IV (Figure 24). Several of the subclusters within the major divisions are the result of the pairing of two sites with small sample sizes, usually 40 or fewer flakes. Although these subclusters may represent actual patterns within the overall scheme, their small sample size casts doubt on their validity. More confidence can be placed in clusters with more than two sites, or with sites that have a significantly larger number of flakes.

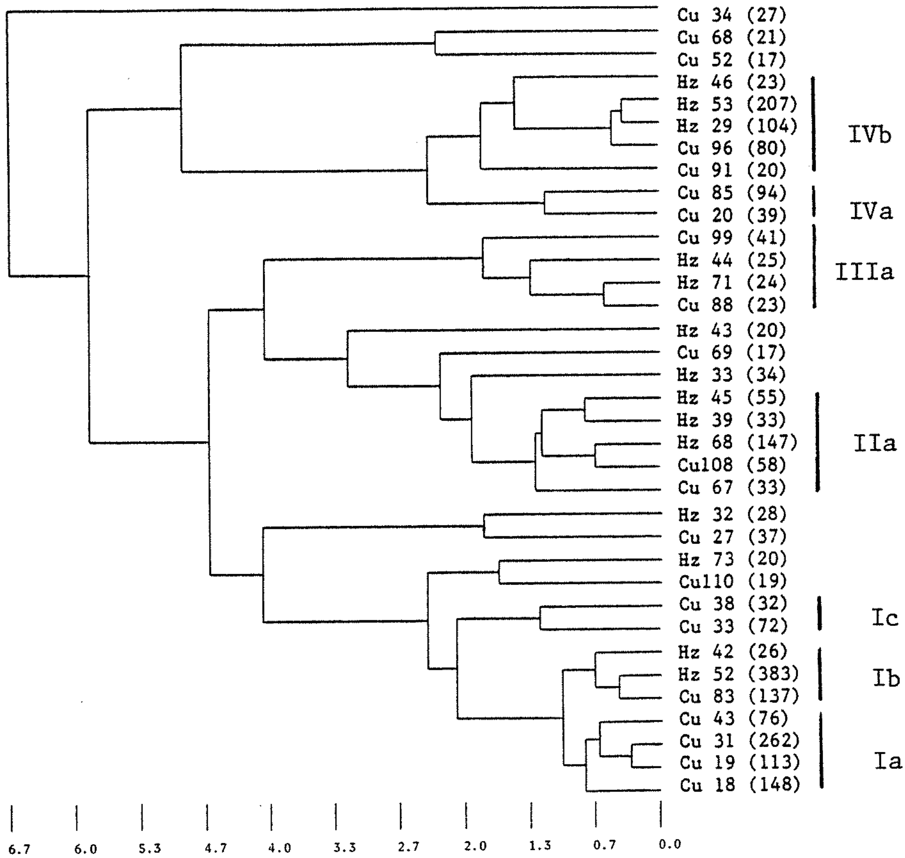

Figure 24. Clusters standardized by flake forms.

Before discussing the result of the clustering analysis, it should be noted that CU34 is unique in that of the 27 flakes that could be analyzed fewer than 30 percent corresponded to one of the 29 flake forms chosen for further analysis. Significantly, all but 8 of the 27 flakes had cortex on their bodies or platforms, and of these 8, 5 were classed as either thick or angular in body thickness. The initial stages of lithic reduction were carried out here, probably by hard hammer percussion.

Seven subclusters were selected for interpretation, three from Cluster I, two from Cluster IV, and one each from Clusters II and III. In the discussion that follows, each cluster is accompanied by a site location map and a cumulative percentage line graph that shows the percentage of each flake form for each site in the cluster.

It should be noted that the cumulative percentage graphs in Figures 25 through 31 differ from the one in Figure 19 in the order in which the flakes are listed. Figure 19 reflects clustering without standardization of the flake frequencies; however, the clustering of sites based upon their flake assemblages incorporates standardization of the flake frequencies. Consequently, the cumulative percentage graphs use the clustering of flake forms standardized by case (flake forms), as shown in Figure 23.

Cluster Ia (Figure 25) is made up of four sites, with sample sizes ranging between 76 and 262. Flakes with straight platforms account for a large part of the variation in this group; only a few flakes have complex, shattered, or broken platforms. Flakes with cortex are relatively abundant when compared to other clusters. This cluster has no temporal significance, as all ceramic periods are represented; however, only one sherd was found at CU43, casting doubt on the assignment of a ceramic date to that site. All of the sites are fairly large; two (CU31 and CU43) are near springs and the other two are in an area where there are many other sites. Product group ii and iii flakes are very well represented, and the absence of product group iv and v flakes suggests that unifaces were being produced in considerable numbers. If this is the case, it is likely—assuming that the unifaces were used as scrapers in domestic situations—that Cluster Ia represents a group of sites where domestic activity was the dominant behavior. Unifaces and hearths are common, especially at CU18 and CU19.

Cluster Ib (Figure 26) is in many respects similar to Cluster Ia. Three sites compose this cluster, and the sizes of the flake samples range between 26 and 383. It is questionable that the smallest site, HZ42, should be included, due to the possibility of chance or sampling error. Like Cluster Ia, the collections from the other sites are fairly large, and these sites were called campsites by the field crews. HZ52 is a well-dated early ceramic site, and the other sites,

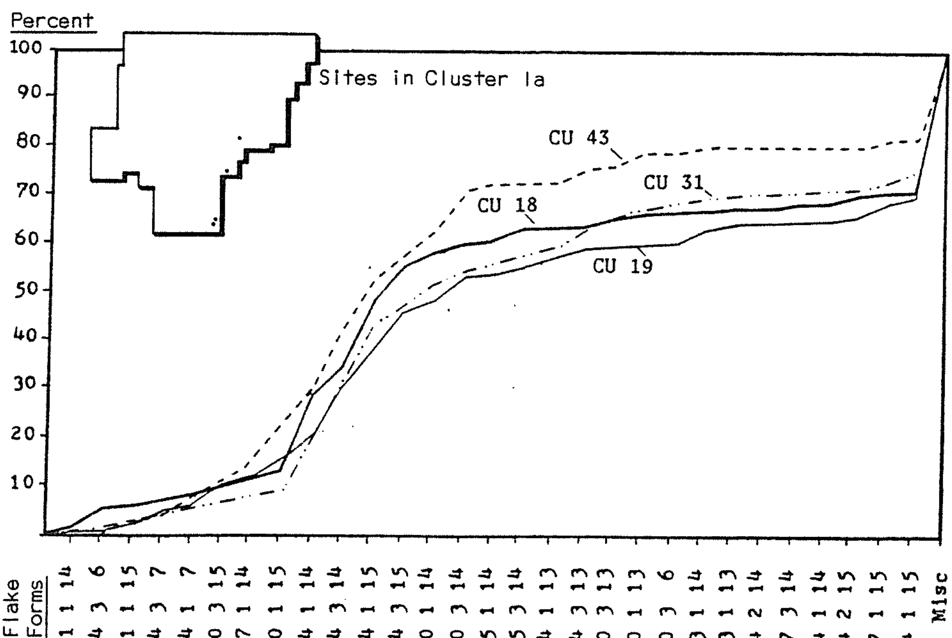

Figure 25. Flake forms in Cluster Ia.

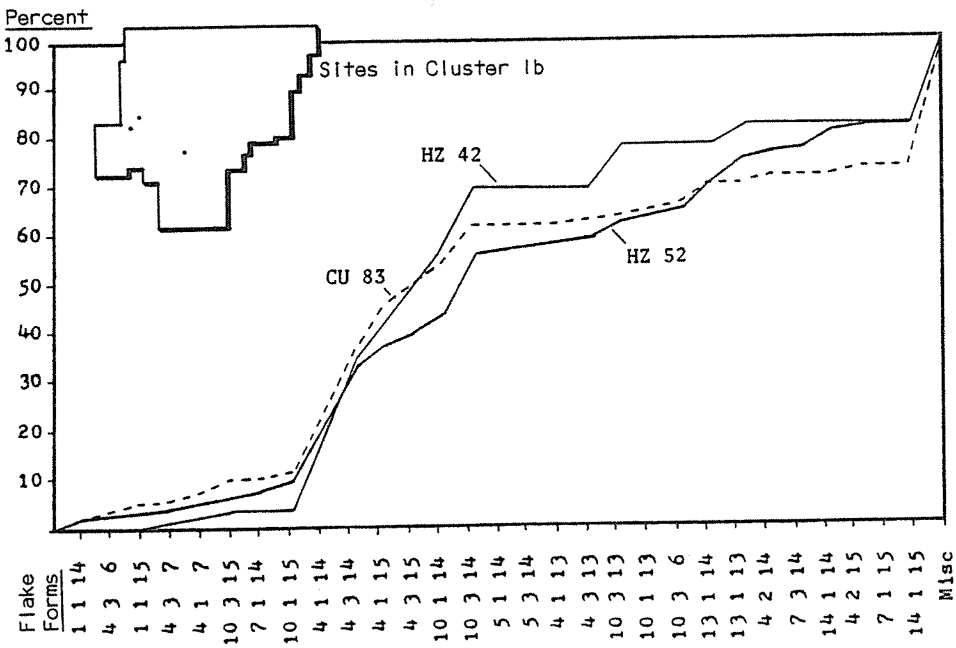

Figure 26. Frequency of flake forms in Cluster Ib.

HZ42 and CU83, are aceramic, suggesting a late preceramic to early ceramic period occupation. The difference between these sites and Cluster Ia is the larger proportion of bifacial retouching flakes (flake Cluster IIc). Although there are indications of a slightly larger component of product group iv flakes (flake Cluster IIb), flakes with straight platforms predominate. The evidence indicates that there was some manufacture of bifacial implements here and, at least at sites HZ52 and CU83, probable manufacture of a considerable number of unifaces.

