THE INFLUENCE OF TRADE ON THE ORGANIZATION OF LITHIC TECHNOLOGY

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This study examines the influence of trade on the organization of flake stone tool technology from a Late period prehistoric shell mound located on the shore of San Francisco Bay. We argue that the inhabitants of the Stege Mound (CA-CCO-297) did not have direct access to the Napa obsidian source. Finished obsidian implements were manufactured elsewhere by specialists who had established a sole-source relationship with Bay Area traders. Indirect acquisition and formal trade relationships are reflected in the flaked stone artifact assemblage of the site.

Optimal foraging theory is an ecological perspective used to understand the foraging behavior of living organisms. It assumes that organisms adopt cost-benefit behaviors that have a tendency to maximize their net gain and minimize their expenditures. Anthropologists have adopted optimal foraging theory to model hunter-gatherer adaptive strategies. The theory has been successfully applied by lithic analysts in the study of raw material procurement, processing, and transport (Beck 2008; Beck et al. 2002). Lithic analysts tend to measure procurement costs in terms of distance traveled, transit time, and manufacturing effort. Costs are then weighed against benefits to model decision-making strategies. This scenario assumes that individuals have direct access to resources. Individuals travel to the resource, procure materials, and return to the site. Although social factors undoubtedly have a strong influence on decision making, they are often ignored by researchers modeling stone tool procurement and production strategies.

The Late period of central California is characterized by high population densities, well-defined territorial systems, and competition among groups over geographically discrete, highly desirable resources. Direct access to resources would have necessitated travel though neighboring territories, which likely would have increased the risk of violent conflict (Barrett 1908; Bean and Theodoratus 1978; Driver 1936; Gifford and Kroeber 1939; Kniffen 1939; Kroeber 1925, 1932; Kunkel 1962; Levy 1978; Loeb 1926). We reason that the risk of violent conflict with outside groups strongly influences human decision making. Individuals are less likely to embark on excursions to procure resources located outside of the residential estate when there is an elevated level of competition. This scenario predicts that trade is a cost-effective, low-risk alternative for procurement of exotic resources. Acquisition of exotic materials through trade will have specific archaeological signatures.

METHODOLOGY

This methodological background describes many of the concepts and defines some of the key terminology used in the analysis of the CCO-297 flaked stone assemblage. Most importantly, this section helps to focus the research goals in relation to the broader understanding of lithic analysis and its archaeological application.

The Organization of Technology

Technological organization refers to “the selection and integration of strategies for making, using, transporting, and discarding tools and the materials needed for their manufacture and maintenance” (Kelly 2001:65). The organization of stone tools and raw materials is a complex subject because it does not at all times follow a sequence of stages, but is often characterized as a flexible continuum (Muto 1971:115). Hunter-gatherers often need to anticipate or respond to situations where environmental constraints like distance and access to lithic raw material strongly influence and sometimes bias the decisions. This behavioral process has been documented in the ethnographic and archaeological records with reference to mobility and settlement (Binford 1979, 1980; Gould 1978; Kelly 1988; Shott 1986), lithic material availability and selection (Andrefsky 1994; Gould and Saggers 1985; Wilson 2007), efficiency and subsistence (Bamforth 1986, 1991; Jeske 1992; Ricklis and Cox 1993), and distance decay theory (Ericson 1977; Hodder and Orton 1976; Odell 2000; Renfrew 1977).

Lithic Processing and Transport

Recently, Beck (2008) adapted Metcalfe and Barlow's (1992) field processing model to the study of Great Basin lithic assemblages. This new model predicts that processing time and tool utility are expected to relate directly to the transport of material across a given distance (Beck 2008). An individual will spend less time at the quarry and transport nodules if the habitation site is located nearby. Conversely, if the habitation site is located far away, individuals are expected to spend more time, manufacture bifaces at the quarry, and transport these items to the habitation site.

We argue that the assumption of direct procurement biases the model and, as a result, limits its applicability to the study of Late period lithic assemblages from central California. Given the overwhelming evidence of ethnographic territoriality and conflict within this crowded prehistoric landscape, direct access to tool stone quarries would likely have been unavailable.

