LITHIC PRODUCTION AT THE MESILLA PHASE PLACITAS ARROYO SITE COMPLEX, DOÑA ANA COUNTY, NEW MEXICO

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Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

August 2019

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Younger, Alexandra C. *Lithic Production at the Mesilla Phase Placitas Arroyo Site Complex, Doña Ana County, New Mexico*. Master of Science (Applied Geography), August 2019, 83 pp., 18 tables, 23 figures, references, 103 titles.

This study of lithic analysis shifts attention from typological studies to explicitly behavioral analyses, complimenting studies of both intrasite and intersite patterns of variability and change. Analysis of several assemblages from the Placitas Arroyo site complex reveals changing patterns of raw material procurement and selection, core reduction strategies, as well as tool production and discard. The most striking result thus far is the quite uniform emphasis on flake production from well-prepared cores, and the near absence of manufacture or maintenance of bifacial tools, especially projectile points. Associated with common ground stone artifacts, the flaked stone materials may well represent intensive food processing. Regardless, the technological patterns being revealed by this approach illustrate a productive new means to gain insights into changing behaviors in the Jornada Mogollon cultural tradition.

By

Alexandra C. Younger

ACKNOWLEDGEMENTS

Important projects such as this do not come easy nor without the help of a lot of people. My parents Laura and Ray are my champions, and it is from them I possess the confidence and belief in my abilities. My partner Christopher has joined this wonderful team of advocates who work hard to foment my personal and intellectual growth, but importantly, he was at the frontlines of my emotional support and for that I feel profuse gratitude. Reid Ferring bestowed me his intellectual gifts involving artifact analysis and interpretation that one can only glean with decades of experience equivalent to the careers of many archaeologists. Not one interaction with Dr. Ferring could be classified as casual or trivial, rather, one would always leave a conversation feeling enlightened. I thank my sounding board and mentor upon arrival at UNT, Steve Wolverton who has the unique ability to set you on a journey of self-discovery you never expected would happen in just a couple of years. I would also like to thank Dr. Nagaoka and the Department of Geography for their encouragement and gentle humor. A special thank-you to Myles Miller for your advice and mentorship. Your grand expertise provided a huge foundation for this work, though I hope our collaboration never ceases. Others I want to thank are Larry Kimball, Jen Frederick, Tambri Hunteman, Matt Taliaferro, Tim Perttula, Fumi Arakawa, Dylan Person, Robert Dello-Russo, and other professionals I did not mention for generously assisting me in my research efforts. To my late grandfather, Ray, Sr., thank you for sharing your tales of avocational archaeology adventures. I will never forget the twinkle of nostalgic joy on your face, Pop. Thank you to my cohort for sharing this experience, and my dearest friends and family, Bridget, my twin brother Raymond, my deeply affectionate grandparents, all who offered reassurance and positivity since the beginning. Thank you all sincerely.

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CHAPTER 1

INTRODUCTION

This thesis is a study of lithic artifacts which represent an important subfield of archaeological research, so much so that there are whole academic journals dedicated to its interpretation and significance. This kind of research involves analysis of lithic assemblages as they relate to subsistence strategies, technological evolution, cultural exchange patterns, and social structures (Andrefsky 2008). Each of these perspectives requires a critical understanding of the process of material procurement, manufacture, and production of stone tools.

Importantly, understanding the lithic production process helps us to understand human cognitive capabilities (Eren et al. 2005). In a broader context, some research examines subsistence-settlement strategies—or how people lived upon and related to past landscapes—as a driver for specific lithic production strategies (*see* Binford 1979; Kuhn 2014). This perspective relates mobility, settlement patterns, and the subsistence strategy of a population to (1) the mode of tool production with respect to formal (refined and complex) and informal (simple and expedient) tool forms and (2) perceived curation of tools as an economic response to resource limitation. Behavioral perspectives in archaeology seek to understand choices made by people during production and also concern human social interaction (Schiffer 1976) that relates to the landscape. Thus, interpretations of human behavior can employ an ecological-economic framework. For example, from human behavioral ecology, Optimal Foraging Theory (OFT) relates resource availability to behavior in terms of costs and gains of raw material procurement (Bettinger et al. 1997). A similar framework expressed in different terms, distance decay, provides a geographic explanation that discusses economizing behavior through resource use (Henry 1989).

Indeed, lithic resource availability and raw material quality are major determinants of stone tool production (Andrefsky 1994). Identifying these kinds of links requires a formal critical analysis of the process of stone procurement and production. A combination of attributes identified are used to interpret the process of procurement, use life, and discard of lithic artifacts. This is referred to as *chaîne opératoire* (Bar-Yosef et al. 2009). This study investigates the factors that influence the technological assemblage of prehistoric people in the lower Rio Grande Valley of southern New Mexico and evaluates lithic production within the surrounding landscape.

The "lithic landscape" (Foley and Lahr 2015; Ford 2011; Hiscock 2014) as described by Schriever et al. (2011) illustrates both settlement strategy and lithic resource availability as key factors in stone tool organization of two Late Pithouse period residential settlements of the Mimbres Mogollon culture area of south-central New Mexico. Similar research has not been done regarding lithic procurement and production in the Jornada Mogollon culture area to the east. To further explore lithic production in the Jornada-Mogollon area, this thesis will analyze the lithic assemblage of pithouse period archaeological sites LA13145 and LA13151 at Placitas Arroyo, near Hatch, New Mexico, to determine if the availability of stone resources and raw material quality related to settlement type and organization. Stone tool organization is defined as, "the study of the selection and integration of strategies for making, using, transporting and discarding tools and the materials needed for their manufacture and maintenance" (Nelson 1991: 57). In the study conducted by Schriever et al. (2011) mentioned above, the authors concluded through analysis of production techniques and material procurement that there was a difference in overall lithic organization (strategies) between long-term versus intermittently occupied sites that date to the Late Pithouse phase (AD 500–1000). The culture area in which Placitas Arroyo in the Jornada Mogollon area, which is approximately contemporary with the early Formative of the nearby Mimbres Mogollon cultural complex (see the following section for details).

Data from Placitas Arroyo archaeological sites may reflect similar patterns to those documented by Schriever et al. (2011) who described higher prevalence of formal tools at intermittently-occupied sites. Settlement patterns at Placitas Arroyo are difficult to assess based solely on architectural features and limited evidence of horticulture. Although Morenon and Hays (1976) suggested occupations at Placitas Arroyo were likely seasonal, frequency and intensity of occupation remains unknown because site formation, primarily deflation, diminished stratification between occupations resulting in a palimpsest. Patterns found in the stone tool assemblages may provide supporting evidence for either sedentism or ephemeral settlement patterns at the sites. Study of the extensive lithic assemblages from Placitas Arroyo provide an opportunity to expand archaeological understanding of stone tool production and use in the region and surrounding areas.

Prior to delving into the research questions that will guide the study objectives, it is important to provide detailed information on the culture area and the Placitas Arroyo sites and lithic assemblages. This background on Placitas Arroyo is followed by a literature review of conceptual framework and methodological approaches to stone tool analysis, which informs the precise research questions and hypotheses. How those hypotheses are addressed to meet the thesis objectives (described in the proceeding section) is covered in the methods section. This thesis concludes with the results of testing and subsequent discussion.

CHAPTER 2

BACKGROUND

2.1 Introduction

This prehistoric southwestern culture of the region is known as the Mogollon and can be characterized by the production of Alma plainwares, El Paso brownwares and black-on-white ceramics (Morenon and Hays 1984; Lehmer 1948). Broadly, this area spans the Lower-Pecos, Tularosa, Hueco, and Rio Grande basins. The Archaic Period in dates between 6,000 BCE and CE 200. The Formative period spans three phases from CE 200-1450. The Jornada-Mogollon cultural area also includes the transition from pithouse to pueblo villages, and ancestral relations to the Puebloan groups of the American Southwest (Lehmer 1948; Miller, 2005, 2007, 2009; Miller and Kenmotsu 2004). Sites in which residential mobility decrease during seasonal periods are typically linked with semi-subterranean dwelling types, such as the pithouse (Gilman 1987). While the sizes of pithouses vary substantially (Stuart et al. 1984), those encountered at Placitas Arroyo are small compared to others in the region.

However, substantially less is known about production and use of stone tools in the Jornada region. Previous investigations at Placitas Arroyo indicate the use of groundstone technology for plant food processing and presumably a semi-sedentary subsistence and settlement organization with a tendency toward horticulturalism (Morenon and Hays 1984). Indeed, the diet breadth and degree of mobility of the Mogollon culture area was likely variable, which may link to significant variation in tool types related to different activities.

2.2 Environmental Setting

The Jornada Mogollon region encompasses the northern portions of the Chihuahuan

Desert as well as the Mexican Highland Region within the Basin and Range Physiographic Province (Havistad and Schlesinger 2006; Hawley 1975). The Basin and Range region is described as north-to-south trending mountain ranges separated by basins (or bolsons). The Placitas Arroyo site complex is located along the southern margin of the Jornada del Muerto Bolson (Keyes 1905). The Jornada del Muerto Bolson extends from Socorro to Las Cruces, New Mexico, and is flanked by the Sierra Oscura, San Andres Range, and Organ Mountains to the east, the Fray Cristobal and Caballo mountains to the west, and the Sierra de las Uvas and Doña Ana Mountains to the south. The southern portion of the bolson contains part of the Rio Grande valley, where the river is entrenched up to 100 meters (m) into bolson floors.

Dating to about 9,000 years ago, the Chihuahuan Desert is classified as a desert grassland transition that, in the past, has fluctuated between arid shrubland and grassland (Griffith et al. 2006; Havistad and Schlesinger 2006; Shreve 1917). Woodland vegetation occurs in higher elevations while grasses and shrubs occur in the basins. The topography of the northern Chihuahuan desert constitutes closed basins that run parallel north-south. Outside of the Rio Grande and Pecos River drainages, each individual valley has its own interior drainage systems and contain intermittently-flooded playa lakes (Havistad and Schlesinger 2006).

Placitas Arroyo is also located within the Chihuahuan Basins and Playas ecological subregion, which constitutes alluvial fans created from eroded mountains, internally drained basins, and river valleys that occur mostly below 4,500 feet (ft; 1,372 m). Soils along the playas and basin floors are saline or alkaline and include salt flats, dune, and eolian sands. Vegetation in this subregion is dominated by creosotebush, tarbush, fourwing saltbush, acacias, gyp grama, alkali sacaton, as well as horse crippler and other cacti (Griffith et al. 2006).

2.2.1 Geology and Soils

Within the basin and range province, Placitas Arroyo is situated along the margins of the Jornada Basin created by Tertiary-age Rio Grande rift system. Mountains are generally composed of Tertiary volcanic rock and Paleozoic sedimentary rocks, and basins are typically filled with sediment from eroded mountain ranges (Griffith et al. 2006). The southern boundary of the sites is characterized by the Tertiary-age Sierra de las Uvas, and to the north is the Camp Rice formation, composed of pebbly sandstones and distinctive gravels of quartz, quartzite, and chert, as well as floodplain mudstones and siltstones (Hawley et al. 1969).

Developing on dunes or sand sheets, the Bluepoint soil series in this area consists of deep, very well drained soils that form in eolian materials derived from mixed rock sources. These thermic soils have an aridic moisture regime, typically on uplands and alluvial fan surfaces. Placitas Arroyo soils mostly consist of the Nickel-Badland Complex which forms along eroded arroyo edges and channels from very gravelly and coarse-loamy alluvium (Bulloch and Neher 1980; Web Soil Survey 2019). These soils are old and weakly developed.

2.2.2 Vegetation

The five major vegetation types include black grama (*Bouteloua eriopoda*) grasslands; playa grasslands; tarbush (*Flourensia cernua*) shrublands; creosotebush (*Larrea tridentate*) shrublands; and mesquite (*Prosopis grandulosa*) shrublands (Peters and Gibbens 2006). Habitats consist of wildlife and rangeland. Lower elevations comprise of C_3 shrubs and C_4 grasses, and juniper savannahs, oak, and pinyon pine woodlands populate higher elevations. Currently, desert shrubland is increasing across lowlands and foothills (Griffith et al 2006; Peters and Gibbens 2006).

2.2.3 Hydrology

Placitas Arroyo is located just along the southern margin of a smaller hydrologic basin, the Palomas (Figure 2.1; Land 2016). This basin merges to the south with the eastern side of the Mimbres Basin; extends north to the city of Truth or Consequences; bordered to the east by the Caballo Mountains and Red Hill; and the Black Range, Animas and Saldado hills, and the southern Sierra Cuchillo borders the west.

The Placitas Arroyo subwatershed receives water from the Sierra de las Uvas. Its headwaters begin along the eastern perimeter of the Rio Grande-Caballo watershed at the mouth of Horse Canyon, and is fed by a series of springs, the closest of which, Souse Springs is located approximately 3.7 kilometers (km; 2.3 miles [mi]) south-southeast of the Placitas Arroyo archaeological sites. Placitas Arroyo channel flows from southwest to northeast, through the town of Hatch, and empties into the Rio Grande approximately 5.5 km (3.4 mi) northeast of the archaeological sites.

2.2.4 Climate/Paleoclimate

The environment of the northern Chihuahuan Desert was cooler and likely wetter during the last glacial maximum approximately 20,000 years ago. According to pollen records, conditions here in last 10,000 years of the Holocene transitioned generally from grassland, to scrubland, and back to grassland during the late Holocene (Buck and Monger 1999). Temperature and interannual variability are not fundamentally different present-day. Within the study region, the average annual precipitation is about 127 millimeters (5 inches) and the average annual air temperature is about 66 degrees Fahrenheit (19 degrees Celcius).