Cluster Ic (Figure 27) also is similar to the other subclusters, although sites CU33 and CU38 yielded only 72 and 32 flakes, respectively. Much of the materials from these sites, including the chippage, was limestone, which may account in part for the configuration of the curves. The margin of difference between this cluster and Clusters Ia and Ib results from the smaller proportion of straight-platformed flakes. In part, the difference is made by flakes with cortex and, at CU38, a larger number of bifacial trimming flakes. Because there are only two sites in this cluster, they are difficult to assess. Since no ceramics are present at either site, they may have been preceramic occupations or peripheral occupations by later peoples. The flaking technique suggested for these sites relates most strongly to the earlier stages of implement manufacture, for at only one of the sites (and there probably only one item) was there a possibility of some final reduction.

Five of the eight sites in Cluster II form a subcluster that is suitable for interpretation (Figure 28). The sample size in Cluster IIa varies from 33 to 68,

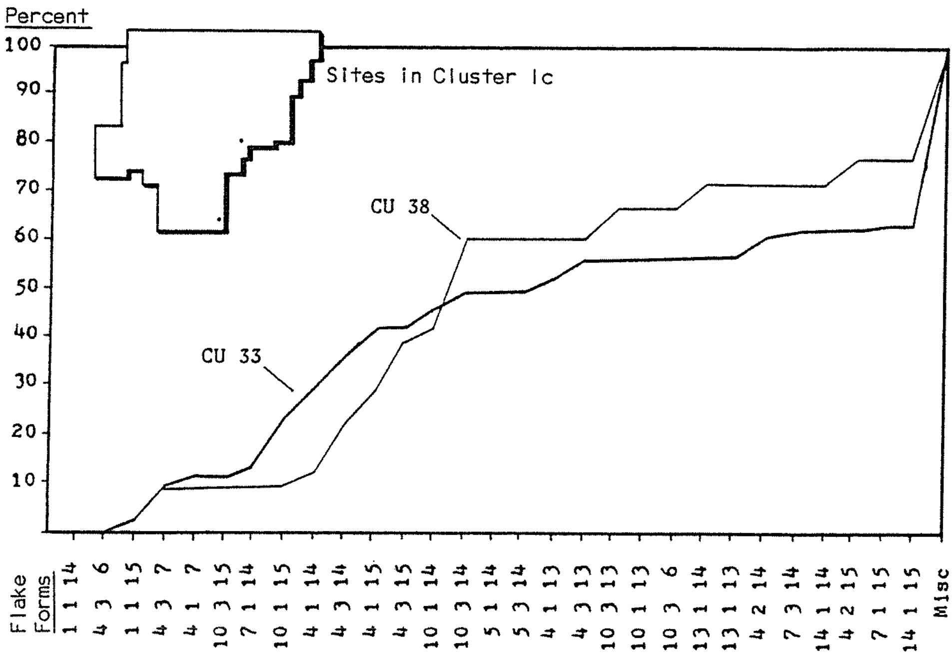

Figure 27. Frequency of flake forms in Cluster Ic.

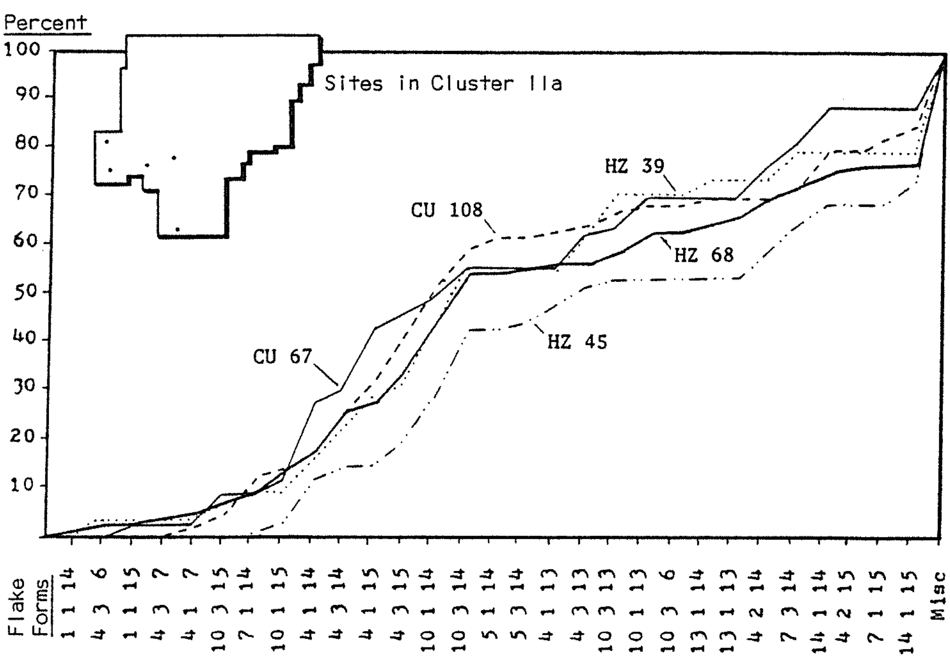

Figure 28. Frequency of flake forms in Cluster IIa.

indicating that the sites have little chippage. The curves in the cluster all reveal the same trend; a very low percentage of flakes associated with product groups ii and iii, but fairly high and consistent percentages of flakes associated with product groups iv, v, and vi. The activity suggested here is the processing of bifaces that have been started at another place. The evidence is clear that the later stages of implement (probably bifaces) manufacture were carried out at these sites. There does not seem to be any temporal loading to this cluster, since two sites are ceramic, two are early ceramic, and one is late ceramic.

If Cluster II represents later stages of lithic reduction, then Cluster III certainly represents earlier stages (Figure 29). Product group iii flakes, especially flake Cluster Ia, account for the bulk of the flakes. The manufacture of unifaces seems to have been the prime activity at the sites in Cluster III, since evidence for further artifact reduction is lacking. Too, there are very few flakes with cortical areas, implying that initial reduction of cores was not being done in any quantity.

Cluster IV contains two subclusters suitable for interpretation. Cluster IVa has two sites, CU20 with 39 flakes and CU85 with 94 flakes (Figure 30), but there is little apparent similarity between the sites. Site CU20 has a much larger percentage of flakes with shattered platforms and with straight platforms than does CU85. Sites CU20 and CU85 are, however, more similar in their proportion of Cluster IIIc flakes. This seems to be a poor cluster and may be an indication of inadequacies in the clustering program and the data base.

Cluster IVb appears to be more cohesive than IVa (Figure 31). Three sites, CU96, HZ29, and HZ53, compose the core of the cluster. Two other sites with much smaller sample sizes (20 flakes each) were tentatively added to the cluster. Their curves resemble those of the core sites, although they run above and below the larger sites. Sample size is again a problem. The interpretations of this subcluster apply primarily to the larger sites, and may or may not apply to the other two. In many respects Cluster IVb resembles Cluster IIb, with a high proportion of final shaping flakes and a fair number of intermediate flakes, but there is a decided scarcity of flakes with broken platforms and a higher proportion of Cluster IIIc flakes. The flaking was apparently more successful at the Cluster IVb sites than at the IIb sites. Two of the sites are aceramic (CU91 and CU96), two (HZ46 and HZ53) have intermediate period ceramics, and one (HZ29) has early period ceramics. Thus there is no obvious temporal loading in this cluster.

Summary of Site Clustering

The cluster analysis of the sites with at least a fair representation of chippage provides some interesting insights into stone tool manufacture in the southern Guadalupes. No particular patterns were related to temporal manifestations; indeed, many of the activities that produce chipped stone implements occur in all time periods, thus masking any sensitive indicators. Knappers had to meet and solve a variety of problems with a limited number of solutions, and it is not surprising that many of the same methods were used over long periods of time.

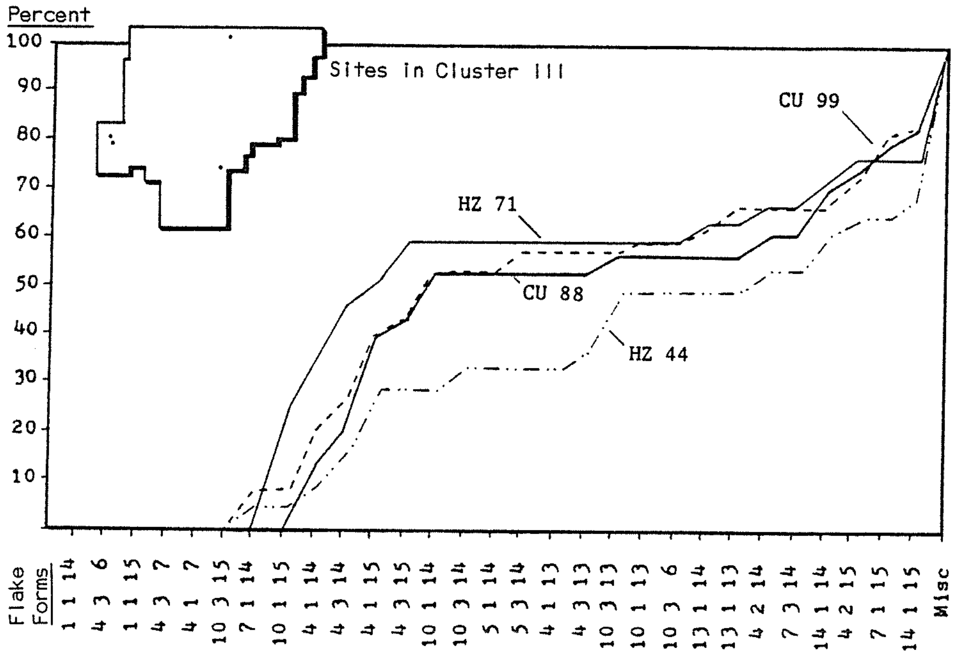

Figure 29. Frequency of flake forms in Cluster III.