Lithic Raw Material Availability

Within the lithic landscape of CCO-297, locally available tool stones were primarily derived from Quaternary alluvium, while nearby sources of Mesozoic metasedimentary and plutonic rocks, as well as Tertiary volcanics, can be found along the Hayward fault subduction zone in the Berkeley Hills. These scattered deposits contain micro- and macro-crystalline chert, serpentine, feldspar, schist, and quartz (California Geological Survey 2010). The Napa Glass Mountain source is located approximately 70 km north-northwest of the site. This source, although distant, is concentrated and contains high-quality obsidian. Archaeological investigations at the Stege Mound complex completed by Banks and Orlins (1981) documented changes in lithic procurement through time.

> At CCO-298, the early Berkeley Pattern Stege Mound, many chert cores and flakes were recovered, all of locally available materials. Flint-knapping, using at-hand raw materials, was an important activity at the site (despite the fact that no chert tools were recovered). This situation is in sharp contrast to the case at CCO-297, the Phase 2 Augustine Pattern Stege mound, where locally available stone materials had little currency, where flaking activities were limited primarily to retouching and reworking arrow points, and where more than half of the flaked stone items, both tools and debitage, are of obsidian, a material not locally available that had to be obtained through trade [Banks and Orlins 1981:8.93].

Tool Production and Function

The production of high-utility curated rather than low-utility expedient tools would have mediated transport costs and managed risks associated with tool use and maintenance, like breakage and loss. The process of curation results in the discard of formal tools at archaeological sites. Formal tools have been characterized as "flexible tools, or tools that are designed to be rejuvenated and have the potential to be redesigned for use in various functions" (Andrefsky 1994:22). In comparison, informal or expedient tools are much less costly to produce because they are not organized in anticipation of various activities, but in reaction to at-hand situations requiring specific tasks (Binford 1979). Although formal tools may have been expensive to produce, they likely provided long-term insurance against anticipated risk. In contrast, production of informal tools was a short-term, cheap solution.

Trade likely biased the form in which obsidian arrived at CCO-297 and also what decisions could have been made in regards to its use. Therefore, we cannot assume that distance and raw material transport costs directly influenced what types of tools were produced and used by the site's inhabitants. It is more likely that the value of an item was a more significant indicator of its importance within the organization of the CCO-297 tool kit. The following section will summarize a few methods needed to determine where tools came from, what production costs were associated with their manufacture, and whether or not they were used and maintained on-site.

METHODS

Technological Analyses

In order to determine the production costs associated with the organization of tool technologies at CCO-297, measurements of arrises per cm are recorded for projectile points and bifaces in combination with length, width, and thickness measurements using digital calipers. The arris is a ridge formed on the dorsal surface of a flake or tool "by the intersection of flake scars from previously removed flakes" (Crabtree 1982:14; Kooyman 2000:14). A measurement of arrises per cm is the average number of arrises produced during the initial manufacturing and preceding re-sharpening of a tool. Both the numbers of deep (mid-face) and shallow (margin) arrises per cm are summed, giving an arrises per cm count (White et al. 2002:535). The arris count reflects the approximate amount of flaking it took to produce the tool. It takes time to flake a tool, and as a result, the more time invested flaking, the more costly the tool production.

A technological study of the size and frequency of flakes types, as well as the amount of cortex present on flake surfaces, is used to determine whether tools were manufactured at CCO-297 or were produced elsewhere and transported to the site as formal tools. All obsidian flakes are visually sourced and separated by material type. All flakes are counted and size-sorted based on a measurement of maximum diameter (Ahler 1989:89-90). Size-sorted flakes are categorized according to reduction technology, as either biface or core reduction. Identification of biface versus core reduction is determined based on platform, bulb, and arris morphology (Kelly 1988:724; Kooyman 2000:51). Flake fragments and shatter are also separated. The presence or absence of cortex is estimated by counting the number of primary cortical, secondary cortical, and interior flakes within each reduction technology, as well as flake fragments and shatter. This level of analysis helps to determine where lithic raw materials originated, to determine in what form(s) they arrived at the site, to recognize how the material was reduced, and to identify stone tool production trajectories.