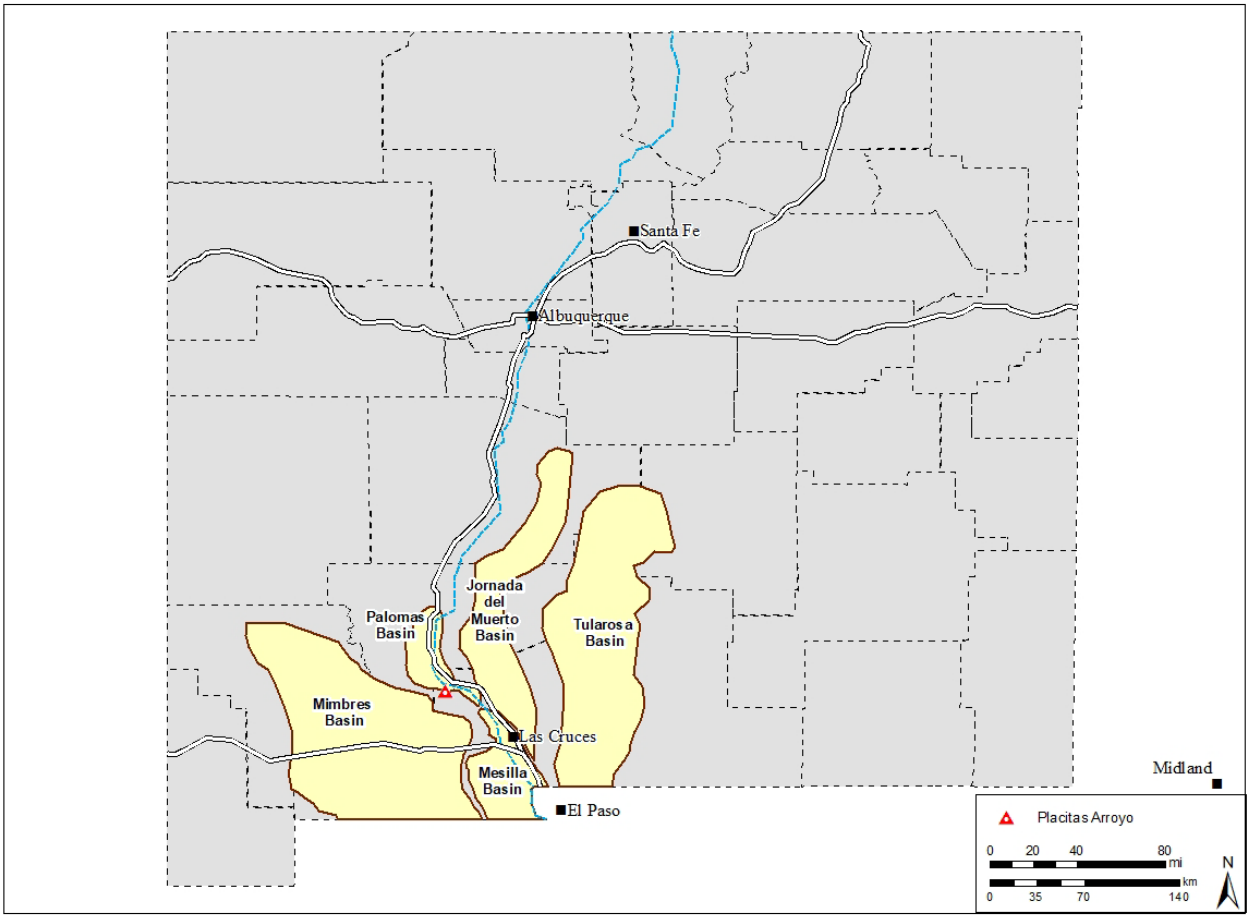


Figure 2.1: Map of hydrologic watersheds in south-central New Mexico. The Study area is located within the Palomas Basin.

2.3 Culture Area

The culture history of the assemblage from Placitas Arroyo in Doña Ana County, New Mexico, is challenging to parse due to differential deflation and lack of vertical integrity across the sites. A general overview of the culture history of the Jornada-Mogollon provides context in which to frame this palimpsest of the culture sequences that were recovered in 1974. Placitas Arroyo generally spans from the late Archaic to Ceramic period. Analyzed prior to 1980, radiocarbon dates largely extracted from pithouse features returned an approximate un-calibrated range of CE 200-800. Referred to as the Hueco and Mesilla phases, Morenon and Hays'

(1984) interpretations of the culture sequences was borrowed from Lehmer's (1948) phase designation for the Jornada Mogollon.

2.3.1 Paleoindian

The Paleoindian period (12,000-6,000 BCE) of the Jornada does not presumably intersect Placitas Arroyo. One distal portion of a projectile point in the Placitas Arroyo assemblage shows fluted and lanceolate characteristics indicative of Paleoindian components. The tool has not been formally analyzed. Through cross dating lanceolate points to chronometrically dated sites in adjacent regions and the Great Plains, the earliest evidence of prehistoric occupation of the Jornada Mogollon area is during the Paleoindian period. At the time of this study, no reliable absolute chronometric dates have been obtained from Jornada Paleoindian sites. Within the Tularosa Basin and the Hueco and Mesilla Bolsons some isolated Paleoindian artifacts and a few open-air sites have been recorded. Subsistence patterns characteristic of the Paleoindian tradition include highly mobile bands hunting large game such as mammoths and bison. Many today consider the Clovis more generalized hunter-gatherers. Some groups adopted more Archaic tradition of hunting and other groups turned toward specialized techniques of perusing migratory game (Stuart et al. 1984). The environmental setting of this period is also characteristic of late-Pleistocene, early-Holocene transition of moister climate, robust stream flow at higher elevations, and wide, open lakes and marshes in the lower-elevation bolsons (Miller 2018).

Recent studies aimed at tool form and raw material indicate the emergence of mobility patterns divergent from Great Plains Paleoindian patterns. Amick (1994, 1996) argues that the distribution of local and non-local lithic raw materials at sites point towards a home-base subsistence practice aimed at game other than bison. This includes evidence of non-local material deposited with discarded tools indicative of manufacturing prior to transport. Drier trends in climate toward the end of the Paleoindian period may have resulted in shifts in game populations and an increase in dry-adapted plant distributions that contributed to the shifts in settlement and technology associated with the desert Archaic tradition. The end of this period is marked by the retreat of big game specialists and their prey out of the Southwest.

2.3.2 Archaic Phases

Although no projectile point sequence has been developed for the Jornada Mogollon region, its 7,000 years of Archaic tradition (6,000 BCE to 200 CE) refers to typologies from adjacent regions. New period terms and sequences were produced by MacNeish and Beckett (1987) and MacNeish (1993) for the northern Chihuahua Archaic. Prior to 1990, the majority of Archaic period Jornada investigations comprised of rock shelters from the Hueco, Organ, and Sacramento Mountains (Alves 1930; Bohrer 1981; Cosgrove 1947; Human Systems Research 1972; MacNeish 1993; Wimberly and Eidenbach 1981). Due to processes related to upland deposition and desert conditions, multicomponent palimpsests are characteristic of the Archaic period (Miller 2018).

2.3.2.1 Early Archaic

Beginning about 6,000 BCE the Early Archaic tradition begins with a shift in land use practices, technological diversity and settlement intensity (Miller 2018). Representative of high residential mobility (Kuhn 1989), projectile points from this period reflect the technological system that involves replacement following exhaustion, as well as a shift from lanceolate to stemmed. Most of these projectile points have been encountered on the surface. In addition, thermal features are rare. However, these features contain cooking stones and are associated with ground stone technology (Beckett 1973; O'Laughlin and Martin 1992), pointing to a shift in technology. Miller (2004) and Willis (1988) note that medium-to-coarse grained material such as basalt can be found in Early Archaic points, and Bleed (1986) asserts there is a common reduction in tool maintenance coupled with increased production of locally-procured material. Overall, data pertaining to the Jornada Early Archaic sequence is sparse (Mallouf 1985).

2.3.2.2 Middle Archaic

While technology and subsistence remained the same as that of the Early Phase, these traits intensify in conjunction with population growth in the Trans-Pecos region (Mallouf 1985) during the Middle Archaic. More favorable climatic conditions occurred. Recovered radiocarbon dates show sites were distributed along interior basins, along upper terraces of the Rio Grande, and around drainages. Referred to as the Keystone phase, it is associated with communal plant-baking and the presence of maize coinciding with formal thermal rock features which include large quantities of burned rock (Miller 2018; Miller ad Kenmotsu 2004). Of note, plant baking is documented in the record as early as 5,000 BCE coinciding with the introduction of maize (Miller 2018). Short-term residences emerge with small huts called pithouses, which are small, typically less than two meters in diameter and roughly 15 to 20 centimeters (cm) below surface. Organization of sites like these would include extended-family or multi-family groups (O'Laughlin 1992). Intensification of thermal features suggest desert succulents such as cacti become a dietary staple (Mallouf 1985).

During this phase the first village settlements and evidence of houses or huts appear. In association with warmer-wetter conditions this period marks the beginnings of more favorable climatic conditions as a result of the end of the Altithermal, what Miller (2018: 127) refers to as a “watershed period” of the Archaic Jornada. Technological developments from settlements of this period include projectile points exhibiting contracting stems, the baking of cacti and succulents, and possibly, farming practices. The primary traits in technological and settlement adaptations in this region intensify in the beginning of the second half of the Middle Archaic, around 2,000 BCE. While technologically similar to the Early Archaic, shifts in settlement organization and settlement periods occur in the Middle Archaic, which ends approximately 1,200 BCE.

2.3.2.3 Late Archaic

The beginning of the Late Archaic (approximately 1,200 BCE) represents shifts towards settlement intensity and technological adaptations. This includes the emergence of side-notched and hafted projectile points and other diverse material culture (Miller 2018). Plant processing evidence is attributed to groundstone tools associated with burned rock thermal features (Beckett 1973; MacNeish 1993). Other features of note include extramural pits or hearths.

Two phases make up the Late Archaic (Fresnal and Hueco). The Early, Fresnal Phase, contemporaneous with the San Pedro Phase of southern Arizona, marks the emergence of early agriculture and expansion of plant baking. The Jornada Mogollon region was not predominant in horticulture or agriculture, as subsistence pursuits emphasized medium-sized game such as artiodactyls while maize remained an intermittent component mostly restricted to mountain uplands (Miller 2018). Miller (2018) also suggests an additional phase during the Middle Late Archaic, named for the most documented site for this period, El Arenal, which spans approximately 750 to 300 BCE. This period lacks radiocarbon dates and thermal features, a large percent of pithouses which lack interior hearths, and settlements mostly located near playas during warm-season occupations. This may have been a period of much wetter conditions (Frechette and Meyer 2009), as well as one of high mobility and low intensity site use.

The Terminal Archaic, Hueco Phase (1,000 BCE – 200 CE) which coincides with earliest dates of Placitas Arroyo occupation, marks the end of the Jornada Mogollon Archaic tradition. Representative of broad developments, this period is comparable to the Basket-Maker with relation to hunting and gathering and early adaptations of agriculture. After the hiatus of El Arenal Phase, maize and plant baking see a resurgence. This was a notable period in which population grew, technology shifted to the bow-and-arrow and incorporated ceramics. While subsistence and settlements are indistinguishable from the proceeding Mesilla Phase, these types of organization vary geographically across the region. As population expanded, settlements extend into desert highlands and basins, components of this period occur across all topographic settings including rockshelters and alluvial fans. Maize, which was as much part of the uplands as well as the basins, shifted with considerable occupation of and into the interior basins (Carmichael 1986; Seamen et al. 1988). This period is also characterized by large storage pits and middens, a movement into open-air sites in which domestic structures become increasingly formal within lowland settings (Miller 2018). Found outside of the Hueco Bolson, circular ring middens become prominent, defined as, “circular to oval heaps of burned rock, sometimes accompanied by large quantities of ash, charcoal, and lithic artifacts, with a central depression” (Miller and Kenmotsu 2004: 229). Although this period sees the agricultural incorporation of maize, desert succulents remained a large part of the diet and subsistence strategy. The use of these features, Mallouf (1985) argues, are evidence of consumption of succulents.

In addition to new agricultural pursuits, the Hueco Phase of the Jornada sequence maintaina an emphasis on hunter-gatherer subsistence. Interestingly, no large communal structures or water-control features emerge, like those of the Sonoran tradition (Miller 2018). Of note, however, is the documentation of communal features in the form of rock circles, and massive plant-baking pits. It is suggested that these kinds of features were distributed across a landscape, specifically along mountain foothills, but not within village settlements. At this time, settlements remained temporary or seasonally occupied (Miller 2018).

2.3.3 Formative Period

The Formative Trans-Pecos as defined by Lehmer (1948) spans three distinct periods: The Mesilla (CE 900-1,100), Doña Ana (CE 1,100-1,200) and El Paso (CE 1,200 – 1,400). Although, depending on the presence of Brownware ceramics, the Mesilla phase includes as far back as CE 200 (Miller 1995). Other regions in the Jornada culture area may vary from these dates. For example, in the La Junta region CE 100-900 is referred to as the Chisos Phase, followed by the Livermore (CE 900-1,100) and La Junta Phase (CE 1,100-1,200; Kelley et al. 1940).

The Mesilla phase is characterized by El Paso ceramics, or nonlocal wares such as Mimbres whiteware, ephemeral circular house structures—referred to here as *pithouses*—and includes a mobile settlement system centered around hunting and gathering with light emphasis on cultigens (Miller and Kenmotsu 2004). Much of the Archaic subsistence continued into the Early Formative, such as incorporation of hunting medium-sized game, growing cultigens, and plant baking. Settlements can include isolated pithouse structures found largely within basins. To reiterate, these settlement/subsistence patterns vary somewhat by region. Following the Mesilla, the Doña Ana Phase marks the transition from pithouse to Pueblo and represents an increased frequency of nonlocal ceramic wares including polychrome. Although circular pithouse structures remained in some contexts, isolated and continuous room blocks emerge. As the Formative periods represent a continuum of increasing sedentism, the El Paso Period, contemporaneous with the southwest Pueblo III period, represents increasing agricultural dependence (Miller and Kenmotsu 2004) and a reduction in the processing of desert succulents evidenced by lack of burned rock thermal features in the archaeological record post-CE 1,000 (Maudlin 1995). This represents a shift from low-level intensification to a higher intensification strategy related to specialized farming.

2.4 Research Objectives

The goal of this research is to understand the variation in the lithic artifacts through study of the reduction process, which begins with the procurement of raw materials. Were there multiple production systems at Placitas Arroyo? For example, was the technology formally produced with the intent of long-term use through recycling and curation? Conversely, were lithic artifacts informally produced, representing all stages of production in high frequency, with little regard for conservation, recycling, and reuse? Did lithic production differ by material type, and was procurement primarily of local or non-local raw materials? Is there a relationship between lithic production and subsistence patterns?

The University of North Texas (UNT) archaeological lab collection contains the artifacts recovered during excavation in 1974 by T. R. Hays. Artifact collections are organized by provenience, based on horizontal units of differing dimensions and vertical provenience in 5-centimeter (cm) arbitrary intervals. The site report has conducted lithic artifact counts and subsequent analyses (see Chapter 6), organized into aggregate binary counts between surface and subsurface artifacts. Two artifact assemblages were considered in this study. Sites PA2 (LA13145) and PA8 (LA13151) are associated with the only architectural features within the excavation areas (Figure 2.2).