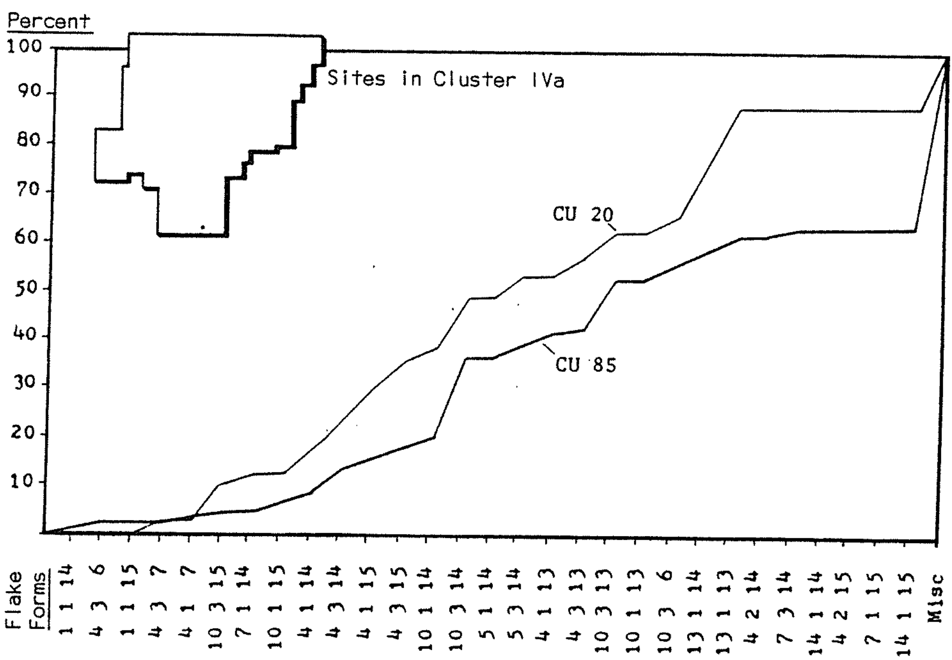

Figure 30. Frequency of flake forms in Cluster IVa.

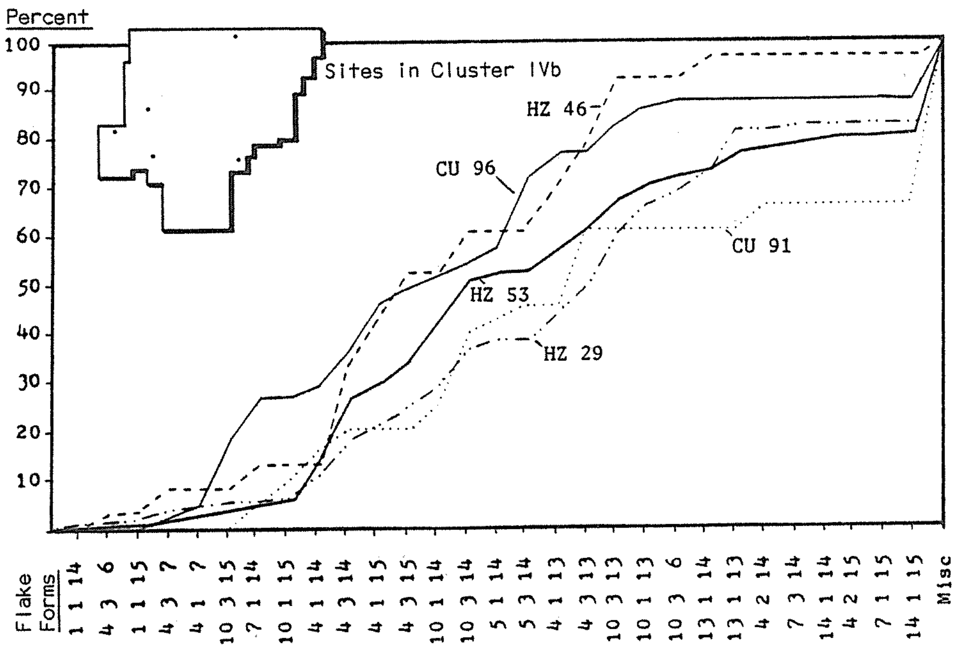

Figure 31. Frequency of flake forms in Cluster IVb.

The clustering analysis does successfully isolate sites at which similar stages of lithic reduction were carried out. Cluster Ib is the closest representation of start-to-finish bifacial implement manufacture. Cluster Ia is similar, but there was probably less final biface trimming. At the sites that constitute Clusters IIa and IVb we find the processing of implements that seem to have been brought to the site in partially finished form. Artifacts with primary trimming or shaping were produced at sites of Cluster III. Whether these artifacts were unifaces or only a stage in the production of bifaces is uncertain.

Biface Fragment Analysis

The second largest category of artifacts in the typology is biface fragments. As the name implies, these are pieces of bifaces that lack diagnostic features assignable to one of the more specific categories.

The Data

The data for this aspect of the study are drawn from the tabulation of nearly 400 bifaces and biface fragments collected by the TAS survey. As part of the initial sorting of the artifacts into the typological categories, the biface fragments and bifaces that were identified as discards during manufacture were set aside for separate analysis. Biface fragments, except for those that were heat damaged, were divided into two basic types: those with transverse fractures, which presumably occurred during manufacture and caused the biface to split transversely along the cross section; and those with snap fractures, which are clean breaks and give no hint of origin.

Eleven criteria for assessing the nature and degree of biface breakage and/or discard were chosen for analysis. Although these criteria do not encompass all possible kinds of chipping errors or problems, they are the ones that occur frequently in replicative experiments and in the archeological record (Collins 1975) and can be identified without elaborate and costly laboratory facilities. All of the features described below could be detected macroscopically or with the aid of a hand lens. Described below are the most frequently encountered causes of broken bifaces.

Heat Damage

Heating can cause a change in the flaking quality of a piece of chert. This is often desirable, but extreme heat causes a considerable amount of damage and breakage. Heat can produce small round spalls, commonly called potlids, on the surface of an artifact and can change the internal structure of the material, causing it to lose its smooth conchoidal fracture and to break irregularly with granular texture. In addition, excessive heating may cause the artifact simply to shatter, presumably along preexisting flaws or stress planes. Often the fracture surfaces on heat-damaged artifacts are indistinguishable from snap fractures, and the heat-damaged pieces are recognizable only from potlids or granular fracture surfaces.

Transverse Fracture

A break that can be identified as the result of an ill-delivered blow to the artifact during manufacture is called a transverse fracture. Either singly or in combinations, a bulb of percussion, ripple marks, or radial shatter lines will occur on some bifaces that have been broken during manufacture. The term manufacturing break is avoided here because experimental knapping indicates that breakage during manufacture does not necessarily produce recognizable attributes on the fracture plane of the broken biface. To use such a term would suggest that all manufacturing breaks can be recognized.

Snap Fracture

A smooth, clean break across the midsection of a biface is termed a snap fracture. The origin of such a break can be manufacturing, usage, or accidental causes (such as dropping or trampling), and in most cases cannot be determined. Occasionally such a fracture will have a lip or hinge on one of the broad surfaces of the biface, usually along the medial axis, indicating that the force causing the breakage was delivered from the opposite face of the artifact directly through the smallest dimension of the piece. It is unlikely that such a blow would be delivered during manufacture.

Overshot Fracture

A biface can be ruined by an overshot fracture: the removal of a flake that extends across the breadth of the biface, over the opposing edge, resulting in a flake with remnants of the bifacial edge on both the striking-platform and terminal ends. In some cases an overshot fracture results in the breakage of the artifacts, and in others, an overreduction of thickness and width so that the artifact is useless. In still other cases the artifact can be salvaged and further processed. Overshot flaking differs from transverse flaking in that the striking platform, location of bulb, ripple marks, and radial shatter lines occur in the plane defined by the intersection of the length and breadth of the artifact (that is, across the face) rather than on the cross section of the artifact (or perpendicular to the face).

Edge Collapse

If an overshot fault in flaking can be considered an overly successful attempt to remove a flake, edge collapse can be considered its reverse. An edge collapse flake is one that is composed essentially of a platform area only, with no appreciable length to its body. The effect of a single edge collapse on a biface is a noticeable notch in the edge.

Hinge Fracture

A hinge fracture is a common error or problem in flaking. A hinge fracture flake differs from a normal flake only in that the end of the flake opposite the striking platform terminates in a smooth edge, which rolls back onto the exterior surface of the flake, rather than in a sharp or feathered edge. The result on the parent piece is a concavity or lip in the medial area of the artifact's surface (Crabtree 1972:68). The effect of this flaking error varies greatly, depending upon its size and placement, and a hinge fracture can be of little concern to the knapper. Hinge fractures can be found on finished artifacts that are apparently perfect in shape and outline.

Knot

A knot is a lump of unremoved material that has been left on the surface of a biface by several hinge fractures originating from different directions, all terminating in one spot. Thus a knot is not one flaking error, but is the end product of several flaking errors—unsuccessful attempts to remove material from the surface of the biface. Knots normally occur in the medial part of a biface, but they can occur near the edges.

Edge Crushing

Edge crushing, as the term implies, occurs when, rather than successfully removing a flake from the surface of a biface, the knapper crushes or shatters the platform area, effectively blunting the edge and reducing the width of the artifact without succeeding in reducing the thickness.

Flaw

Flaws result from circumstances that are often beyond the control of the knapper. Very few cryptocrystalline materials are without impurities, fossil inclusions, or fracture planes either preexistant or the by-products of previously delivered blows to the stone. Otherwise well-struck blows can result in the breakage of the entire piece at the point of the flaw. Occasionally a flaw plane can be detected by a slight patina where it has weathered when a thin fissure existed for some time. In such an instance the knapper might recognize the flaw and abandon the project.

Unsuccessful Shaping

This problem faces all knappers, especially those who are inexperienced and inept. Often the best efforts of the knapper fail to shape or thin the artifact successfully, leaving it an irregular, unshaped mass. Usually such pieces will have other errors. Failure to remove a knot is a relatively rare but recognizable case of unsuccessful shaping. It is difficult at best to determine that a piece is improperly shaped, because the analyst can hardly judge what was in the mind of the prehistoric tool maker.