Macroscopic Functional Analyses

An analysis was conducted in order to characterize the nature and distribution of stone tool fragments deposited at CCO-297 in relation to tool use on and off site. Identification of tool parts, such as ends, midsections, and margin fragments, can be used to measure the rate of fragmentation, discard, and completeness within each tool class. This analysis also aids in the identification of fracture types (e.g., impact, snap, bending, etc.) that are present on tools. Fracture types can help determine the likely type of activities that resulted in damaged tools.

Formal and informal types of edge modification associated with task-specific repetitive use (e.g., burin, bevel, drill, spokeshave, battering, etc.) are identified by analyzing tool edge morphology. Tracking the frequency and distribution of stone tool edge types across all tool classes not only determines what types of activities the tool use supported but also their significance and importance to the site's inhabitants.

RESULTS

This section reports the analytical findings from the CCO-297 flaked stone assemblage. Archaeological excavations at CCO-297 yielded a rich flake stone assemblage (Table 1). The assemblage is characterized by a relatively high number of formal tools. Projectile points, bifaces and formed flake tools (FFTs) comprise nearly one-quarter (23.3 percent) of the entire flaked stone assemblage.

Table 1. Summary of flaked stone artifacts from CCO-297.

		Banks and Orlins 1981	DeGeorgey 2013	DeGeorgey 2014	Total
Projectile Points		11	87	94	192
Bifaces		2	32	47	81
Core		1	4	23	28
Edge Modified Flakes		3	4	59	66
Formed Flake Tools		9	17	20	46
Debitage	Obsidian	35	215	582	832
	Chert	28	32	60	120
	Other	1	--	2	3
Total		90	391	887	1,368

Table 2: Flaked stone assemblage: 2013-2014 investigation

Class	Material Type							Total
	Obsidian	Chert	Chalcedony	Feldspar	Quartz	Schist	Serpentine	
Debitage	582	61	--	--	--	--	1	644
Projectile Point	92	2	--	--	--	--	--	94
Edge-modified Flake	48	10	--	--	--	1	--	59
Biface	43	3	1	--	--	--	--	47
Core	15	6	--	1	1	--	--	23
Formed Flaked Tool	19	1	--	--	--	--	--	20
Total	799	83	1	1	1	1	1	887

For the purpose of this study, only the most recent data from the 2014 excavations are formally analyzed. Baseline statistics, including stone tool class frequencies and lithic material variability, are presented, preceded by an overview of dimensional and attribute-based data broken down by tool class. A technological analysis of the debitage assemblage and a macroscopic functional analysis of tool parts and morphologies are provided.

The 2014 excavation at CCO-297 generated a flaked stone assemblage comprised of a total of 887 specimens (Table 2). The flaked stone assemblage is divided into eight general classes. In order of abundance at the site, the flaked stone assemblage includes debitage (n = 644), projectile points (n = 94), edge-modified flakes (EMFs) (n = 59), bifaces (n = 47), cores (n = 23), and FFTs (n = 20). An overwhelming proportion of the flake stone assemblage is represented by Napa Glass Mountain obsidian (n = 799; 90 percent). One projectile point and two bifaces were manufactured from Borax Lake obsidian. A total of 88 specimens were derived from chert, chalcedony, feldspar, quartz, schist, and serpentine, which are locally available.

Projectile Points

A total of 94 projectile points were recovered during the 2013 excavation (Figures 1 and 2). Almost all projectile points (Stockton Serrated and small corner-notched) were visually sourced as Napa Glass Mountain obsidian. One specimen was manufactured from Borax Lake obsidian, and two projectile points were made from Franciscan chert.

All 94 specimens possess measureable thickness and width dimensions. Projectile point thickness ranges from 1.5 to 8.4 mm. The mean thickness of points is 3.9 mm. There is some variability in the thickness of points (standard deviation = 1.2 mm). Projectile point widths exhibit a broader range, from 6.6 to 40.7 mm, have a mean width of 15.3 mm, and a high standard deviation of 4.4 mm. Overall, points appear to be characterized by some degree of variability of form.