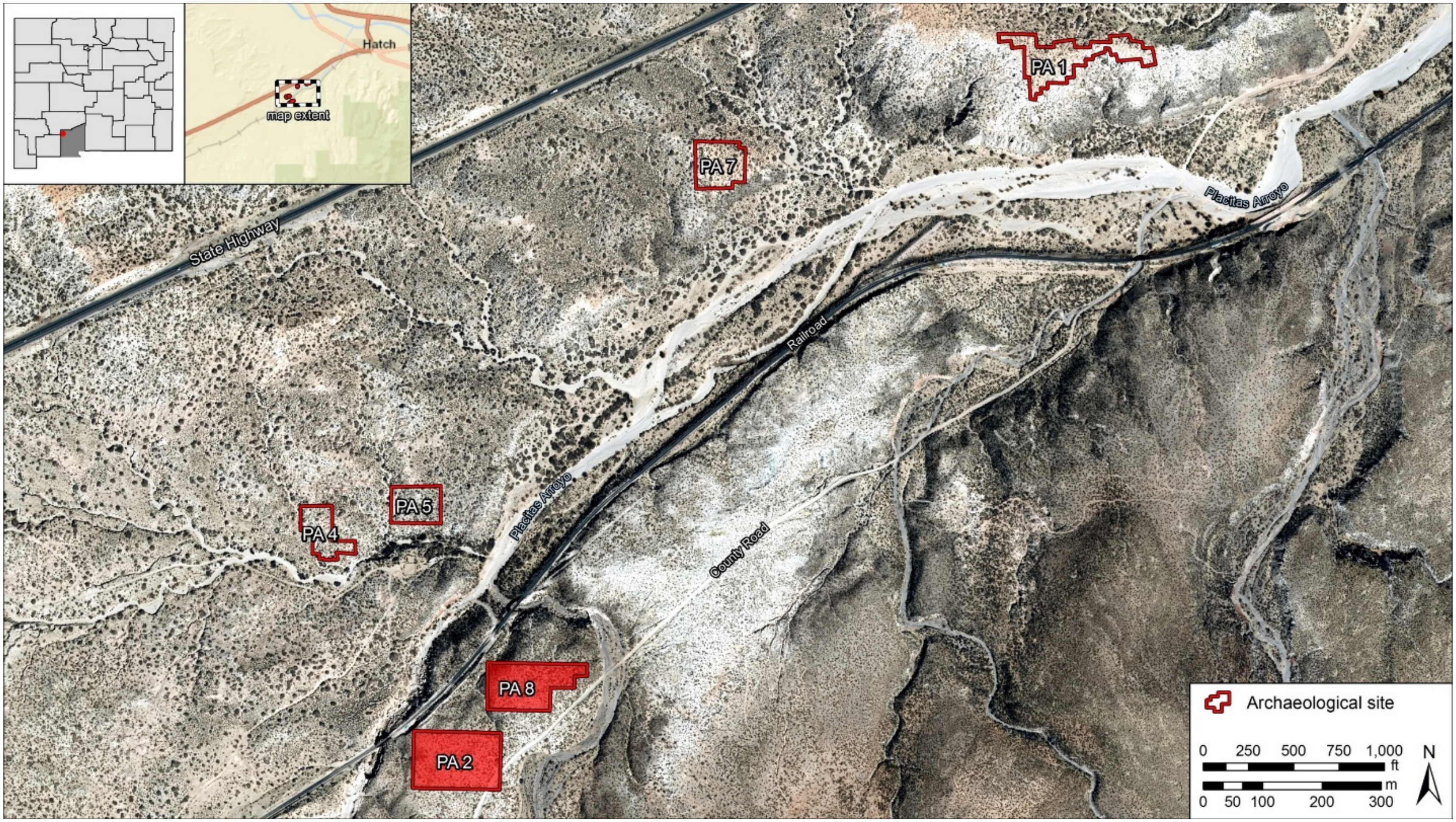


Figure 2.2: Aerial photo of Placitas Arroyo archaeological sites. Sites PA2 and PA8 are associated with pithouse architectural features, the focus of this study

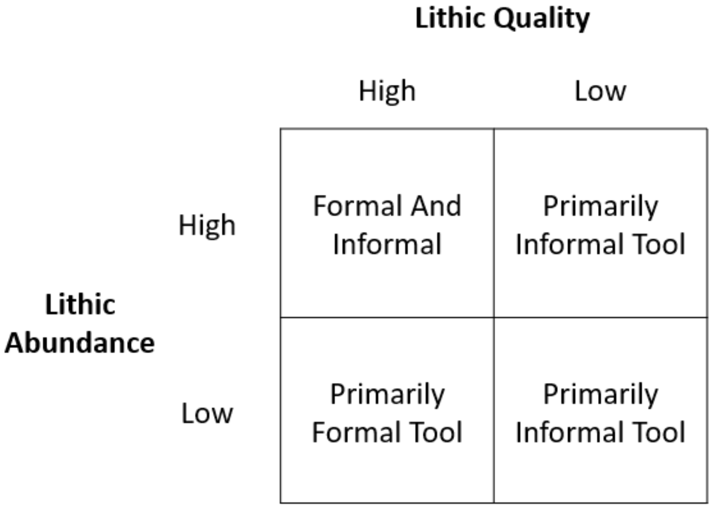
CHAPTER 3

PREVIOUS RESEARCH IN LITHIC ANALYSIS

Historically, lithic technology studies tend to adopt two general perspectives. The first concerns a typological and culture history approach. The second perspective looks at the process of stone tool production to understand past behavior. This thesis is concerned with the second perspective, the cultural processes of procurement, use, and discard in order to understand past behavior.

The study of lithic production refers to the procurement of raw material, the manufacture of stone tools, the production of tool types, as well as re-use and discard. Such investigations are framed to answer questions about the systemic context of cultural processes and behavior (Schiffer 1972). The lithic production process represents a cognitive, planned, logistical, or strategic, adaptive response (Bamforth 1991; Bamforth et al. 1997; Morisaki and Sato 2014). It is also framed as an economic process (Binford 1979; Kuhn 1994, 2014; Surovell 2012). For example, Lewis Binford opposed typological approaches to tool variation in favor of developing a functional perspective (Kuhn 1991). He related subsistence-settlement organization to stone tool production, emphasizing raw material procurement, manufacture, and discard processes (Binford, 1973; 1979; 1993), via reduction strategies. He associated formalized tools with longer-term camps. Formalized generally refers to items that were manufactured for long-term use. This, he suggested, was a curation strategy intended to save energy in the long term by curating better, longer-lasting stone tools from high quality raw materials. Binford reinforced his theories through ethnographic analogy via studies of foraging societies, such as the Nunamiut and !Kung San (1980). Several other researchers point to the relationship between stone tool organization and settlement-subsistence practices (Bamforth, 1986; Henry, 1989; Andrefsky, 1994). Notably, systems theory and Binford's adaptation of middle range theory provided a general framework for empirical perspectives on technological relationships as studied in the archaeological record. That framework in conjunction with Schiffer's behavioral archaeology branched into economic and ecological perspectives to explain human behavior in terms of cultural-environmental interactions.

This thesis focuses on lithic artifacts under these general processual frameworks presented by Bradley (1975), Binford (1973; 1979), Schiffer (1987), and others. Like previous studies, this study examines the relationship of past people to proximity to sources, settlement type, and lithic production (Bamforth, 1986; Johnson, 1989; Andrefsky, 1994; Roth and Dibble, 1998; Beck et al., 2002). For instance, it is well documented that rare high-quality raw materials tend to be highly curated (Figure 3.1). This may be reflected at Placitas Arroyo. Distance decay is a geographical approach that supports this view of economizing behavior (Henry 1989). It also links not just distance to lithic sources, but also mobility patterns to lithic reduction sequences. According to Henry (1989), reduction strategy reconstruction is traditionally most influenced by resource distributions, site placement, and site permanence. Subsistence settlement patterns often relate to resource use economics. Since not all settlements are placed into binary mobile or sedentary camps, variability in mobility, once recognized, invites more questions about the kinds of relationships between resources and mobility across a landscape. Absent of a globally accepted law of behavior related to stone tools, local and environmental factors serve to mediate any previously accepted links to these relationships (Bamforth, 1991; Roth and Dibble, 1998). Each landscape and cultural complex is uniquely related to its environmental setting, thus subsequent technological phenomena are contingent upon those contexts and thus individuated. Kuhn (2014), for instance, argued that the majority of stone tool technology produced within Mousterian assemblages were not for extraction purposes, but rather, for other means such as processing. In other words, lithic production strategies can point to activities other than hunting. A more refined method of analysis can lead to identifying that variability. To this end, Ferring (1979) presented a finer resolution methodology in his study of blade technology from Negev, Israel. In his dissertation, he analyzes inter- and intra-assemblage variability to recognize behavioral related strategies indicative of cultural variability. His more comparatively systematic approach will be applied to the assemblages of Placitas Arroyo.



		Lithic Quality	
		High	Low
Lithic Abundance	High	Formal And Informal	Primarily Informal Tool
	Low	Primarily Formal Tool	Primarily Informal Tool

Figure 3.1: Relationship between abundance and quality of lithic materials and types of tool production (from Andrefsky 1994: 30; Figure 2).

In addition to using Ferring's refined approach for studying stone tool production, the proposed research provides the opportunity for an interesting regional comparative analysis. In this study, comparison to how stone tool production was assessed in the nearby Mimbres area can be made. Schriever et al. (2011) in their study of sites within the Mimbres Valley, west of Placitas Arroyo, investigated approaches to lithic procurement and production with respect to resource availability and settlement organization. They compared results from Late Pithouse period agricultural, semi-sedentary sites and short-term seasonally occupied hunting camps. Their study investigated differences in modes of subsistence and raw material procurement. Differences in lithic artifacts between the two site types were characterized by quality and availability of material as well as stone tool curation. Statistical analysis between the campsite and a pithouse site showed a difference in fine- and coarse-grained material selection between both sites, which showed more fine-grained reduction at the camps and more coarse-grained reduction at the pithouse site. Additionally, more formalize tools were observed at the camp site, and more informal tools at the pithouse agricultural site.

Morenon and Hays (1984) assessed that the Placitas Arroyo lithic assemblage supported the assumption that its previous inhabitants practiced lithic reduction using economizing strategies. They believed that materials were selected for different uses and that the materials in the assemblage reflect technological variability. The driver, they argued, is the accessibility of different (quality) of raw material.

Differences in lithic artifacts that suggest economizing strategies related to availability and quality of resources is expected at Placitas Arroyo. This is articulated with two general research questions: (1) Are there differences between the stone lithic production derived from local and non-local resources such as formal or informal tool production? (2) Are there differences in the quality and characteristics of raw materials, such as materials exhibiting crystalline (coarse-grained) versus cryptocrystalline (fine-grained) attributes between local and non-locally available materials? Further, two hypotheses from the research questions will be tested: (1) If distance to raw material influences lithic production, then materials outside of the local area will exhibit late stage production in flake debitage, whereas locally available resources will express all stages of production. (2) Similarly, fine-grained material will exhibit a higher frequency of late-stage production, whereas coarse-grained material will exhibit all stages of production. The underlying logic of both of these hypotheses is that late-stage reduction reflects greater investment in tool production, refinement, and curation, which is likely to be emphasized for higher quality raw material, particularly if such material was rare near Placitas Arroyo and had to be procured from distant sources. A corollary to these hypotheses is the prediction that the resulting lithic strategies are linked to specific activity areas between sites.

To address these hypotheses, stages of lithic production must be distinguished for debitage at Placitas Arroyo via the study of a reduction sequence. The debitage must be classified according to a set of attributes that relate to stages of production. Several approaches for studying lithic reduction are available (see the literature review). In addition to the production sequence, the geologic raw material must be identified through comparison to a representative collection from the vicinity of the archaeological sites. This study of lithic reduction will be organized in relation to processes that would have played out in the systemic context (Figure 3.2). To study the reduction sequence using this framework, attribute data of the debitage will be recorded. Artifact variability in assemblages is assumed to relate to the process of production and thus intended products (Ferring 1979). Approaches to identify patterns of variability such as chaîne opératoire allow an assessment of the complexity of a lithic assemblage and the choices made during lithic reduction (Sellet 1993). Regarding lithic raw materials and sources, the landscape surrounding the Placitas Arroyo is similar geologically to the nearby Mimbres Valley that was studied by Schriever et al. (2001). However, stone quality and composition are unique to the study area, and therefore will be analyzed separately.

In sum, this thesis will build upon previous studies in two ways. First, Ferring's (1979) refined system will be applied in the unique context of Placitas Arroyo to study local variability in stone tool organization related to settlement type, raw material location, and modes of subsistence. Second, Schriever et al. (2011) did a similar study of lithic production in the nearby Mimbres cultural area, dating to roughly the same period. Thus, this analysis of stone tool organization at Placitas Arroyo will be studied in comparison to similar studies filling a regional gap in the archaeological record. Both aspects of the proposed research will advance understanding of culture processes related to lithic production in the American Southwest.

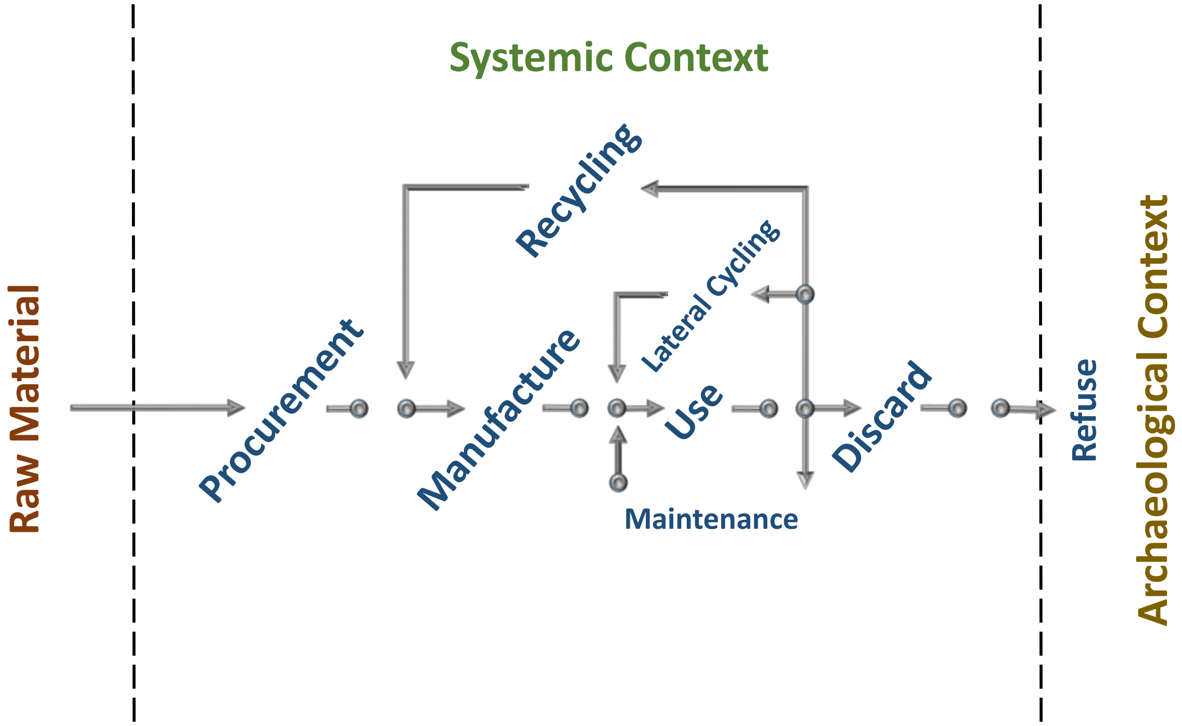


Figure 3.2: Life cycle of a durable element (from Schiffer 1972).