Methodology

A total of 386 bifacial artifacts, including all the biface fragments and bifaces identified as being unsuccessfully shaped, were examined for the presence or absence of various flaking problems, and these data were recorded for each artifact (Table 10). The flaking errors were subdivided according to the kinds of fractures, and the distribution of the unsuccessfully shaped and discarded or aborted bifaces was tabulated. The number of recorded problems for each category naturally exceeds the number of artifacts in the category, since there is often more than one flaking problem on an artifact. In addition, the number of artifacts exhibiting only fractures and no other flaking problems is also presented. For purposes of comparison, the figures for each cell in the display have been standardized by computing the raw percentage of occurrence of the flaking problem.

Overshot failures were not put into the same category as transverse fractures because they are not morphologically the same as transverse fractures. However, they are a variety of manufacturing break, and, since they are included among the broken bifaces, they are incorporated into this part of the study.

Results and Interpretations

The distribution of the various kinds of flaking problems reveals certain patterns that may be significant in the interpretation of lithic technology in the southern Guadalupes. The category defined as abortion has the highest proportion of knapping errors and problems. Unsuccessful shaping (on 44 percent) and edge collapse (on 43 percent) are two of the most frequent problems occurring on the aborted specimens. Hinge fracturing (on 39 percent) and edge crushing (on 27 percent) are also quite common. Knots are relatively rare, but they occur more than four times as frequently on aborted bifaces as on fractured bifaces of either type. The unsuccessful flaking category is an end result of combinations of other flaking errors, especially edge collapse, hinge fractures, knots, and edge crushing, and as such it is not a truly independent variable. Knots in particular are produced by a variety of flaking errors. Furthermore, continued edge collapsing, hinge fracturing, and edge crushing make bifaces increasingly difficult to flake effectively. Flaws are relatively rare in aborted bifaces.

Aborted bifaces are most likely to have both a variety and a high frequency of flaking errors, which illustrate in large part the major reasons for discard. They were inappropriately shaped for either further flaking or use.

Table 10. Distribution of Flaking Problems

Flaking Problem	Kind of Fracture																Total No. of Speci-mens
	Overshot		Edge Collapse		Hinge Fracture		Knot		Edge Crushing		Flaw		Unsuccessful Shaping		Fracture Only		
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	
Heat damage			2	18	3	33									5	55	9
Transverse fracture			8	13	22	35	1	2	6	10	4	8	14	22	12	20	59
Snap fracture			32	12	65	26	3	1	30	12	24	6	42	16	114	45	251
Aborted biface	16	24	29	43	26	39	6	9	18	27	3*	4	30	44	NA	NA	67
TOTAL	16	4	71	18	116	30	10	2	54	14	31	8	76	20	131	34	386

*Visible in specimen, but not constituting a fracture.

The snap and transverse biface fragments have both similarities and differences. In some categories, the percentages of flaking errors are close, if not virtually equal. Edge collapse and edge crushing differ by 2 percent or less when transverse and snap fractures are compared. The frequency of knots is very low—only four in 310 fragmentary specimens—and the significance of the similarity or difference is questionable. The same is also true of flaws. However, hinge fracturing and unsuccessful shaping do appear to vary significantly. Hinge fractures occur on 35 percent of the transverse biface fragments and on 26 percent of the snap fractures. In addition, 22 percent of the transverse fracture bifaces and 16 percent of the snap fractures were defined as unsuccessfully shaped. Thus artifacts that were broken, presumably during manufacture, seem to have more problems with hinge fracturing and, as a result, a somewhat higher frequency of unsuccessful shaping. The further fracturing of the bifaces may have resulted from unsuccessful attempts to correct the problems arising from the hinge fractures and unsuccessful shaping of the artifact.

The most significant variable found in comparing the transverse and snap fractures is the frequency of specimens with no apparent errors or problems other than the fracture. Only 20 percent of the transverse fractures fall into this category, but the fracture is the only problem in 46 percent of the snap fractures. This indicates that there is significant difference between the two groups in distribution of flaking problems.

The most probable explanation is that the snap fracture category includes not only the completed and perfect, or nearly perfect, bifaces that have been snapped by lateral stress, but also bifaces broken during manufacture, which do not have the characteristic attributes of transverse fractures. This would result in an assemblage of artifacts with similar kinds of fracture planes across their midsections and a distribution of flaking problems suggestive of both well-flaked and finished forms broken after completion of flaking, and forms broken during manufacture. Replicative experiments demonstrate that bifaces broken in manufacture can have the attributes of snap fracture.

Analysis of the biface fragments and aborted bifaces from the southern Guadalupe Mountains and adjacent desert has revealed a patterned distribution of flaking errors and problems. Biface fragments with transverse fractures had a higher frequency of flaking problems, with hinge fractures and unsuccessful shaping particularly common, than did the snap fractured bifaces. Aborted bifaces, as expected, also had a high frequency of flaking problems. This overall pattern suggests that there may be even more patterning of flaking errors that might be recognized in larger collections and in collections with better contextual information. These patterns could be related to the kinds of material used, intended form of the artifacts, or the knapping tradition used by the tool maker.

Summary and Conclusions

Within the limits of accuracy of the interpretations of the flake clusters set forth above, it is possible to isolate some specific activities that went on at sites in the survey area. It is apparent that the process of manufacturing chipped stone tools, particularly bifaces, was not continuous. Segments of the process are evident at different sites. More comprehensive studies of the region may reveal patterns of chippage distribution that suggest movement among the sites.

In addition, it is possible to isolate stages in the reductive process. Replicative experiments can generate data concerning knapping behavior and tangible by-products that are applicable to the archeological data base, with tremendous implications for the study of lithic technology and archeology. We can now isolate with some precision certain activities relating to the manufacture of chipped stone tools. Since it is rare that chippage debris is transported great distance from the point of production, we can pinpoint the locations of these activities. Analysis of chippage debris, in conjunction with other archeological data, greatly increases the potential for describing and, it is hoped, explaining the mechanisms of stone knapping behavior.

Two conclusions can be reached from this study of biface fragments and aborted bifaces. First, the categorization of the three basic groups, snap fractures, transverse fractures, and aborted bifaces, is accurate and meaningful. Aborted bifaces have a very high percentage of flaking problems, which seem to combine to make the bifaces either unworkable or unusable. Second, there is a difference between the transverse and snap fractured bifaces, not so much in the relative percentage of flaking problems observed as in their distribution.

THE IMPLEMENTS

Methodology

The objective of this section is to isolate meaningful groups of artifacts, with the goal of defining both their functional and temporal significance. To do this, the HCLUS clustering program was again used, but the ever-present problem of differential sample size was compounded by the fact that many artifact types were rare, and missing data were quite common, even on sites with large artifact assemblages. Consequently, the cluster analysis of this data has met with only limited success.

The Data

The data input consisted of implement frequencies from the sites surveyed by the TAS. In many cases the site inventories were extremely small or nonexistent, especially when the debitage and preforms were removed. An arbitrary cutoff of seven artifacts was established, and sites with biased samples, as determined by the same criteria used for the sites in the debitage analysis, were withdrawn. The correspondence between the two groups of sites is close, with a few additional sites unique to each analysis. (Artifact frequencies for all sites are tabulated in Boisvert 1980:Appendix 2.)

Analysis and Interpretation, the Artifacts

The artifact clusters were generated (Figures 32 and 33) both with and without standardizing each case (artifact class). In all runs, each variable (site) was standardized. Standardization in both situations was accomplished by

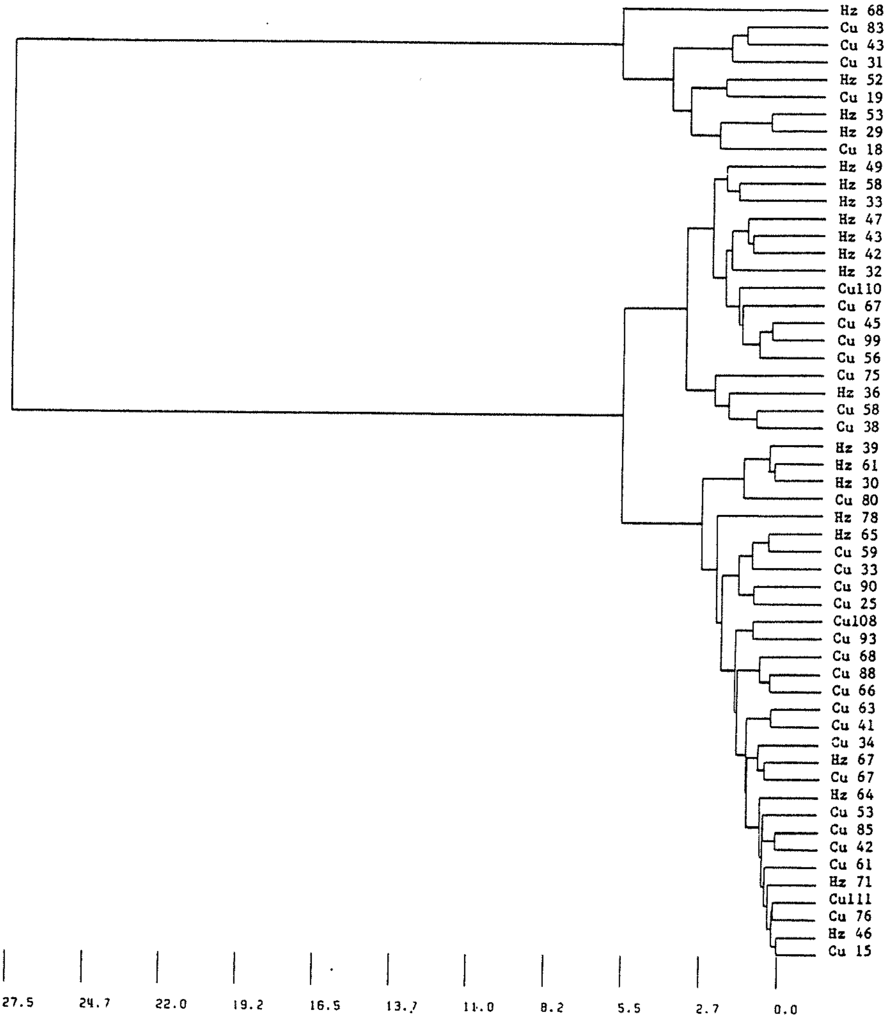

Figure 32. Site clusters standardized by artifact type.

expressing the distribution of artifacts in terms of their (relative) percentages by column or row (variable or case).