CHAPTER 4

METHODS AND MATERIALS

4.1 Artifact Collection

Flake artifacts were selected from the two sites at Placitas Arroyo containing pithouse structure features (PA2 and PA8). Both sites contain the highest concentration of lithic artifacts. Site PA8 contains the highest count of artifacts compared to all six sites excavated at Placitas Arroyo and includes five of six pithouses (Morenon and Hays 1976). PA2 contained a high volume of artifacts and contains one of six pithouses. It is suggested that the two sites may be related, only separated by an erosional gully. PA8 is considered a residential area whereas PA2 may have been extramural.

Following flake attribute classification, comparative statistical analyses were conducted to identify the differences in production to test the hypotheses stated in the previous section. Patterns and differences identified by statistical tests inform interpretation of lithic procurement, manufacture, and discard.

Flake data from the original site report (Morenon and Hays 1976) was entered into a digital spreadsheet from which PA8 and PA2 assemblages were used to inform expectations. Both sites contain pithouses, however, the pithouse at PA2 is located in the northwest corner of the excavation (Morenon and Hays 1976). Radiocarbon dates from pithouse post hole features points to a range of approximately 200 to 450 CE (with an outlier at 1000 CE from carbonized wood) at PA8, and AD 200 to 800 at PA2.

Due to the limited samples of subsurface artifacts, chronometric comparison may be unattainable. Subsequently, feature distributions indicating habitation and non-habitation areas were considered. Consultation of PA2 field maps produced by Morenon and Hays (1984) depict distributions of ceramics by pottery style, specifically, early and late ceramic. Ceramic types provide a temporal context that also reflect external developments. Two maps depicting early and late ceramic style distributions show a north-south distribution. The northern quarter of PA2 shows a higher concentration of early ceramic types, such as El Paso plainware, while other portions of the site contain later wares such as polychromes.

The original 1984 report nor any associated documents recovered from the curation files did not include an official artifact inventory. Subsequently, the artifacts were reevaluated, classified, and organized according to provenience. For example, all artifacts associated with PA8 were extracted, re-bagged and tagged according to the horizontal and vertical location of each unit and grouped accordingly. A general inventory was produced to inform analyses. Cataloguing revealed that despite sizeable samples of lithic artifacts, only complete flakes could be analyzed. This effort reduced the number of flakes anticipated for analysis. Nonetheless, classification comprised of complete flakes for each material type, with the exclusion of obsidian, of which there were no complete flakes. Not surprisingly, from the field observations that were implemented to determine stone source quantity and availability at Placitas Arroyo, obsidian sources, or cobbles, were not observed.

4.2 Raw Material Sources

Geologic material identification required an in-field survey of catchments and outcrops local to the study area. This survey provided baseline information on locally available material as well as a comparative sample with which to confirm material types of artifacts from Placitas Arroyo. Types which are not encountered in survey were presumed non-local.

Data acquisition involved a study of the geographic distribution of local raw materials via a pedestrian survey of catchments within a 2–3 km radius of the Placitas Arroyo archaeological sites. An initial assessment of topographic features using remote sensing data provided information on locations of alluvial drainages and potential rock outcrops were targeted for observation during field reconnaissance. Observations were documented using field notes, photography, and a global positioning system unit to record specific raw material locations to within 3-meter resolution

The intensity of raw material use as it relates to stone tool procurement behavior can be illustrated using Varien's (1999) cross-cultural comparisons. He suggests that the most intensely utilized resources occurs within a 2-km radius of an archeological site, and regular procurement practices occur within a 7-km radius. However, terrain variability, evident at Placitas Arroyo, results in a reduction of these radii (Varien 1999; Schriever et al. 2011). Similar studies within the nearby Mimbres culture area have conducted informal geologic surveys around the Mimbres Valley of New Mexico (Dockall 1991; Nelson 1981; Schriever et al. 2011), an area within the basin and range physiographic region, roughly 80 km to the west which is similar topographically to Placitas Arroyo, but of distinctly different geologic composition (see USGS 1995). Despite these geologic descriptions, identification of the stone tool resources from the UNT archaeology laboratory were verified comparative material from the project area. Previous regional studies conducted such surveys to identify locations of stone tool resources since geologic resources do not necessarily occur within their parent formation due to surface processes such as alluvial transport. In fact, many stone resources occur within alluvial settings as secondary sources, in the form of river cobbles (Nelson 1981; Schriever et al. 2011). The farthest of these resources may also likely include a very high-quality material in the form of obsidian, possibly carried over 200 miles via the Rio Grande from the Jemez Mountains to southern New Mexico (Church 2000; Glassock and Wolfman 1999).

Based on field observations, stone resources derive from a mixture of alluvial and colluvial secondary sources. It is likely that materials were collected from mostly nearby alluvial catchments and outcrops (Figures 4.1 through 4.3), the varieties of which were identified through field observations. Locally sourced materials identified within the drainages in the vicinity of the site included: tuff, basalt, quartzite, and chalcedony (Figures 4.4 through 4.7). Other sources of unknown origin were encountered around the archaeological sites: chert, petrified wood, jasper, obsidian, and other indeterminate material. Field survey did not adequately confirm that the latter group of stone material was in fact non-local. Several explanations for this problem are possible but were not investigated. While gravel material such as chert, quartzite, jasper, or petrified wood could have been sourced from the local gravels it is possible they may have been exhausted from prehistoric collection practices. Alternatively, field survey techniques may have yielded an inadequate sample area. For example, the Camp Rice Formation present to the north of the survey area and the highway, was not investigated. The lack of in-field documentation and analysis of some material could be a result of this researcher's lack of professional expertise in geologic identification. Consequently, a clearer understanding of the material source type (i.e. outcrop or gravel), was accomplished through the flake attribute analysis employed in the laboratory.

Figure 4.1: Photo of alluvium from arm of Placitas Arroyo. Alluvium gravels approximately 30% basalt and 10% tuff.

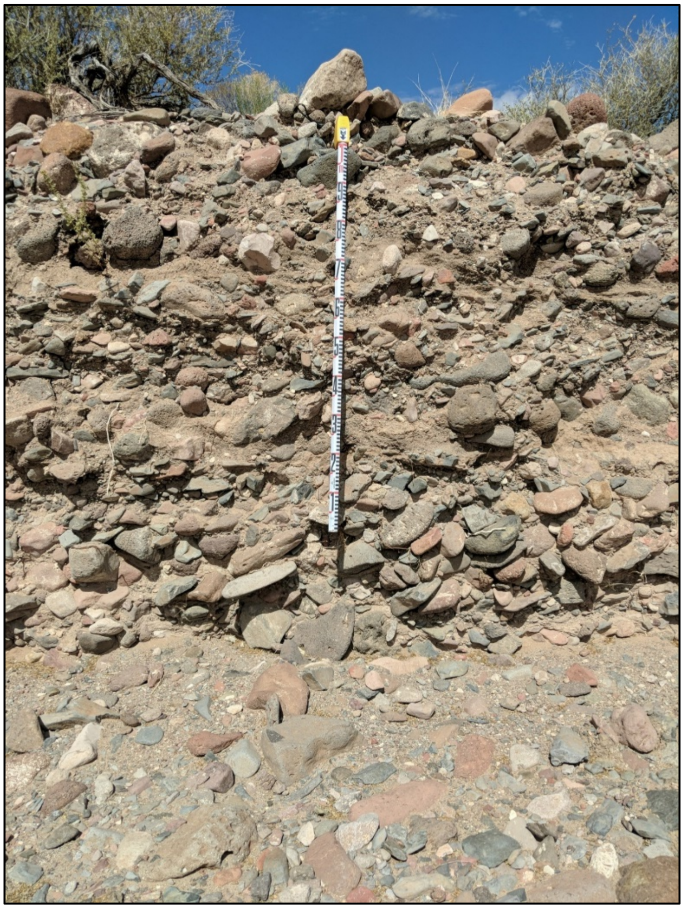


Figure 4.2: Photo of gravels in Placitas Arroyo cut bank. Matrix approximately 40% basalt and 25% tuff.

Figure 4.3: Photo of Placitas Arroyo alluvium, matrix approximately 20% basalt and 10% tuff.

Figure 4.4: Photo of a tuff boulder with chalcedony veins located along Placitas Arroyo channel.

Figure 4.5: Photo of a basalt boulder and cobbles located within Placitas Arroyo channel.

Figure 4.6: Photo of a quartzite cobble with use wear located along Placitas Arroyo drainage.

Figure 4.7: Photo of chalcedony cobble located along Placitas Arroyo channel.

4.3 Data Collection and Analysis

The analytical approach involved identifying visual attributes and measurements of (see below) complete flakes and recorded in a spreadsheet. Artifacts were analyzed using a 10X hand lens, attributes were assigned classes, and dimensions were taken in metric units using non-digital calipers.

This lithic analysis aims to interpret as much as possible the reductive stages of stone tool production beginning with the procurement of raw material, such as obsidian, chert, or basalt. This stage also involves testing and the initial reduction of the material, including removal of cortex, undesirable nodules, and preform creation (Ferring 1979). The second stage involves the shaping and preparation of blanks, raw material nodules to form cores or from the flake blanks, all of which have distinct morphologies. The final stage is the discard or loss of the artifact. Fracturing behavior, linked to the predictability of a stone when it breaks, is related to the mechanics of the Hertzian cone (Ferring 1979; Faulkner 1973; Speth 1972). Quality reflects the ability of a material to produce a desirable conchoidal fracture (Gramly 1980) which directly relates to texture, or size of the crystalline structure (Nelson 1981). Typological considerations and terminology in this study derive from Bradley (1975), Ferring (1979), and Debénath and Dibble (1994). Predictability of fracturing behavior of stone and a reliable typology enables a more refined technological analysis of tool life that conveys use strategies (Sellet, 1993).

Descriptive and inferential statistics were used to make inter- and intra-site comparisons of material type and lithic production attributes related to subsistence and settlement, and material abundance and availability. Statistical analyses compare local and non-local sources, such as coarse-grained versus fine-grained, as well as statistical variance comparisons of other attributes.

The flake attribute classes for this study includes the following listed variables:

- Discrete
  - Material
    - Tuff
    - Basalt
    - Rhyolite
    - Chert
    - Quartzite
    - Petrified wood
    - Chalcedony
    - Jasper
    - Obsidian
    - Rhyodacite
    - Other
  - Texture

        - Vitreous
        - Fine grained
        - Coarse grained
        - Poor
    - Cortex type
        - Indeterminate
        - Bedrock
        - Cobble
    - Platform type
        - Cortical
        - Unfaceted
        - Facetted
        - Crushed
    - Dorsal scar pattern
        - Unidirectional
        - Opposed
        - Crossed (transverse to the axis)
        - Radial (≥3 directions)
        - Core Trimming Element (CTE)
        - Cortical
- Continuous
    - Dorsal cortex
        - 0%
        - 1-25%
        - 25-50%
        - 50-75%
        - 75-99%
        - 100%
    - Length
    - Width
    - Thickness

Statistical tests were run to compare patterns among flake attributes. Continuous variables signify the sequence of the reduction continuum. This framework is achievable because the lithic process is reductive, as opposed to additive. For example, it is expected that smaller flakes with lower dorsal cortical percentages relate to later stages of reduction and larger flakes with higher dorsal cortical percentages to earlier stages of reduction. During reduction of flake technology, flake size and cortical content continuously reduces, and flake shape (width/thickness) may increase.

Analysis of assemblages from the Placitas Arroyo site complex reveals changing patterns of raw material procurement and selection, core reduction strategies, and tool production and discard. The most striking result thus far is the uniform emphasis on flake production from well-prepared cores, and the near absence of manufacture or maintenance of bifacial tools, especially projectile points. Associated with common ground stone artifacts, the flaked stone materials may represent intensive food or plant processing. Regardless, the technological patterns revealed by this approach illustrate a productive means to gain insights into changing behaviors in the Jornada Mogollon cultural tradition. Tools and debitage from two sites associated with pithouse structures, PA2 (LA13145) and PA8 (LA13151), were selected using stratified random sampling. Using SPSS software, sdscrete and continuous variables were recorded and analyzed using chi-square test of independence and Kruskal-Wallis H-test statistics to identify differences in chipped stone tool production techniques. Due to low frequencies of other material, statistical tests conducted on the assemblages compared differences in reduction between tuff (49% of total PA2 and PA8 sample) and basalt (32% of total PA2 and PA8 samples).

CHAPTER 5

RESULTS

5.1 Introduction

The goal of this research is to understand the variation in the lithic artifacts through study of the lithic reduction system. This will be determined by first analyzing the frequency of material type and quality within the assemblages, including the cortex types. Reduction patterns of the most common lithic materials in these samples, tuff and basalt were tested. Those results are expected to reveal differences in production systems spatially and/or temporally. Comparison of those test results with tool assemblages and morphologies were analyzed to characterize patterns of variability within and between sites. Following the results is a discussion about the relationship of lithic production at the two sites and subsistence patterns at Placitas Arroyo.

5.2 Procurement

5.2.1 Sources

Lithic materials procured by past residents at Placitas Arroyo include both local and non-local types (Table 5.1). This study intends to test whether there was an emphasis of high-quality non-local material or lower-quality local material. The 1984 report data revealed that non-local, fine-grained resources, such as obsidian, show a lower frequency than the local coarser-grained resources. Analogous patterns among flakes was found in this study. Insufficient subsurface collection samples resulted in no stratigraphic evaluation of reduction patterns. However, sites PA2 and PA8 serve as the analytical units to compare results. Lithic evaluations in the 1984 report show the early stage of decortification, expressed as a primary flake (100% cortex on the dorsal surface), shows counts among the coarse-grained material and less often or never for the fine-grained material. This indicates that the early-stage flake removal among finer-grained material likely occurred before those materials were transported from their source then entered the archaeological site. Lithic reduction analysis by the 1984 report categorizes cortical percentage as primary (100% cortex), secondary (1-99% cortex), and tertiary (0% cortex) flake types. This thesis study reclassified cortical percentages into more categories (see Chapter 4 Methods and Materials) in order to identify patterns or techniques used during decortication and reduction. Further support of these relationships is supplemented by site reconnaissance conducted in the summer of 2018, and the following statistical tests.

Of the total sample of chipped stone flakes analyzed at both sites (n=937), 49% of the assemblage is comprised of tuff and 32% is comprised of basalt. Of the analyzed flakes, cobble cortex types comprised of almost all tuff flakes ate PA2 and PA8, and 100% of all basalt flakes (Table5.2). Flake sample sizes of other materials encountered at Placitas Arroyo falls below the standards of statistical testing and were therefore excluded from the following results (Table 5.1).

Table 5.1: Analyzed flake sample material from PA2 and PA8.

Stone Material	n PA2	Percent	n PA8	Percent	Grain Size
Tuff	132	37.1	327	56.3	Vitreous to very coarse
Basalt	149	41.9	155	26.7	Fine to very coarse
Other	19	5.3	36	6.2	Vitreous to very coarse
Chert	19	5.3	25	4.3	Vitreous to fine
Quartzite	23	6.5	1	0.2	Vitreous to fine
Chalcedony	10	2.8	11	1.9	Vitreous to coarse
Rhyolite	3	0.8	15	2.6	Vitreous to fine
Jasper	1	0.3	7	1.2	Vitreous
Petrified Wood	1	0.3	4	0.7	Vitreous to coarse
Total	356	100	581	100	

Further evidence that the majority of lithics at Placitas Arroyo are locally procured was revealed by identification of cortex types on the flake samples. Lithic analysis revealed that both tuff and basalt flakes derived from cobble sources (Table 5.2). Indeterminate typically indicates flakes absent of cortex. Bedrock comprised of nearly 0% of lithic sources. The highest frequencies of cores and core fragments reported by Morenon and Hays (1984) were tuff, basalt, and chert. Most common at PA2 and PA8 were tuff cores, followed by basalt. Most common at PA2 and PA8 were tuff cores, followed by basalt (Table 5.3).

Table 5.2: Cortex type for tuff and basalt flakes.

Site	Material	% Cobble	% Bedrock
PA2	Tuff	98.6	1.4
	Basalt	100	0.0
PA8	Tuff	99.3	0.7
	Basalt	100	0.0

Table 5.3: Core and core fragment counts from PA2 and PA8 (from Morenon and Hays 1984).

Material		n PA2	Percent	n PA8	Percent
Tuff	Core	55	17.3	48	26.0
	Core Fragment	139	43.7	83	44.9
Basalt	Core	88	27.7	39	21.0
	Core Fragment	36	11.3	15	8.1
Total		318	100	185	100

5.2.2 Material Quality

Attributes between tuff and basalt as well as patterns in reduction techniques were compared using statistical testing. Frequency calculations revealed differences in texture between tuff and basalt (Table 5.1), thus, whether material texture and material type had any significance was tested. Tuff is typically more fine-grained than basalt. A chi square test of independence was performed to determine if there is an association between material type and quality. A significant difference was observed ($X^2_{(3)}=374.80$, $\alpha=0.01$, $\phi=0.70$) with a strong effect. Basalt was predominantly coarse grained of poor quality, whereas tuff was predominantly fine-grained (Table 5.4).

Table 5.4: Grain size frequency among analyzed flakes (PA2 and PA8 combined samples).

Texture	% Tuff	% Basalt
Vitreous	18.1	0.7
Fine Grained	54.0	2.6
Coarse Grained	20.3	43.3
Poor Quality	7.6	53.3

5.3 Lithic Reduction

Differences in texture between the two most frequent lithic materials at Placitas Arroyo may lead to differences in reduction strategies. Chi-square testing was done to determine if strategies such as flaking patterns or platform preparation relate to cortex amount. It is expected that these patterns will change as cortex is removed or reduced. In addition to cortex amount, flake size and shape was also compared to faceting and platform preparation patterns using Kruskal-Wallis tests. It is expected that these strategies will change with differences in shape and size of flakes.

5.3.1 Cortical Removal

Cortical removal testing compares tuff and basalt flakes at both PA2 and PA8. Cortical reduction may associate with techniques such as patterns of flake removal from the dorsal surface. This study also looks at potential platform preparation patterns against cortical reduction. The following eight chi-square tests were done to identify lithic reduction patterns during cortex removal (Table 5.5). They reveal that flaking patterns change with cortical removal, specifically for basalt flakes from both sites. Unidirectional and radial flaking patterns increase in frequency when initial cortex is removed from basalt core blanks. PA8 tuff flakes exhibit a stronger distribution of unidirectional over radial flaking patterns. Overall, this relationship is stronger among basalt flakes at both sites. Platform types do not vary with cortex removal.

Table 5.5: Chi Square of cortical reduction comparing attributes to the dorsal cortical amount.

Test Variables	Site	Material (n)	Test Stat	p value[a]	ϕ Phi
Scar Pattern	PA2	Tuff (129)	23.09	.111	-
df = 16		Basalt (134)	63.99	<.001	0.69
	PA8	Tuff (316)	42.73	<.001	0.37
		Basalt (142)	60.02	<.001	0.65
Platform Type	PA2	Tuff (129)	24.95	.015	-
df=12		Basalt (134)	13.14	.359	-
	PA8	Tuff (316)	14.76	.542	-
		Basalt (142)	10.52	.570	-

5.3.1.1 Cortical Reduction and Dorsal Scar Patterns

A chi square test of independence was performed to determine if there is an association between dorsal cortical percentage and scar pattern for tuff and basalt flakes at PA2 and PA8. The null hypothesis is that there is no association between dorsal cortical amount and scar patterns. All dorsal scar patterns were included in the test except for 100% cortical category of flaking patterns, because it represents the absence of a scar pattern. Crosstabs comparing scar patterns with dorsal cortical amounts, however, does include the 100% cortex category for scar patterns so that accurate observations of differences are identified.

5.3.1.1.1 PA2 Basalt

A chi-square test of independence was performed with basalt at PA2, with a significant difference ($X^2_{(16)}$=63.99, α=0.01, P<.001, ϕ=0.69) with a strong effect. Flaking patterns in basalt at PA2 varied during the reduction of cortex. A crosstabs analysis shows that unidirectional flaking was implemented across 36.2% of the sample, and radial was implemented across 40.3%.

The distribution of these two patterns between the dorsal cortical percentages reveal a gradually increasing use of both flaking techniques. Core trimming and fully cortical flakes were among the highest cortical percentages. Flakes exhibited both unidirectional and radial scar pattern types as cortex amount reduces. Both scar patterns occur predominantly with very low cortical percentages between 0-25%. Opposed flaking patterns were predominantly without cortex. Crossed patterns were produced evenly between the bottom four cortical percentages (0%, 1-25%, 25-50%, 50-75%; Table 5.6).

Table 5.6: Crosstabs of PA2 basalt scar patterns with dorsal cortex amount

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
Unidirectional	% within Scar Pattern	42.6%	24.1%	18.5%	11.1%	3.7%	0.0%
	Residual	1.1	0.4	1.2	-0.3	-1.2	-2.3
Opposed	% within DScarPat	50.0%	25.0%	0.0%	12.5%	12.5%	0.0%
	Residual	0.8	0.2	-1.0	0.0	0.4	-0.9
Crossed	% within DScarPat	25.0%	25.0%	25.0%	25.0%	0.0%	0.0%
	Residual	-0.3	0.2	0.7	0.7	-0.6	-0.6
Radial	% within DScarPat	38.3%	26.7%	13.3%	16.7%	5.0%	0.0%
	Residual	0.5	0.9	0.1	0.8	-1.0	-2.5
CTE	% within DScarPat	0.0%	0.0%	0.0%	12.5%	87.5%	0.0%
	Residual	-1.7	-1.3	-1.0	0.0	7.5	-0.9
100% Cortex	% within DScarPat	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	Residual	-2.3	-1.8	-1.4	-1.4	-1.1	11.0
Total	% within DScarPat	34.2%	21.5%	12.8%	12.8%	8.7%	10.1%

5.3.1.1.2 PA8 Basalt

PA8 basalt flakes were also tested. A significant difference was observed ($X^2_{(25)}$=220.51, α=0.01, P<.001, ϕ=0.65) with a strong effect, and the null hypothesis was rejected. Unidirectional flaking was implemented 42.6% of the time, and radial was implemented 27.1% of the time. Basalt flakes at PA8 differ in that they had a higher proportion of unidirectional flaking. PA8 basalt core trimming and fully cortical flakes were among the highest cortical percentages. Flakes exhibited both unidirectional and radial scar pattern types as cortex amount reduces. Both scar patterns occur predominantly with very low cortical percentages between 0-25%. Opposed flaking patterns were predominantly 1-50% cortex. Crossed patterns were produced with cortical percentages at 0% or 25-50% (Table 5.7).

Table 5.7: Crosstabs of PA8 basalt scar patterns with dorsal cortex amount

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
Unidirectional	% within Scar Pattern	31.8%	24.2%	18.2%	15.2%	10.6%	0.0%
	Residual	-0.2	1.5	0.1	0.8	-0.4	-2.4
Opposed	% within Scar Pattern	0.0%	20.0%	40.0%	20.0%	20.0%	0.0%
	Residual	-1.3	0.2	1.2	0.6	0.5	-0.6
Crossed	% within Scar Pattern	33.3%	13.3%	20.0%	33.3%	0.0%	0.0%
	Residual	0.0	-0.3	0.2	2.5	-1.4	-1.1
Radial	% within Scar Pattern	59.5%	16.7%	19.0%	0.0%	4.8%	0.0%
	Residual	2.9	0.0	0.3	-2.2	-1.4	-1.9
CTE	% within Scar Pattern	7.1%	0.0%	14.3%	14.3%	64.3%	0.0%
	Residual	-1.7	-1.5	-0.3	0.3	5.6	-1.1
100% Cortex	% within Scar Pattern	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	Residual	-2.1	-1.5	-1.5	-1.2	-1.3	11.4
Total	% within Scar Pattern	33.5%	16.8%	17.4%	11.6%	12.3%	8.4%

5.3.1.1.3 PA2 Tuff

PA2 tuff was the only test pertaining to cortical reduction that was not significant (Table 5.9). Most of the flakes were unidirectional or radial. Core trimming elements ranged from 50-99% cortex. Radial and unidirectional flakes were primarily without cortex. Opposed flake patterns were 0-25% cortex, and crossed patterns were either 0% or 50-75% (Table 5.8). PA2 overall does not have a difference in reduction strategies. Scar patterns were implemented as needed while cortex was reduced.

Table 5.8: Crosstabs of PA2 tuff scar patterns with dorsal cortex amount

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
Unidirectional	% within Scar Pattern	41.3%	21.7%	13.0%	13.0%	10.9%	0.0%

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
	Residual	-0.6	0.0	0.0	1.1	1.1	-1.0
Opposed	% within Scar Pattern	37.5%	37.5%	0.0%	12.5%	12.5%	0.0%
	Residual	-0.4	0.9	-1.0	0.4	0.6	-0.4
Crossed	% within Scar Pattern	33.3%	0.0%	33.3%	0.0%	33.3%	0.0%
	Residual	-0.4	-0.8	1.0	-0.5	1.8	-0.3
Radial	% within Scar Pattern	58.0%	21.7%	14.5%	4.3%	1.4%	0.0%
	Residual	1.2	0.0	0.4	-1.1	-1.7	-1.3
CTE	% within Scar Pattern	0.0%	33.3%	0.0%	33.3%	33.3%	0.0%
	Residual	-1.2	0.4	-0.6	1.5	1.8	-0.3
100% Cortex	% within Scar Pattern	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	Residual	-1.2	-0.8	-0.6	-0.5	-0.5	11.2
Total	% within Scar Pattern	47.7%	22.0%	12.9%	8.3%	6.8%	2.3%

5.3.1.1.4 PA8 Tuff

A significant difference was observed with PA8 tuff flakes ($X^2_{(25)}=42.73$, $\alpha=0.01$, $P<.001$, $\phi=0.37$), with a moderate effect. Crosstabs revealed that unidirectional flaking had a higher frequency at 44% of PA8 tuff flakes, and radial had a frequency of 31.5%. PA8 tuff core trimming elements are found with the most cortical content, however, the majority of flakes in that cortical category are unidirectional. Unidirectional flaking is implemented just as often throughout the entire cortical reduction sequence. Radial flaking patterns are mostly implemented when the cortex is nearly or entirely removed. For most PA8 cortical reduction unidirectional flaking is preferred, and radial patterns are sometimes implemented when nearly cortex is removed. This later stage removal preference is also present in PA8 basalt flakes. (Table 5.9).

Table 5.9: Crosstabs of PA8 tuff scar patterns with dorsal cortex amount

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
Unidirectional	% within Scar Pattern	59.7%	18.1%	10.4%	5.6%	6.3%	0.0%
	Residual	0.2	0.3	-0.2	0.5	0.4	-2.2
Opposed	% within Scar Pattern	42.9%	14.3%	23.8%	9.5%	9.5%	0.0%
	Residual	-0.9	-0.3	1.8	1.1	0.8	-0.8
Crossed	% within Scar Pattern	85.2%	7.4%	7.4%	0.0%	0.0%	0.0%
	Residual	1.8	-1.2	-0.6	-1.1	-1.2	-1.0

Scar Pattern		Dorsal Cortex Amount					
		0%	1-25%	25-50%	50-75%	75-99%	100%
Radial	% within Scar Pattern	65.0%	20.4%	9.7%	3.9%	1.0%	0.0%
	Residual	0.9	0.8	-0.4	-0.3	-2.0	-1.9
CTE	% within Scar Pattern	28.6%	19.0%	19.0%	4.8%	28.6%	0.0%
	Residual	-1.8	0.2	1.1	0.0	4.5	-0.8
100% Cortex	% within Scar Pattern	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
	Residual	-2.5	-1.4	-1.1	-0.7	-0.8	17.5
Total	% within Scar Pattern	58.4%	17.1%	11.0%	4.6%	5.5%	3.4%

5.3.1.2 Cortical Reduction and Platform Types

Across basalt and tuff flakes at PA2 and PA8, dorsal scar patterns associated significantly with cortical removal. In order to determine if platforms were prepared according to how much cortex was removed, chi-square tests of independence were performed to determine if there is an association between dorsal cortical percentage and platform type for tuff and basalt flakes from PA2 and PA8. The null hypothesis is that there is no association between dorsal cortex amount and platform types. No significant difference was observed between tuff flakes or basalt flakes at PA2 (Table 5.5). Comparison with PA8 resulted in no significant results between tuff and basalt flakes as well. This means that at both sites platform preparation was done on an as-needed basis for both material.

5.3.2 Flake Size

In addition to dorsal cortical removal, this study also focuses on what patterns of removal and platform preparation on which flake size is dependent. As with cortical reduction, flake size is tested against dorsal scar pattern types and platform preparation. In order to determine whether size of flakes is dependent on a given test variable, a Kruskal-Wallis H non-parametric test was used. Very little association was identified between the variables with flake size (Table 5.10). There was one significant result, however, between scar pattern and flake size among tuff flakes at PA8. Mean sizes of tuff flakes are significantly different, in which after initial cortex is removed, radial flaking is often applied. This strategy is consistent with the patterns of radial flaking associated with cortical removal, and other complex flaking patterns emerge with the reduction of flake size. A more complex reduction system is seen at PA8, but PA2 tuff results indicate larger flakes were the intended product and smaller flakes did not require a system of flaking patterns.