The clustering of artifacts was not much altered by the standardization of cases, although some improvement of cluster definition was apparent. The basic problem evident in both versions of HCLUS with this data set was the many instances of missing data. The artifact cluster based upon raw frequency shows an unmistakable skew toward artifact classes with larger frequencies (especially implement fragments and some types of unifaces). Some redefinition was achieved by standardizing the size of the artifact classes, but the same basic patterns prevailed.

Figure 33. Site clusters, not standardized by artifact type.

Some of the lower order mergings remained the same. Type I unifaces merged with ovate bifaces: Types IVb and IVc unifaces retained their close association, as did marginal bifaces and convex manos. Two projectile styles, Types 8 and 9, continued to show a close association. This is most interesting, since both fall into Johnson's Group H points.

One cluster seems to be especially significant, the grouping of battered stone, flat manos, tabular limestone bifaces, and metate fragments. This cluster may represent an activity set or a functionally related group of implements. The mano and metate indicate plant grinding activity, but the function of the tabular limestone bifaces is conjectural. The battered stones

Table 11. Artifact Distribution, Cluster I

Site	Life Zone	Ceramic Age	Battered Stone	Flat Mano	Tabular Limestone Biface	Metate Fragments
CU15	LS	L			1	
CU18	LS	E	3	1	4	4
CU19	LS	I	2	1	2	
CU27	LS	-			2	
CU29	LS	-			2	
CU53	US	-			1	
CU60	LS	-		1		
CU61	LS	-	1	1	2	
CU68	US	-		1		
CU69	LS	-		1		
CU75	LS	I			1	
CU80	T	-		1		
CU84*	US	E		1		
CU85	LS	I				1
CU96	US	-		4		
CU99	US	I		1		
CU108	LS	E	1	1		
HZ29	LS	E	1		1	
HZ33	LS	L	3	3		
HZ41*	LS	I	1	1		
HZ43	LS	E/L	1			1
HZ44*	LS	L	2	1		
HZ46	LS	I			1	1
HZ49	LS	E/L	2	1	1	8
HZ52	LS	E		1		
HZ53	LS	I	2			1
HZ64	LS	I	1			
HZ67*	LS	L		1		
HZ68	LS	L	2	5	9	4
HZ73*	LS	I	1	1		
HZ77	LS	E		1		
HZ78	LS	E	1	2		

*Overall sample size too small for inclusion in clustering analysis.

LS = Lower Sonoran
US = Upper Sonoran
T = Transitional

\- = Aceramic
E = Early
I = Intermediate
L = Late

may have been used to pound foodstuffs or to pound leaves for fibers, or they may have been used to produce the tabular limestone bifaces.

There is also a significant distribution of sites with artifacts from this cluster in terms of their spatial distribution. Table 11 lists the sites on which were found one or more artifacts from the cluster. Figure 34 shows their distribution within the park. Of the 32 sites, 26 are in the Lower Sonoran arid division of the lower Austral life zone; 5 are in the Upper Sonoran, and 1 is in the Transition zone. One site, CU68, is at the lower edge of the Upper

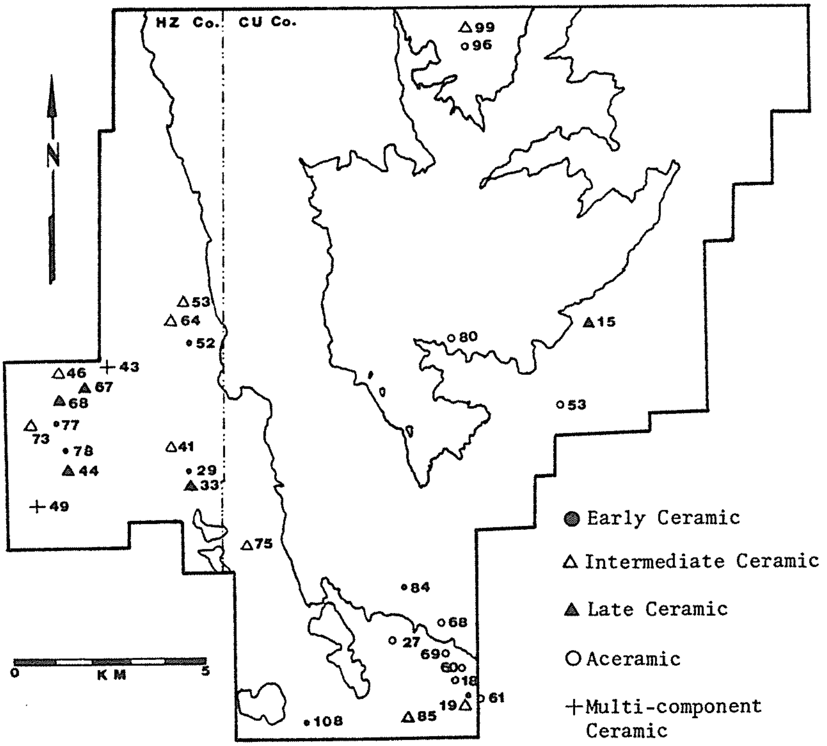

Figure 34. Map of Guadalupe Mountains National Park showing distribution of sites with one or more battered stone, tabular limestone biface, flat mano, and metate fragment.

Sonoran life zone and could conceivably be included in the Lower. The boundary definition of these zones is arbitrarily tied to elevations and fluctuates somewhat. If this association of the artifact cluster is indeed related to the processing of plants, this correlation with the Lower Sonoran zone suggests that this is an area where such plants could be found.

There are also indications of temporal significance for this cluster. Using the presence or absence of ceramics on these sites and the probable age of the ceramic assemblages with reasonable numbers of potsherds, a fairly late date is inferred for the artifacts (Table 11). There is a definite loading for intermediate and late ceramic sites. Other typologically late artifacts are found in loose association with this group. All five sites where Livermore projectile points were found also contain artifacts from the cluster. The frequency of projectile points in the Guadalupes is low (due in part to the activities of relic collectors), making it unlikely that they would cluster with many other artifacts.

The flat manos, metates, tabular limestone bifaces, and battered stones seem to represent tool kits or activity sets used fairly late in the prehistoric occupation of the Guadalupe Mountains. They were found predominantly on the south and west flanks of the mountains in the Lower Sonoran zone. If they were associated with the exploitation of plants from this zone, identification of the plants should shed light on some aspects of subsistence and possibly settlement patterns.

A closer look at the other distinctive clusters in the dendrograms makes it clear that they are made up of the most ubiquitous and least typologically specialized artifacts in the collections. This is most evident in the cluster produced through standardization by case. Here all of the implement fragments—the two kinds of biface fragments and uniface fragments—are clustered together, and the three most frequent uniface types (IVa, V, and VI) are also clustered together. These artifact forms are widespread both in time and space, so no temporal significance can be attached to them.

Analysis and Interpretations, the Site Clustering

The attempt to cluster the sites in terms of their artifact assemblages was disappointing. The dendrograms in Figures 35 and 36 were generated using

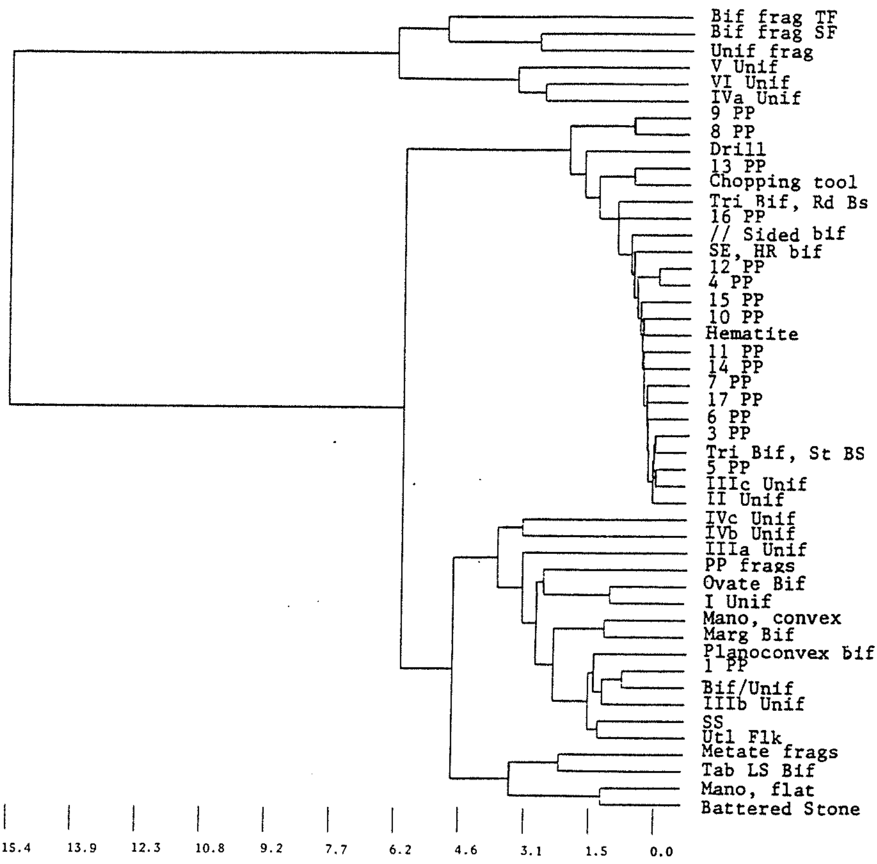

Figure 35. Artifact clusters standardized by sites.

both standardized and nonstandardized data and reveal a significant skewing, which can be attributed to sample sizes. The eight sites with the largest inventories (CU18, CU19, CU31, CU43, CU83, CU96, HZ52, and HZ68) are grouped together in both dendrograms. All of the other sites merge at a very low order, due to the common lack of artifacts in most categories.