Table 5.10: Kruskal-Wallis H test for size[a] of flake.

Test Variable	Site	Material (n)	Test Stat	p value[b]	η^2 Eta Squared
Scar Pattern	PA2	Tuff (132)	69.09	.676	-
df=5		Basalt (149)	9.93	.077	-
	PA8	Tuff (327)	30.56	<.001	.95
		Basalt (155)	13.80	.017	-
Platform Type	PA2	Tuff (108)	8.92	.012	-
df=2		Basalt (141)	0.91	.636	-
	PA8	Tuff (276)	2.11	.348	-
		Basalt (138)	2.85	.241	-

a = (L x W x T) / 1000; b = Denotes values with a confidence level of 0.01.

5.3.2.1 Flake Size with Scar Patterns

A Kruskal-Wallis H test was performed to determine the difference between scar pattern and median flake size for tuff and basalt flakes from PA2. The null hypothesis that there is no size difference among scar patterns was accepted for both tuff and basalt (Table 5.10)

PA8 dorsal scar patterns returned different results than PA2. The null hypothesis for basalt flakes from PA8 was accepted (Table 5.10), however, the null hypothesis for tuff flakes was rejected ($X^2_{(5)}$=30.56, α=0.01, P<.001, η^2=0.95) with a strong effect. The highest mean rank flakes observed are either core trimming type or 100% cortex. Smaller tuff flakes exhibit unidirectional, opposed, and crossed patterns. Radial ranks a higher mean than the latter three categories (Table 5.11; Figure 5.1). The strong effect supports the conclusion that flake size is dependent on the type of scar patterns. Once the largest flakes are removed, radial flaking is then applied to remove flakes, but opposed, crossed, and unidirectional patterns are applied to achieve smaller size flakes.

Table 5.11: Mean rank PA8 tuff flake size with dorsal scar pattern: size.

Dorsal Scar Pattern	N	Mean Rank
Unidirectional	144	141.91
Opposed	21	138.38
Crossed (proximal scars to axis)	27	137.28
Radial (>/= 3 directions)	103	189.51
CTE	21	220.19
100% Cortex	11	221.55
Total	327	

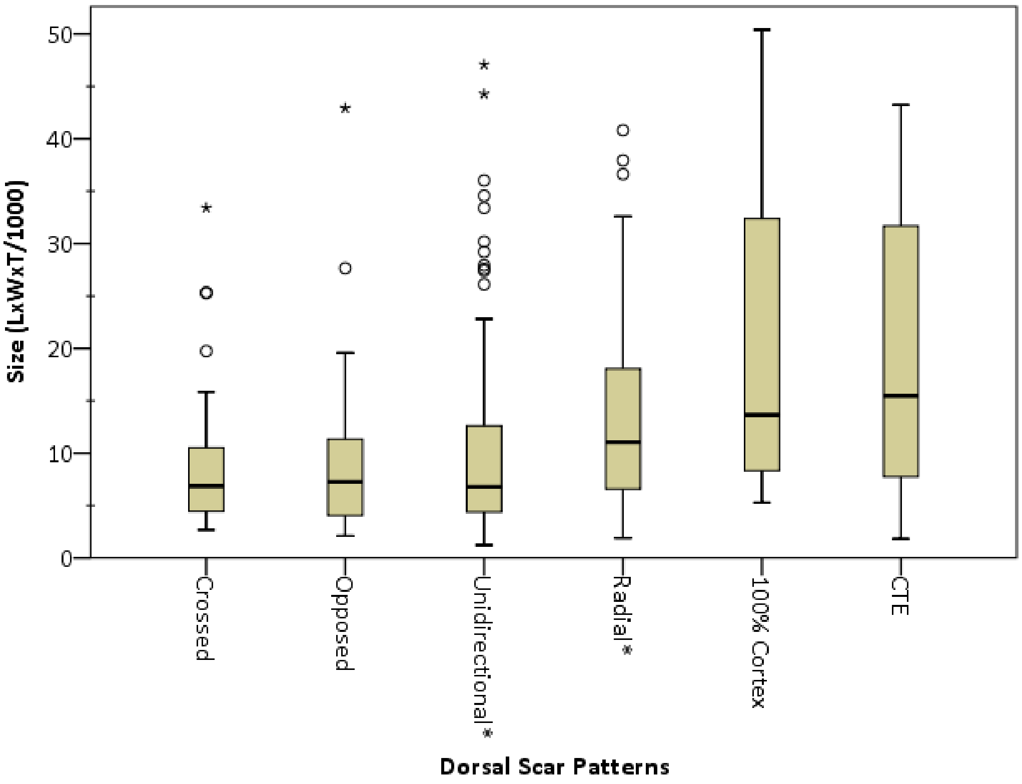


Figure 5.1: Boxplot of PA8 tuff flake size among scar patterns.*= Denotes categories that contain outliers above 50.

To summarize, at PA2 size of flakes was found not dependent on dorsal scar patterns for either tuff or basalt. However, flake size of PA8 tuff flakes was significantly dependent on dorsal scar patterns (Table 5.11). PA2 flakes may have been the result of a different desired product.

5.3.2.2 Flake Size with Platform Types

The same tests were performed to determine the difference between platform type and median flake size for tuff and basalt flakes from PA2 and PA8. The null hypothesis is that there is no size difference among platform types. The null hypothesis was accepted for all four tests. Between PA2 and PA8, both basalt and tuff flakes exhibited no difference of flake size against platform types. Flake size was not dependent on platform preparation in any case (Table 5.11).

5.3.3 Flake Shape

Like flake size, flake shape may be influenced by specific reduction techniques. When the intent is to increase the width to thickness ratio of a blank, flake shape likewise increases. The following results reflect similar phenomena to the previous tests with flake size. In order to determine whether shape of flakes is dependent on a given test variable, a Kruskal-Wallis H non-parametric test was used. Again, platform type has no effect on flake shape. PA8 tuff flaking patterns had a strong effect on size of flakes, and a weak effect on shape of flakes. Just as unidirectional and crossed flaking methods were applied to achieve smaller flakes, as flakes increase in shape the same is true. Core trimming elements rank lowest because these pieces are often thick which is why they are removed much earlier. The irregular trend (Figure 5.2) and weak effect show that reducing flake size fits the patterns of reduction better than reduction in thickness of a blank among PA8 tuff.

Table 5.12: Kruskal-Wallis H test for shape[a] of flake.

Test Variable	Site	Material (n)	Test Stat	p value[b]	η^2 Eta Squared
Scar Pattern	PA2	Tuff (132)	4.85	.435	-
df=5		Basalt (149)	12.31	.031	-
	PA8	Tuff (327)	13.04	.001	.10
		Basalt (155)	3.46	.629	-
Platform Type	PA2	Tuff (108)	2.68	.262	-
df=2		Basalt (141)	0.01	.993	-
	PA8	Tuff (276)	2.22	.329	-
		Basalt (138)	0.61	.739	-

a = Width/Thick

5.3.3.1 Flake Shape and Dorsal Scar Pattern

A Kruskal-Wallis H test was performed to determine the difference between scar pattern and median flake shape for samples from PA2. The null hypothesis is that there is no shape difference among scar patterns. For tuff and basalt at PA 2 the null hypothesis was accepted (Table 5.12).

When flakes from PA8 were tested, the null hypothesis was accepted or basalt (Table 5.13), but for tuff the null was rejected ($X^2_{(5)}=13.04$, $\alpha=0.01$, $P=.001$, $\eta^2=0.10$), with a weak effect. Between PA2 and PA8, only PA8 tuff dorsal scar patterns had an effect on flake shape. Among tuff flakes from PA8, the highest mean ranked flake shapes are associated with a crossed scar pattern (Table 5.13). This means that later in the reduction process, as shape is achieved by increasing the ratio of width to thickness, a crossed pattern of flaking is utilized. The earlier stages of cortical removal that include full cortical coverage or core trimming elements, the mean rank is smallest, suggesting that thicker flakes are removed early during reduction. Opposed flaking patterns were likely applied to thicker flakes as well. However, the weak effect of shape dependency may relate to the variability of median shape of flaking patterns (Figure 5.2).

Table 5.13: Mean rank PA8 tuff flake size with dorsal scar pattern: shape.

Dorsal Scar Pattern	N	Mean Rank
Unidirectional	144	174.85
Opposed	21	136.12
Crossed (proximal scars to axis)	27	202.52
Radial (>/= 3 directions)	103	161.14
CTE	21	97.71
100% Cortex	11	133.91
Total	327	

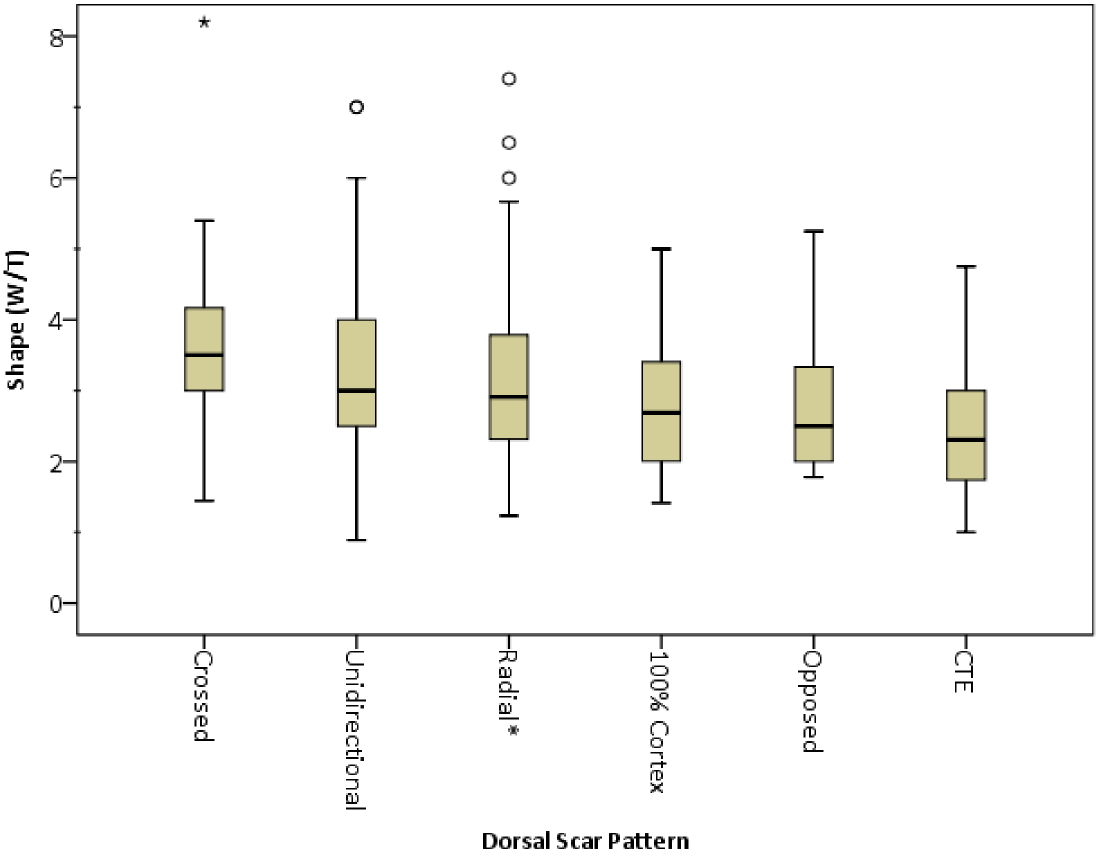


Figure 5.2: Boxplot of PA8 tuff flake shape among scar patterns.*= Denotes categories that contain outliers above 8.

5.3.3.2 Flake Shape and Platform types

The same tests were performed to determine the difference between platform type and median flake shape for tuff flakes from PA2. The null hypothesis is that there is no size difference among platform types. The null hypothesis was accepted for all four tests. Between PA2 and

PA8, both basalt and tuff flakes exhibited no difference of flake shape against platform types. Like with flake size, flake shape was not dependent on platform preparation in any case (Table 5.13). Of all the flakes analyzed from both sites, only PA8 tuff flake shape varied among dorsal scar patterns (Table 5.13). Flake shape does not depend on platform types at both PA2 and PA8.

5.3.4 Interior Flake Size

In order to analyze the reduction process further, interior flake size and shape were tested by comparing the same variables among flake samples using the Kruskal-Wallis H test. For this portion of the study, interior flakes are classified as having 0% cortex on the dorsal surface. This portion seeks to identify similar techniques to later stages of reduction. In concert with flake size tests of the previous sample, PA8 tuff flakes again emerge as the only significant result (Table 5.14). A strong association with size and dorsal scar patterns supports previous findings in which radial flaking is followed by unidirectional, opposed, and crossed flaking patterns amid decreasing flake size (Table 5.14, Figure 5.3).

Table 5.14: Kruskal-Wallis H test for size[a] of interior flake.

Test Variable	Site	Material (n)	Test Stat	p value[b]	η^2 Eta Squared
Scar Pattern	PA2	Tuff (63)	3.60	.309	-
df=3		Basalt (51)	3.16	.367	-
	PA8	Tuff (185)	22.39	<.001	.96
		Basalt (51)	2.33	.311	-
Platform Type	PA2	Tuff (48)	4.02	.133	-
df=2		Basalt (46)	0.19	.909	-
	PA8	Tuff (156)	1.20	.549	-
		Basalt (45)	1.14	.287	-

a = (L x W x T) / 1000

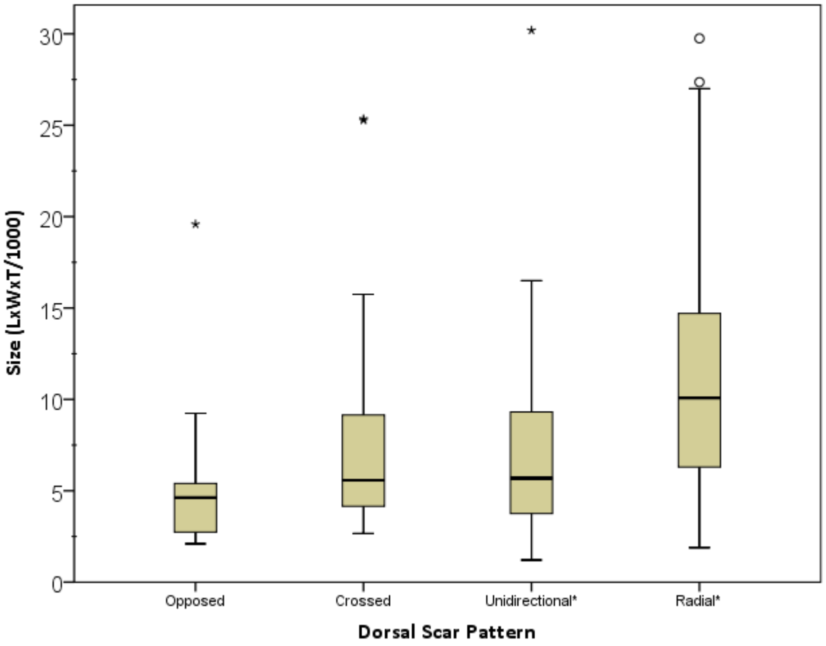


Figure 5.3: Boxplot of PA8 interior tuff flake shape among scar patterns.* = Denotes categories that contain outliers above 30.

5.3.4.1 Interior Flake Size and Scar Pattern

A Kruskal-Wallis H test was performed to determine the difference between scar pattern and median flake size for interior tuff and basalt flakes from PA2 and PA8. The null hypothesis that there is no size difference among scar patterns was accepted for both tuff and basalt at PA2, as well as basalt flakes at PA 8 (Table 5.15). However, for PA8 tuff interior flakes the null was rejected ($X^2_{(3)}$=22.39, α=0.01, P<.001, η^2=0.96), with a strong effect. Larger tuff interior flakes are a result of radial flaking patterns, whereas crossed, opposed, and unidirectional flaking patterns result in smaller interior tuff flakes (Table 5.15, Figure 5.3).

Table 5.15: PA8 tuff interior flake size with dorsal scar pattern: size.

Dorsal Scar Pattern	N	Mean Rank
Unidirectional	86	79.96
Opposed	9	60.72
Crossed (proximal scars to axis)	23	84.52
Radial (>/= 3 directions)	67	116.99
Total	185	

5.3.4.2 Interior Flake Size and Platform Type

The same tests were performed to determine the difference between platform type and median interior flake size for basalt and tuff flakes from PA2 and PA8. The null hypothesis is that there is no size difference among platform types and was accepted for all four tests. Between PA2 and PA8, both basalt and tuff interior flakes exhibited no difference of flake size against platform types. Interior flake size was not dependent on platform preparation in any case (Table 5.15).

5.3.5 Interior Flake Shape

Interior flake shape was tested by comparing the same variables among flake samples. Again, interior flakes are classified as having 0% cortex on the dorsal surface, and a Kruskal-Wallis H test was used to determine if dorsal flaking patterns or platform types had an effect on flake shape. As before, platform types had no effect on flake shape. Only one test came back significant, but it was not consistent with previous tests. Dorsal scar patterns of interior tuff flakes from PA2, not PA8, had a strong effect on shape. What remains consistent with previous tests of flake size and shape, is the material type and the relationship of radial and crossed patterns to later stages of reduction (Table 5.16, Figure 5.4). The site is different, and there is less emphasis of crossed and opposed patterns than was expected among PA8 tuff flakes. Radial patterns in this case associate with larger shape size, which, in contrast to tuff flake patterns from PA8, is more consistent with discoidal reduction in which there is no directional change in flake size/shape during reduction.

Table 5.16: Kruskal-Wallis H test for shape[a] of interior flake.

Test Variable	Site	Material (n)	Test Stat	p value[b]	η^2 Eta Squared
Scar Pattern	PA2	Tuff (63)	10.29	<.001	.78
df=3		Basalt (51)	2.67	.445	-
	PA8	Tuff (185)	5.37	.146	-
		Basalt (51)	0.90	.636	-
Platform Type	PA2	Tuff (48)	0.75	.688	-
df=2		Basalt (46)	0.11	.946	-
	PA8	Tuff (156)	1.31	.519	-
		Basalt (45)	0.80	.372	-

a = Width/Thick

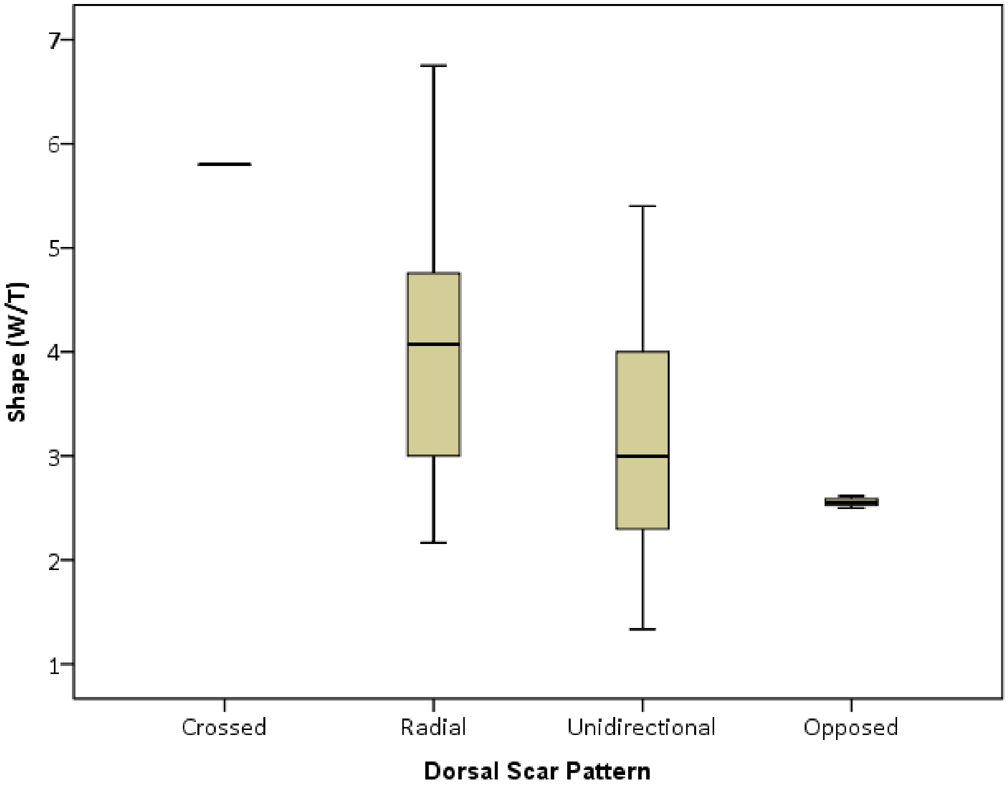


Figure 5.4: Boxplot of PA2 tuff interior flake shape and dorsal scar pattern.

5.3.5.1 Interior Flake Shape and Dorsal Scar Pattern

A Kruskal-Wallis H test was performed to determine the difference between scar pattern and median flake shape for interior tuff and basalt flakes from PA2 and PA8. The null hypothesis that there is no shape difference among scar patterns was accepted for PA2 basalt, and PA8 tuff and basalt flakes (Table 5.16). For PA2 tuff flakes the null hypothesis was rejected ($X^2_{(3)}$=10.29, α=0.01, P<.001, η^2 = 0.78), with a strong effect. Unidirectional flaking techniques were found on relatively thick flakes. As the width to thickness radio increased, later in reduction, radial flaking patterns were applied (Figure 5.4). The effect is strong, but this may be skewed due to the very low counts of two categories, or, a different intended product at PA2 than PA8.

Table 5.17: Mean PA2 interior tuff flake shape and dorsal scar pattern: shape.

Dorsal Scar Pattern	N	Mean Rank
Unidirectional	19	24.50
Opposed	3	15.00
Crossed (proximal scars to axis)	1	61.00
Radial (>/= 3 directions)	40	36.11
Total	63	

Interestingly, this is the first test regarding flake shape or size that did not return a significant result for PA8 tuff flakes. In previous tests, PA2 flakes did not return significant results between selected variables among either flake size or shape. Interior tuff flake shape, however, showed strong dependence on flaking patterns that transition from unidirectional to radial flaking patterns during the removal of interior tuff flakes (Table 5.17).

5.3.5.2 Interior Flake Shape and Platform Type

The same tests were performed to determine the difference between platform type and median interior flake shape for basalt and tuff flakes from PA2 and PA8. The null hypothesis is that there is no shape difference among platform types. The null hypothesis was accepted for all four tests. Between PA2 and PA8, both basalt and tuff interior flakes exhibited no difference of flake shape against platform types. Interior flake shape was not dependent on platform preparation in any case (Table 5.17). Between PA2 and PA8, both basalt and tuff interior flakes exhibited no difference of flake shape against platform types. Interior flake shape was not dependent on platform preparation. This was true for all flake types in this study.

5.4 Tools

The Placitas Arroyo assemblages were dominated by flake tools, with very little emphasis on projectile points. Tool types which were not analyzed in this lithic study were metates and manos and core tools, but are considered for context (see Chapter 6 Discussion and Conclusion). Of the flake tools from PA2 and PA8, no significant association with material and tool type were found due to low counts of complete flake tools (Table 5.18). The report shows PA2 surface tuff retouched flakes (n=140) far exceeding basalt retouched flakes (n=46), and PA8 surface and pithouse retouched tuff tools (n=160) exceeding basalt retouched flakes (n=44; Morenon and Hays 1984).

Conclusively, tuff flake tools are much more common than basalt flake tools. Conversely, basalt represents a large percentage of cores (Figure 6.3). Observation of cores reveals a radial pattern of flake removal on basalt cores (Figures 5.6 and 5.7) and tuff cores with a unidirectional flaking pattern (Figure 5.8). This evidence suggests that basalt may have been reduced to produce different tools while tuff was reduced to create flakes.

Table 5.18: Complete flake tool counts by material type.

Tool Type	Tuff	Basalt	Rhyolite	Chert	Chalcedony
Retouch	2	0	0	1	0
Denticulate	3	2	0	0	0
Scraper	5	1	2	0	1
Notched	4	0	0	0	0

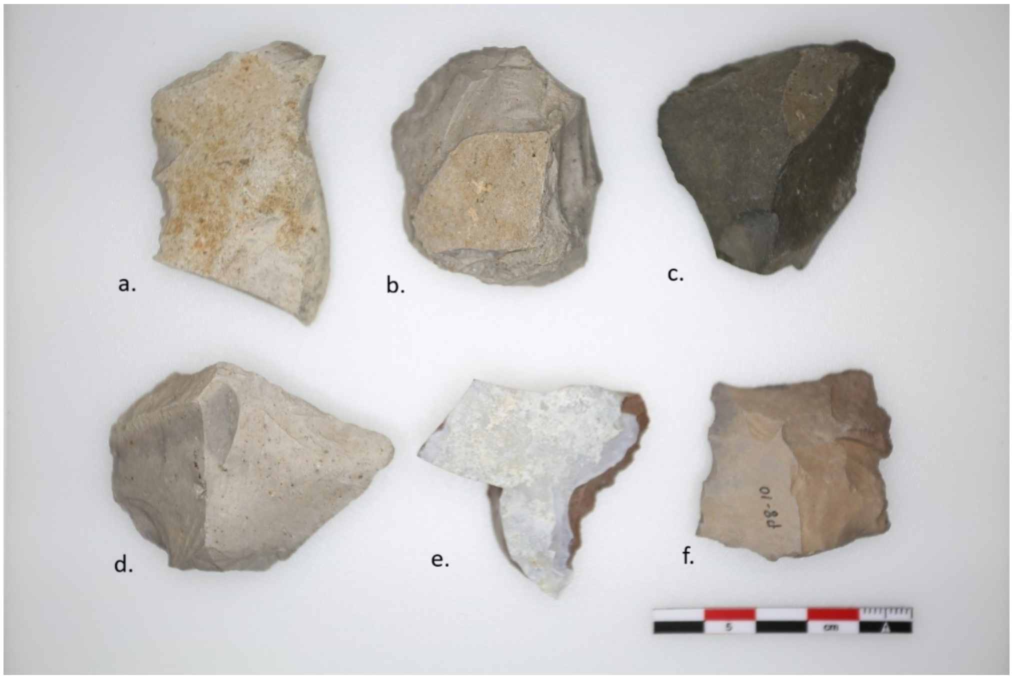


Figure 5.5: Tuff flake tools (a, b, d, f), tuff flake tool with chalcedony (e), and basalt flake tool (c). These specimens are typical size for Placitas Arroyo flake tools.

Figure 5.6: Artifact photo of basalt core with radial flaking pattern. This specimen illustrates the removal of edge flakes followed by the removal of a larger flake across the face of the blank.

Figure 5.7: Artifact photo of basalt core with radial flaking pattern.

Figure 5.8: Artifact photo of tuff cores with unidirectional flaking pattern (left, side view; right, platform view).

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 Introduction

This study bases conclusions off of three major lines of evidence: (1) previously documented and analyzed lithic artifacts in the 1984 report; (2) in-field observations during pedestrian survey; and, (3) laboratory analysis of flake artifacts and their attributes to identify patterns of variability as they relate to production strategy. Ideally, reconstruction of the pathway sequence achieved by this study reveals all patterns of reduction strategy applied by the prehistoric inhabitants of Placitas Arroyo: Expressed as a continuum based on a systemic framework that begins with procurement, followed by manufacture, recycling, and finally, artifact loss and discard.

Distinct lithic strategies at Placitas Arroyo were revealed by this study, providing a better understanding of stone tool production by generating knowledge about source procurement and various patterns of lithic reduction, specifically between tuff and basalt. Information relating to recycling and discard, however, yielded fewer results than the procurement and manufacture process. This chapter reveals the patterns and differences in variability identified by this study.

6.2 Procurement and Material Quality

Overall PA2 and PA8 assemblages are predominantly locally procured materials. However, the PA2 sample had 13% more basalt than tuff, while over half of the PA8 sample comprised of tuff, and only about one quarter was basalt (Table 5.1). The following discussion of the reduction methods at each site reveal that PA8 tuff flakes exhibit the most complex strategies of the assemblages studied. These patterns may relate to the residential activities associated with

PA8. Higher frequencies of basalt reduction suggests tasks and activities in this area differ from PA8. In terms of ease of knapping, tuff is a better, more predictable material. Basalt is of substandard quality, but also harder and thus would withstand longer use. The following summarizes the differences and similarities in reduction systems between the two sites.

6.3 Cortical Reduction Variability

A total of 40 statistical tests were conducted comparing reduction of lithics to flake attributes. Commonly across both sites and material types, platform preparation did not apply to specific modes of flake removal and reduction, rather, it was implemented as needed at both sites. During cortical removal, material types differ in production more markedly than between sites. The following discussion patterns of differences within and between sites and material types.

6.3.1 Basalt

Based on crosstabs data a number of differences between basalt flakes stood out (Tables 5.6 and 5.7). At both sites basalt core trimming elements exhibited very high cortical amounts. Additionally, crossed patterns span from 0-75% cortex, and unidirectional and radial flaking patterns are strictly very little-to-no cortical amounts. Differences between both sites observed is that opposed flaking patterns at PA2 are typically used in the absence of cortex, whereas PA8 opposed flaking patterns are shown from 1-50% cortex. In both cases, basalt flaking patterns become increasingly complex.