There is one subcluster consisting of the essentially aceramic sites CU31, CU43, and CU83 (Figure 37) that might have some significance. The sites have proportionately large numbers of unifaces, especially Type V unifaces. Sites CU31 and CU43 have ring middens, and the debitage analysis indicates that CU83 is a lithic workshop.

These three sites may represent primarily Archaic occupations in the southern Guadalupes. Types 7, 8, and 9 projectile points, which resemble Johnson's Type H Archaic points, and a Meserve point were found at CU31, and Type 10 (Shumla point) was found at CU43. These sites are also near

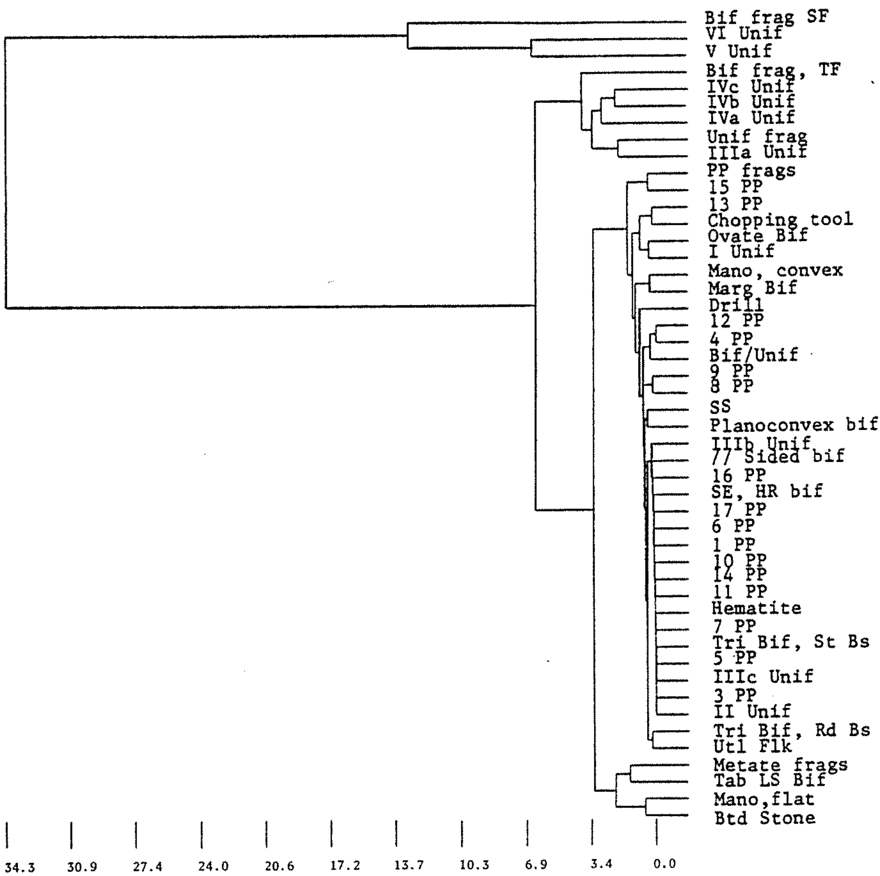

Figure 36. Artifact clusters, not standardized by site.

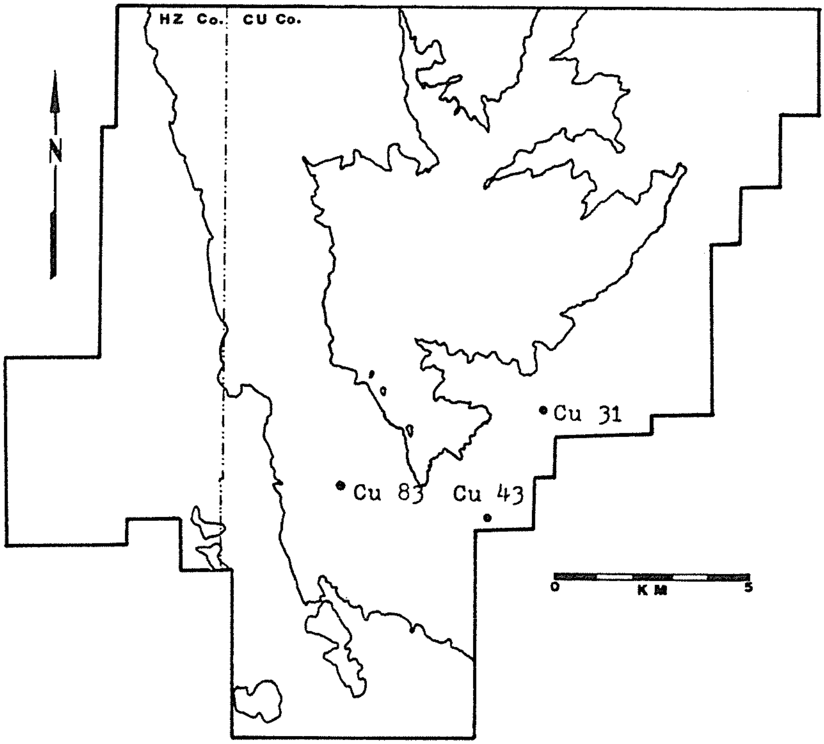

Figure 37. Map of Guadalupe Mountains National Park showing probable Archaic intensively utilized sites.

three of the largest springs in the park: Guadalupe (CU43), Pine (CU31), and Bone springs (CU83). If they were habitation sites that were used repeatedly, that would explain the high proportion of unifaces if the unifaces were assumed to be scrapers associated with domestic activities.

The results of the implement analysis are not as extensive as are the results of the debitage analysis, but one possible activity set that may have temporal and spatial significance has been tentatively isolated. In addition, one small group of sites that may be Archaic base camps has been tentatively defined. However, the goal of isolating well-defined clusters of sites that cover a spectrum of temporal and spatial variation has not been attained, mainly because the methodology applied was not compatible with the data at hand. The sample (case) sizes were too small to produce meaningful clusters, and it is unlikely that additional manipulation of the data by combining artifact categories and increasing minimum sample size would result in any significant improvement. The collection acquired by the TAS survey is not large enough to permit a comprehensive understanding of the cultural and historical sequence in Guadalupe Mountains National Park.

CONCLUSIONS

The analysis of the lithic assemblages recovered by the TAS survey in Guadalupe Mountains National Park was aimed at determining what lithic technologies were practiced there and interpreting their meaning in terms of the culture history of that region. Although it has not been possible to wring this information from the data with the research methods at hand, several conclusions can be drawn.

The best-quality materials, that is, the fine-grained silicates such as chert, were most frequently used to produce morphologically complex bifaces, especially projectile points and drills. These materials were also used for other artifacts, but less frequently.

The local limestones are ubiquitous in the park and may have some degree of conchoidal fracture. They were used primarily for simple tools by the prehistoric inhabitants. The bulk of the limestone artifacts were unifacial forms, presumably scrapers, and indeed some limestone flakes that were used for resharpening unifaces have been identified in the collection. Among the bifaces produced from limestone were the morphologically unique, if not overly complex, tabular limestone bifaces. When they are found unbroken they are relatively large and subtriangular.

Cherty limestone occupies a curious position in the lithic inventory of the southern Guadalupe Mountains. Occurring with frequency at only a few sites, it has qualities of both chert and limestone, as the name implies. Not only was it used in a manner somewhat similar to both, but its reaction to flaking, as demonstrated by the flake analysis, is also intermediate between chert and limestone.

Quartzite was used to make two fundamentally different kinds of tools. On the one hand, it was used for the manufacture of manos and metates, presumably because of its durability, convenient size, shape, and availability. On the other hand, it was chosen for flake knives, often similar in form to Old World blades.

Greenstone was quickly isolated in the collection, but, in spite of its abundance, it does not seem to have been heavily used. Analysis of the greenstone debitage revealed that it had an exceptionally high proportion of broken platforms, which must reflect failed attempts to shape it into usable implements.

The choice of raw materials by the prehistoric flint knappers of the Guadalupes can be viewed as a balance between convenient and abundant local sources (limestone, quartzite, and possibly cherty limestone) and high-quality chippable stones (exotic silicates and imported cherts), which were apparently less abundant and were probably imported. When morphological complexity was desired, the higher-quality materials were used almost exclusively; when less complexity was desired, a much wider variety of materials was utilized. However, it should not be assumed that chert was an exceptionally scarce resource, for it was frequently used for simple tools that could easily have been made from other materials. For certain implements, local materials were apparently deemed most appropriate, either because of their basic nature (hardness and texture for groundstone tools) or because of natural shapes that facilitated manufacture of particular implements (tabular limestone for specialized bifaces and blocky quartzite for blades). Greenstone, which seems at first glance to have great potential, was generally avoided by knappers.

The difference in sample sizes and a dearth of sites with large artifact assemblages hindered analysis of the artifact clusters, but one group of artifacts—tabular limestone bifaces, flat manos, metates, and battered stones—seem to have both temporal and ecological significance. These artifacts mostly come from the late ceramic period identified by Phelps (1974) as from A.D. 1200 to 1350, and they are found in the Lower Sonoran zone. The functions and interrelations of this group of artifacts should be an avenue for future research in this region. They may represent activity sets or tool kits for particular activities. It is also possible that the people who used these implements were carrying out a variety of essentially unrelated activities, and that this assemblage contains an unrelated set of artifacts from the material culture of a particular group or groups of people. The mano and metate are obviously related, but the interrelationship of the tabular limestone bifaces and the battered stone is not clear.

The place of agriculture in the southern Guadalupes is still an open question. Several sites in the Lower Sonoran arid division, especially along the west flank of the mountains, have many ceramics and food grinding tools, but livestock management practices have significantly altered the availability of water in the region, and it is difficult to determine if sufficient moisture was present to support the cultivation of maize, squash, or beans. Evidence from the Hot Well site about 160 km (100 miles) to the west (Schultz 1966) indicates that the area might have supported agriculture. The association of the tool kit with the sites in the Guadalupes isolated by the clustering analysis remains an intriguing problem.

Analysis of the projectile points suggests a fairly long occupation extending from late Paleo-Indian times into Late Prehistoric times. Continuity with the historic tribes of Jumano and Apache cannot be demonstrated from the TAS collections, but the Trans-Pecos seems to follow the previously defined culture history sequence in West Texas and southern New Mexico. The TAS collection, insofar as the projectile point typologies are accurate and meaningful, contains no particular surprises; indeed the varieties of projectile points are just what would be expected in the Guadalupes.

It had been hoped that analysis of the debitage recovered by the TAS survey would identify the techniques used in manufacturing stone implements in the Guadalupes, but the limited size of the data base and the nature of the collection caused serious problems. Many sites that were reported as having large amounts of lithic material were undercollected; in other instances collections were biased, making the samples from those sites unsuitable for analysis, and many of the sites produced samples that were too small for analysis. Furthermore, the fact that many sites obviously had several components made intersite comparisons difficult to interpret.

Analysis of the chippage reveals that seemingly similar kinds of flakes, when subjected to attribute analysis and hierarchical groupings, fall into constellations of flake forms that may be indicative of the production of bifaces or unifaces. Although biface and uniface production in the early stages can produce quite similar chippage, the results of this study suggest that it may be possible to distinguish between the two activities.

That implements were being produced in quantity in the Guadalupes is evidenced not only by the chippage recovered, but also by recovery of partially finished bifaces in both whole and broken (during manufacture) states. With one possible exception, no sites were identified as loci of activities at or near natural sources of raw material. This is in part a result of the limited area of the TAS survey, an area that does not have substantial chert-bearing deposits, although chert deposits are indeed available in the southern Guadalupes of New Mexico.

As with most scientific endeavors, more questions have been raised than answered in this study, and unsuspected pieces of information surfaced while specifically selected problems remained unsolved. Perhaps the most significant conclusions to be drawn from this study lie in the area of the analytical techniques applied—specifically their utility and limitations. The flake study, based upon an attribute analysis, identified at least some aspects of chipped stone tool manufacture. The fact that specific stages in the reduction of lithic material can be isolated has implications for identification of lithic technologies as practiced by different groups during different cultural-temporal periods, and might even provide some information as to the nature of prehistoric transhumance patterns. In addition, it may be possible to identify the manufacturing debris from different kinds of artifacts. Although such determinations are now only crude and are limited to unifaces and thinned bifaces, the potential exists to further refine the techniques.

In line with the suggestions offered above, it is apparent that hierarchical clustering, such as HCLUS, is useful for eliciting natural groupings of artifacts and sites. However, it is severely limited by the constraints of small sample size and samples with a high proportion of missing data. When used with caution and finesse it can be very helpful.

The IFREQ package, in conjunction with HCLUS, has great potential for investigating variation and patterns in chippage assemblages. The scope of attribute analysis is now limited only by the imagination of the lithic analyst and the capabilities of the computing apparatus. Indeed, other areas of research such as ceramics, folk taxonomies, folklore, and even descriptive linguistics might find useful the techniques presented in this study.

As a result of this study we now know something of the techniques and choices exercised by the prehistoric flint knappers of the Guadalupe Mountains of Texas. Intriguing bits of information have been brought to light and presented, if not as answers to great problems, at least as suggestions that may lead to a greater understanding of the region.

APPENDIX

Flake Morphology

This Appendix describes the various morphological characteristics defined and used for analysis of the flakes. The system employed is an adaptation of the one used by M.B. Collins (1975:161-172) in his analysis of debitage from sites in Texas and southwestern France. Five categories, or attribute states, were defined and incorporated into a coding scheme. These attributes are platform, bulb, body, length, and material type.

The changes from Collins' system are the substitution of a new set of material types and the elimination of any distinction between blades and flakes. Each of the attribute states is given its own code (see Table 4).

Platform

Platforms are defined in terms of two aspects, shape and surface treatment, with a total of 15 states (see Table 4). Collins defines the platform variable as follows:

> Basically, platforms were either straight or recurved when viewed from the top. Each of these shapes, plus any miscellaneous shapes which might be observed, could be placed in one of four categories of degree of treatment: cortex remaining, single-faceted, double-faceted, and multi-faceted. Also noted were those platforms which were either shattered, broken, or ground. A given platform, then, could be described as "straight, single-faceted," or "straight, cortex," etc. Coding standards for these variables were as follows: the recurvate platform shape, designated "sequent," refers to the shallow, U-shaped platform which results from the sequent removal of a flake directly in line with the negative scar left by the removal of a former flake. When the platform is viewed from above, the edge which intersects the exterior of the flake exhibits an inward curve caused by the concavity of the previous negative bulb; the opposite edge curves outward—usually strongly—with the positive bulb of the flake. The category "straight" includes all platform shapes that are rectanguloid or biconvex. A third category, "other," was used to designate platforms whose shape was neither "straight" nor "sequent," such as triangular. Cortex platforms are those which retain the weathered surface of the raw material and indicate that no preparation of that surface was made prior to flake removal. If the platform has been altered by flaking, it may be described as exhibiting one, two, or more facets. These do not necessarily indicate the number of facets produced in preparation of the platform, but they do indicate the nature of the surface area to which force was applied. For example, in experiments the gable-like intersection of two facets is often found to be an advantageous point for the application of force. Shattered platforms are those whose position is observable, but whose form is not (due to crushing or shattering under the force which removed the flake). Broken platforms are similar in that the position of the platform can be determined, but its form is not observable due to breakage (presumably after removal). These two categories are not to be confused with the "broken flake" category which includes flakes with the platform or another edge completely missing. Ground platforms are generally small and "straight" (usually biconvex) with striations across most of the surface. Although these are generally considered to be intentionally ground in platform preparation, the possibility that some represent use wear cannot be overlooked [Collins 1975:161-165].

See Figure 38 for illustration of platform characteristics.

Bulb

Bulbs are classified according to three attribute states: normal, exuberant, and flat. Collins defines the bulb category as follows:

> Under "normal" are recorded flakes which exhibit a bulb of percussion of average properties, i.e., noticeable but not greatly protuberant. "Exuberant" bulbs are those which protrude strongly and are decidedly rounded when viewed either from the side (perpendicular to the axis of flaking) or from either end (parallel to the flaking axis) [Collins 1975:165].

See Figure 39 for bulb characteristics.

Body

The body attribute category encompasses two aspects, the nature and extent of cortex on the flake exterior and the shape of the flake in cross section. Sixteen body states are defined by Collins as follows:

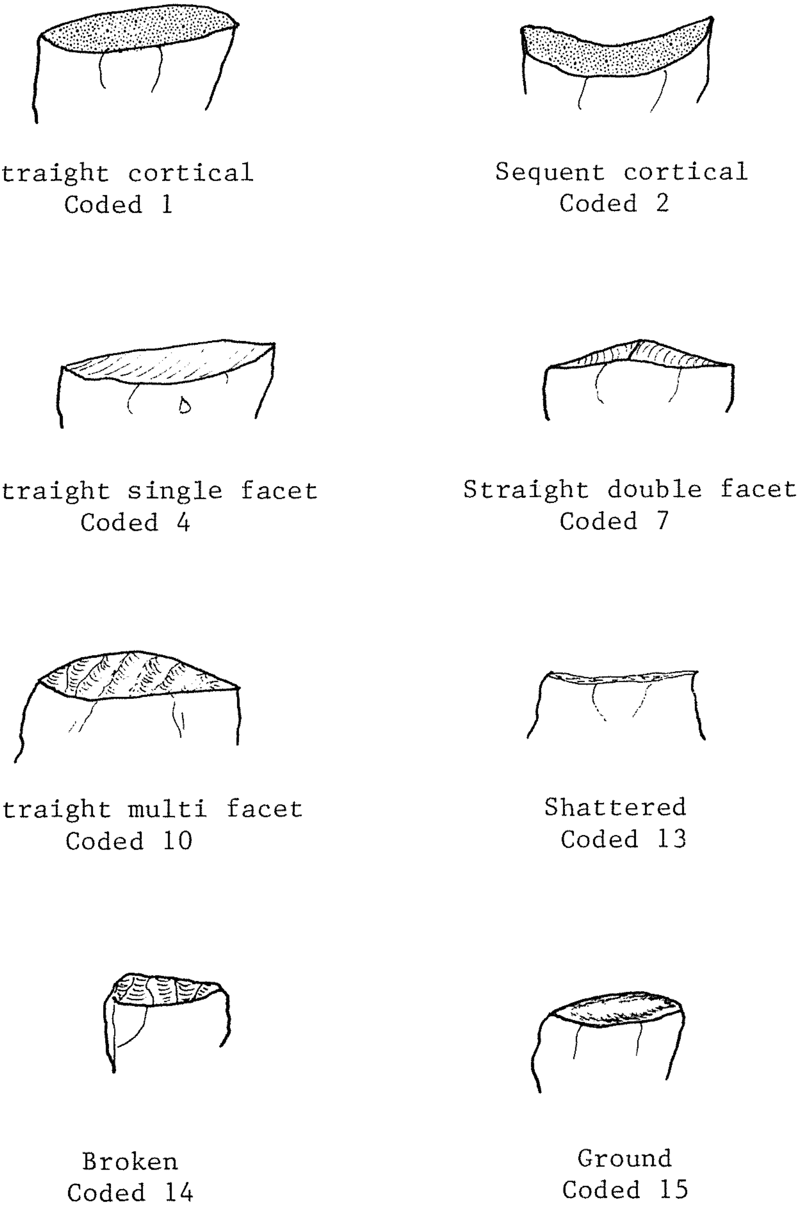

Figure 38. Platform characteristics and their codes.