6.3.2 Tuff

There were no significant differences in scar patterns and cortical removal in the PA2 tuff sample. What is common, however, between PA2 and PA8 cortical removal is that core trimming elements have a wide range of cortex amounts from very little to nearly 100%, and both unidirectional and radial flaking patterns are found with very small cortical amounts, and bidirectional flaking is found between 0 and 50% cortex (Tables 5.8 and 5.9). The stark difference between the two site is that PA8 crossed patterns are spread across 0-50% cortex, but at PA8 this pattern is only found among 0 cortical amount.

6.3.3 Intrasite Cortical Reduction

The lack of significant differences means that there are in fact similarities. Unlike PA2, PA8 tuff differences were significant, but with a moderate effect. Both basalt tests returned a strong effect. This only means that differences in patterns among tuff at the two sites were not as strong as basalt. The driver of those results is that unidirectional flaking patterns were the preferred method, while more complex flaking patterns such as radial or crossed were implemented as needed among individual tuff flakes. This may relate to the ease of reducing tuff due to its respectively better quality to basalt. The basalt cores were treated with increasing complexity as cortex was removed. Flake size and shape are discussed in the following section to explain what happens as a core or blank is reduced in size.

6.4 Flake Size and Shape

Flake size and shape test results reveal two different tuff reduction systems between PA2 and PA8, but markedly similar system of reduction among basalt.

6.4.1 Flake Size

Basalt p-values were close and low enough (.077 and .017) to suggest that at both sites flake size did not differ significantly among scar patterns, but probably enough to observe some differences. The same trend applied to basalt interior flake p-values (.309 and .311). Perhaps over time reduction techniques of basalt do not change.

Mean sizes of PA8 tuff flakes vary with scar patterns significantly strongly. This strategy is in contrast somewhat with the previous finding. PA8 tuff flake patterns are often unidirectional after initial cortex removal and large flake sizes include the high cortical content and core trimming elements, and the numerous outliers of unidirectional flake sizes suggests that this pattern was used with little regard for size. While radial flaking is often associated with the lowest cortical amount, it is also found with larger flake removal. This system is similar to discoidal production in which a series of smaller flakes, of unidirectional, opposed, and crossed patterns, are then followed by removal of a larger, often radially patterned flake. Tests revealing interior flake patterns supports the pattern of complex flaking patterns among smaller flakes, namely larger removal of radial flakes, and smaller flake removal with unidirectional, crossed, and opposed patterns.

Substantially less different, PA2 tuff (P=.676) flake sizes did not differ with scar patterns. This may be where the unidirectional pattern was more uniformly applied. If larger flakes were the desired result for making tools, not much variability would be evident in the reduction in flake size. Interior flakes share this uniformity due to a low but insignificant result (.309).

6.4.2 Flake Shape

Comparing dorsal scar patterns to flake shape showed large p-values for basalt reduction. No complex change in size or shape of flakes among basalt at both sites is consistent with its lower quality. The relationship to activities follows in the next section.

Like with flake size, flake shape differences with dorsal scar patterns are most significant among PA8 tuff flakes, and the PA2 p-value is much higher (.629). At PA8 the lowest shape values are core trimming, high cortex, and opposed flaking patterns, increasing in shape value from radial, to unidirectional, and crossed. This illustrates that a thick blank may require an opposed flaking pattern. This would not be as effective on a thinner blank or core. Like before, PA8 tuff reflects a more complex reduction system. PA2, alternatively, uniformly abandons this system in favor of large flakes.

The interior flake shape did not serve to reinforce flake shape in the same fashion as flake size between PA2 and PA8 tuffs. PA2 interior tuff flakes are thickest with opposed flakes, which shows the use of bipolar reduction for thick cores. An increasingly complex method is employed from unidirectional, to radial, then crossed. While shape and size did not significantly stand out until interior flakes were tested, the sequence remains substantially different from the core reduction system seen at PA8 among tuff.

6.5 Summary of Reduction Systems at Placitas Arroyo

Looking at tuff flake size and flake shape, two systems are evident between PA2 and PA8 at Placitas Arroyo. One focuses on a more complex system of reduction, and the other reflects a substantially less complicated system focused on the production of larger flakes. At both sites, however, tuff cortical reduction was very similar, which may be due to the quality of the material. Comparison of basalt reduction revealed very similar reduction patterns at both sites. As cortex was reduced on basalt, an increasingly complex reduction system is employed, but these patterns were not related to flake size and shape.

Both sites applied platform preparation such as faceting among both material types, but results show that there was no difference in patterns and therefore, platform preparation was a technique reserved for when needed and not according to reduction stages. Overall, cortical reduction was similar among material types at both sites. Flake size and shape as it relates to flaking patterns was different between tuff at PA* and PA2, but the same for basalt at PA8 and PA2.

6.6 Subsistence and Settlement

Expedient tools appear to dominate the Placitas Arroyo assemblages. Although, differential reduction of tuff flakes reveals a more complex production at PA8, and a greater emphasis on expediency at PA2. Higher frequencies of basalt at PA2 may emphasize basalt core technology. Certainly, the flakes were produced for specific purposes that do not include the hunting of game, further supported by the paucity of both retouched tools and weaponry. Numerous grinding stones in the form of metates and manos were recorded at all the sites at Placitas Arroyo. The highest concentration of these were found at PA5, north of sites PA2 and PA8. Manufacture of grinding implements as well as grinding corn with manos and metates is a time-intensive process. Presumably, increased use of these tools implies a growing dependence on agricultural products (Maudlin 1993). However, research involving archaeological components from southwest New Mexico conclude that agricultural intensity fluctuated across different subsistence levels and time intervals. Placitas Arroyo subsistence patterns likewise could have fluctuated between occupations. Ground stone artifacts from the Jornada region were also commonly subjected to secondary uses, such as hearth elements (Black and Thomas

2014), not just grinding implements. Considering the spatial distribution of ground stone, architectural features, and ceramic types, it is clear that there were designated activity areas.

Although occupations of both sites may have occurred in the same general timeframe, dates for PA8 range approximately 200-450 CE, but PA2 dates extend much later suggesting this area continued to be used and revisited for much longer. The latest date provided by the report is 800 CE at PA2. Ceramic samples from these sites analyzed by Myles R. Miller suggest much later wares were found here, perhaps as late as 1500 CE. The small pithouses found at the study area are associated with semi-mobile groups comprised of individual households (Varien 1999), presumably seasonal. The long range of occupations indicated by radiocarbon dates also point to a long history of repeated exploitation of the arroyo watershed. Two subsistence patterns are evident: (1) The previous inhabitants of Placitas Arroyo visited the area in order to exploit its resources during certain times of the year; (2) Much of the activities involve plant processing and supplemental agriculture. Relationships between increasing sedentism, increased reliance of expedient core technologies combined with the use of lower quality locally available material (Parry and Kelly 1987) is a generalization of technological patterns at Placitas Arroyo PA2 and PA8.

Morenon and Hays (1984) remark the large volume of whole and fragmented metates and manos recovered. Composed of locally abundantly available stone such as welded tuff and vesicular basalt, encountered during field reconnaissance (Figure 6.1), groundstone was not transported out of the area. The density of groundstone was so robust that site sampling was dictated by spatial concentrations. Groundstone technology in this region is associated with intense processing of seeds and maize (Diehl 1996, Hard 1996, Maudlin 1993). Samples of burned material from hearths subjected to botanical analysis recorded in the report pursued only evidence of maize and did not account for local vegetation. These ground stone artifacts probably served for hulling and grinding purposes while thermal features could be used for parching and cooking (Moore and Atkins 2014). Surface area forms of metates has been used to measure agricultural intensity (See Maudlin 1993). Morenon and Hays (1984: 6-4) summarized the spatial distribution of site activities as such:

> It may well be that particular locations were optimal for human occupation and subsistence activities and that these locations were the consistent focus of prehistoric development through time. Consistencies in the spatial positions of activities may indicate constancy in the nature of those land uses and/or consistency in the set of environmental constraints which governed the exploitation patterns of populations.

Figure 6.1: Photo of large metate encountered at Placitas Arroyo.

The nearby pre-Pueblo Mimbres people resided in relatively large communities that continuously moved to new valleys after depleting resources (Varien 1999). While the scale of Placitas Arroyo residential groups were not likely large communities, Jornada Mogollon archaeological sites of similar temporal scales show evidence for intensification of succulent processing (Miller and Kenmotsu 2004; Miller et al. 2009). Additionally, the architecture at Placitas Arroyo did not include room houses at the time they were emerging in other ancestral Pueblo areas, supporting evidence that it remained a seasonally occupied site and its purpose was exploitation of local plant resources. Evidence for farming at Placitas Arroyo is negligible. Burned material identified as maize was recovered yet no garden or water capturing features to indicate it was cultivated there. Perhaps Placitas Arroyo was repeatedly visited as part of a complex of functionally specific sites related to larger settlements along the Rio Grande. In this case, Placitas Arroyo was a source extraction site for sotol, yucca, and/or lechuguilla.

Field reconnaissance revealed dozens, if not hundreds, of diffuse hearths and fire cracked rock scatters on the surface at all sites in the study area (Figure 6.2). Unlike the activity areas indicated earlier, thermal features at Placitas are randomly distributed and present at every site. Due to site deflation their specific purposes remain unknown. Commonly recorded in the surrounding region but absent in the Placitas Arroyo archaeological record, earthen ovens, or plant baking features, appear in the Jornada Mogollon as early as 5,000 BCE. Large accumulations of burned rock indicative of formal baking pits emerge in the Middle Archaic Keystone Phase. Incorporation of maize into subsistence co-occurs with this phenomenon. Low-intensification activities such as cacti and succulent baking combined with small-scale farming (beans, maize, and squash), with what are considered Archaic subsistence patterns, persist during the Formative period in much of the Jornada Mogollon (Miller ad Kenmotsu 2004; Miller et al. 2011). While very few formal baking features, and no large accumulations of fire cracked rock (FCR) were recovered during excavations, the extent of hearth fields across the sites points to intensive cooking and processing. Despite the prevalence of FCR, the sites report does not critically evaluate its thermal features. Long-term cooking features are often termed "hearths" when encountered by archaeologists (Black and Thomas 2014), which demonstrates the lack of scrutiny applied to these feature types during archaeological investigation.

Figure 6.2: Photo of deflated hearths at Placitas Arroyo.

Normally, identification of the flake tools at these sites should inform their purpose. Informal and flake tool types are difficult to classify because their morphologies do not provide clues to their use. This assemblage specifically contains debitage or core tools with edge damage.

Since much of these artifacts were found on the surface, they have been exposed to mechanical alterations. Additional testing such as edge-wear analysis could aid in determining on which what kind of materials the tools were, though less reliably for softer material. Retouch is similarly difficult to determine because it can resemble use-wear. Of the identifiable flake tools were a small number of end scrapers (Figure 6.3).

6.6.1 Succulent Processing

Commonly documented in the northern Chihuahua desert are yucca and sotol which are widely known to have been used extensively by southwestern prehistoric groups. Based on ethnographic literature, there are several utilitarian and dietary uses of these desert succulents (Bell and Castetter 1941). For example, yucca roots and stems produce detergent, and its leaves were used to make brushes for decorating pottery, or other items such as basketry, household items, or cordage. Yucca fruit can be eaten, evident in Jemez Cave and other sites in western Texas, depending on the variety of yucca, its fruit could be dried and pulped and cooked into a drink. Other notable vegetation includes cholla buds (*Opuntia* spp.), sahuaro fruits (*Carnegia gigantean*), and mesquite beans (*Prosopis chilensis*). Ethnographic literature documents numerous Native American southwest groups used yucca fiber most often as a woven material, such as basketry or sandals. Included in that category of utility is sotol. The crowns of which were roasted in a similar fashion to agave by the Apache of Arizona and New Mexico (Bell and Castetter 1941). These sotol crowns gathered when flowers emerged, could suggest that it was gathered seasonally, and would require a specific assemblage of tools to extract, cut, pulverize, or processed. The hearts of this plant also provides high food value, and would need to be dug up using a handful of implements for digging and extracting the plant.

Figure 6.3: Two flake scrapers from the Placitas Arroyo collection. Dorsal surface, platform facing down.

Some Jornada Mogollon sites show evidence of succulent processing and extraction. Associated materials include low-quality stone material with tabular fracture. Scraper planes (pulping planes) are a common tool encountered in the southwest (Miller et al. 2011). Tools required to remove spines and leaves from a succulent plant such as agave knives are recorded archaeologically and ethnographically show there is little structure or consistency in the manufacture of these tools (Miller et al. 2011). Initial impression of the flake tools from the Placitas Arroyo assemblages (see Figure 6.3) is that they would perform well for tasks related to cutting and spinal removal of succulents. Otherwise these tools are virtually useless for agricultural purposes such as shucking and processing corn. Core tools with steep and rounded edges exhibiting heavy use-wear patterns are also associated with the extraction of agave (Moore and Atkins 2014). A closer inspection of the core technology from this assemblage would be helpful. While it is uncertain whether agave was common to the Placitas Arroyo watershed, certainly other succulent plants were correspondingly extracted on a regular basis, such as yucca, stool, and lechuguilla. Basalt core artifacts share similarities to a few of these descriptions and may support evidence that Placitas Arroyo was a site for intensive plant processing (Figure 6.4).

Figure 6.4: Photo of two basalt cobble artifacts with one edge flaked and battered. Top: depicting a more tabular morphology.

6.7 Conclusion

The goal of this research was to understand the variation in the lithic artifacts through study of the reduction process. Multiple production systems were evident at Placitas Arroyo archaeological sites that were previously unknown. Statistical testing shows that tuff flakes were manufactured differently from basalt and that areas were designated for different tasks resulting in differential reduction systems.

More research questions stem from these findings. The paucity of utilized tools and flakes representative of material such as obsidian suggests production systems differed among non-local, higher quality sources. These may have been in fact, curated. Additionally, were tools manufactured at Placitas Arroyo transported to other sites? These patterns that were identified were found in context with ground stone and large cores with differing morphologies pointing to subsistence related to intensive naturally-occurring and cultivated plant processing, preparing, and cooking at this intermittently occupied residential site. Use-wear and micro-wear analysis may serve to support these assumptions. Lastly, did Placitas Arroyo transition over time from a residential seasonal camp, to a smaller specialized site that was part of a larger agricultural complex of sites within the Rio Grande watershed?

This study reveals discrete stone tool production systems at Placitas Arroyo. It certainly contributes to the high variability of archaeological site types and different subsistence practices throughout the Jornada Mogollon Formative Period and ultimately highlights the diversity of people who interacted with the northern Chihuahuan landscape. This culture area would greatly benefit from additional research and questions.

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