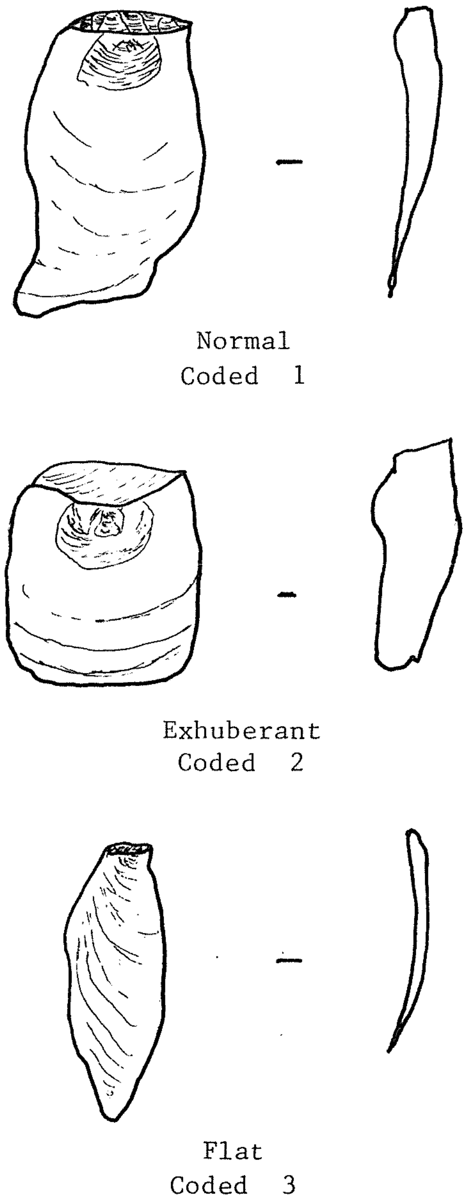

Figure 39. Bulb characteristics and their codes.

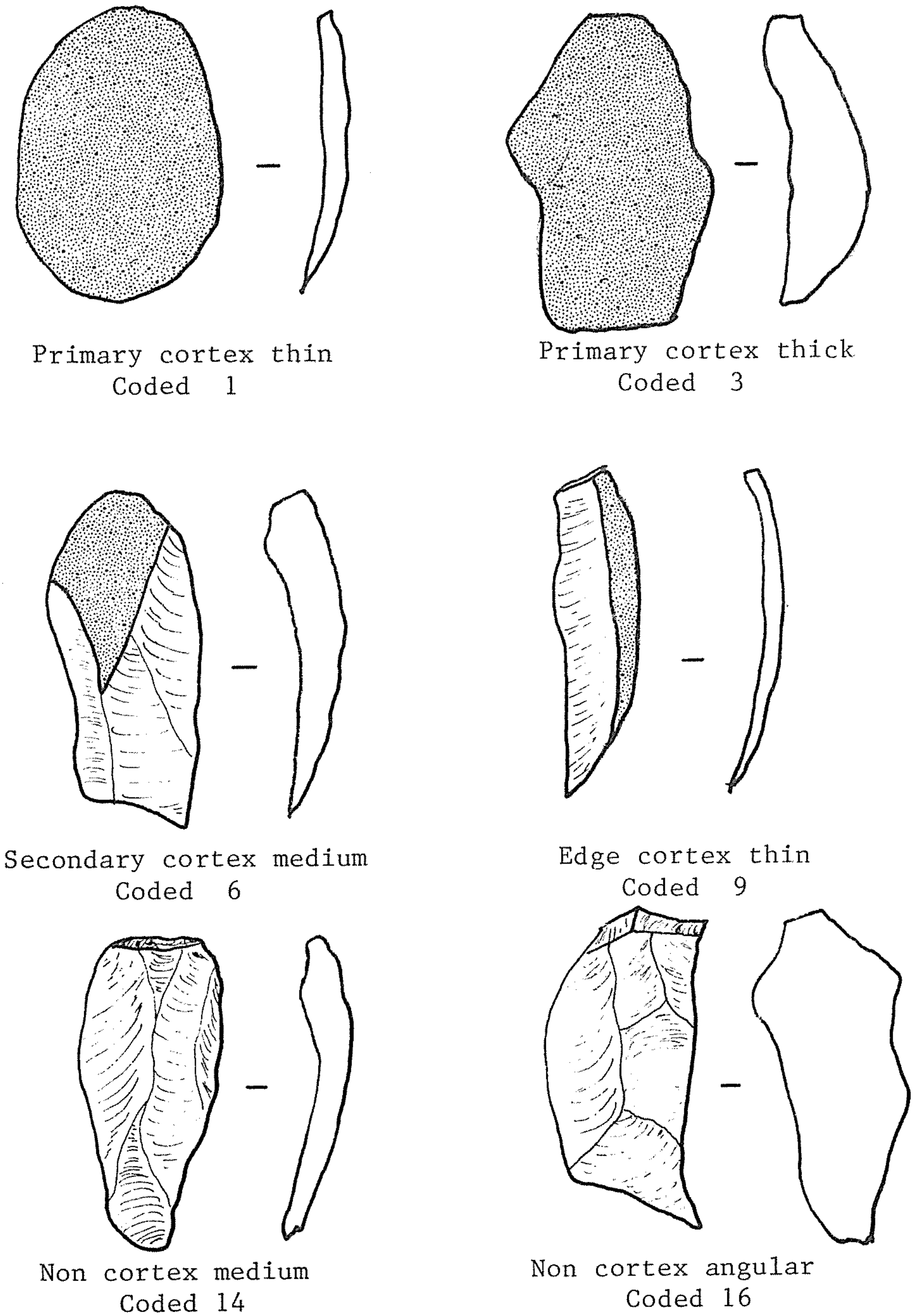

Figure 40. Cortex characteristics and their codes.

> Primary cortex flakes exhibit cortex over the entire exterior and along any edges which are not the sharp intersection between the interior and exterior surfaces. Secondary cortex flakes have cortex on greater than 10 percent of their exterior and may or may not have cortex on any edges. Secondary edge cortex flakes have cortex only along one or more edges, and noncortex flakes lack cortex (or exhibit small patches on less than 10 percent of their exterior). The shape categories are relative. Thin flakes are relatively very thin to length and width, medium ones are intermediate in this regard, and thick ones are relatively thick. Flakes which are thick and have facets on their exterior surface which intersect in an acute angle are recorded as "angular" [Collins 1975:167].

See Figure 40 for illustrations of cortex characteristics.

Length

The length variable was expressed as a discontinuous variable represented by five classes. The length was measured by obtaining the maximum length of the flake perpendicular to the striking platform. The lengths defined are as follows: (1) very small, less than 12 mm; (2) small, 12 to 25 mm; (3) medium, 26 to 50 mm; (4) large, 51 to 100 mm; and (5) very large, more than 100 mm (Collins 1975:169).

Material Type

The material-type variable incorporates the six types defined in the section on stone type analysis. Originally, seven types were defined, including two varieties of limestone. However, after the coding was initiated these two types were combined. Instead of reassigning variable state labels, it was decided simply to combine all limestone under one code number, leaving the other unused.

Each flake in the collection, unless it came from a random surface find, was analyzed according to the five variable states. Site provenience and the attribute state code were recorded on Fortran coding sheets, then keypunched onto cards. These cards provided the basic data, which were processed by the IFREQ and HCLUS programs.

ACKNOWLEDGMENTS

This report would not have been completed if it were not for the support and assistance which I have received from many different quearters, and it is to these people that I wish to extend my most sincere thanks and appreciation. First among those who should be recognized are the members of the Texas Archeological Society who, in the summer of 1970, conducted a survey of Guadalupe Mountains National Park and thus brought together the data that is the focus of this report. Their hard work and diligence is clearly reflected in their copious field notes. Special appreciation is due Harry Shafer, who supervised the survey and who graciously allowed me to use part of the project data. I would like to express my thanks to the University of Kentucky Graduate School, which provided funds to defer travel and subsistence expenses, thus allowing me to travel to the Guadalupe Mountains and conduct my survey of lithic resources. My thanks also go to Roger Reich, park ranger, who offered his advice and assistance to this desert novice during that survey.

The excitement that can be obtained from conducting archeological fieldwork is exceeded only by the tedium that must be endured if anything resembling science is to be obtained from it. Two individuals stand out as ones who shared in that trial and without whose help completion of this report would have been vastly more difficult. Dolores DeCorsey assisted in the coding of flake attributes and relieved me of the task of coding about a third of the assemblage. Carol Straus went far beyond her normal responsibilities as a consultant at the University of Kentucky Computing Center and spent seemingly endless hours, over a period of several months, to bring order out of the chaos of programs. I am deeply indebted to her for for making it possible to utilize the cluster program upon which I have so heavily depended. I also wish to extend my thanks to Don Graybill, who provided me with the clustering program, and to the University of Kentucky Department of Anthropology, which acquired the necessary computer time for me to carry out my research. I am also grateful to Virginia Slattery, who not only typed the manuscript but also caught and corrected many small errors and inconsistencies, thus saving me a tremendous amount of time and worry.

I am sincerely grateful to the members of my thesis committee: to Eugenie Scott for her contributions in the area of statistical application of computers; to Lathel Duffield for his insightful criticisms and appraisal of my methodology and findings; and especially to Michael Collins, chairman, who has guided me through the maze of problems that beset me in my attempt to use lithic technological data in order to understand the behavior behind artifacts. To the extent that this goal has been obtained, Michael Collins shares in the achievement.

Without question this report is as much an accomplishment of my wife Deborah as it is mine. She has patiently endured countless lonely nights as I conducted the analysis and writeup, and she actively encouraged and motivated me to continue when it would have been easier for me to quietly abandon efforts.

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