Arris counts were taken for all 94 projectile points. This measurement tallies the number of deep (mid-face) and shallow (margin) arrises per cm. Deep arris counts range from two to seven, with a mean of 4.5 and a standard deviation of 1.0. Shallow arris counts range from four to 11, with a mean of 6.9 and a standard deviation of 1.3. Deep arris counts associated with initial projectile point manufacture exhibit

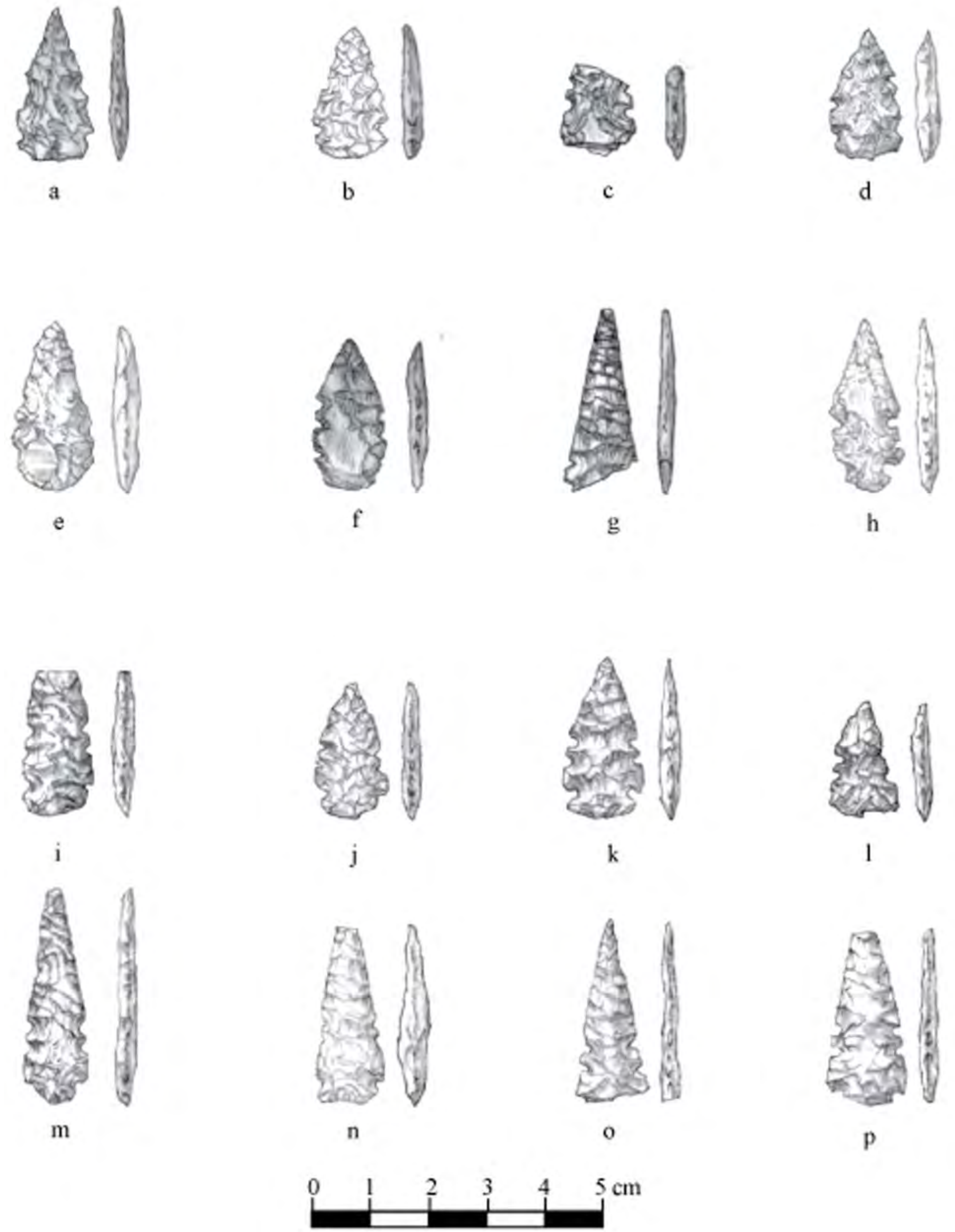

Figure 1. Stockton Serrated points.

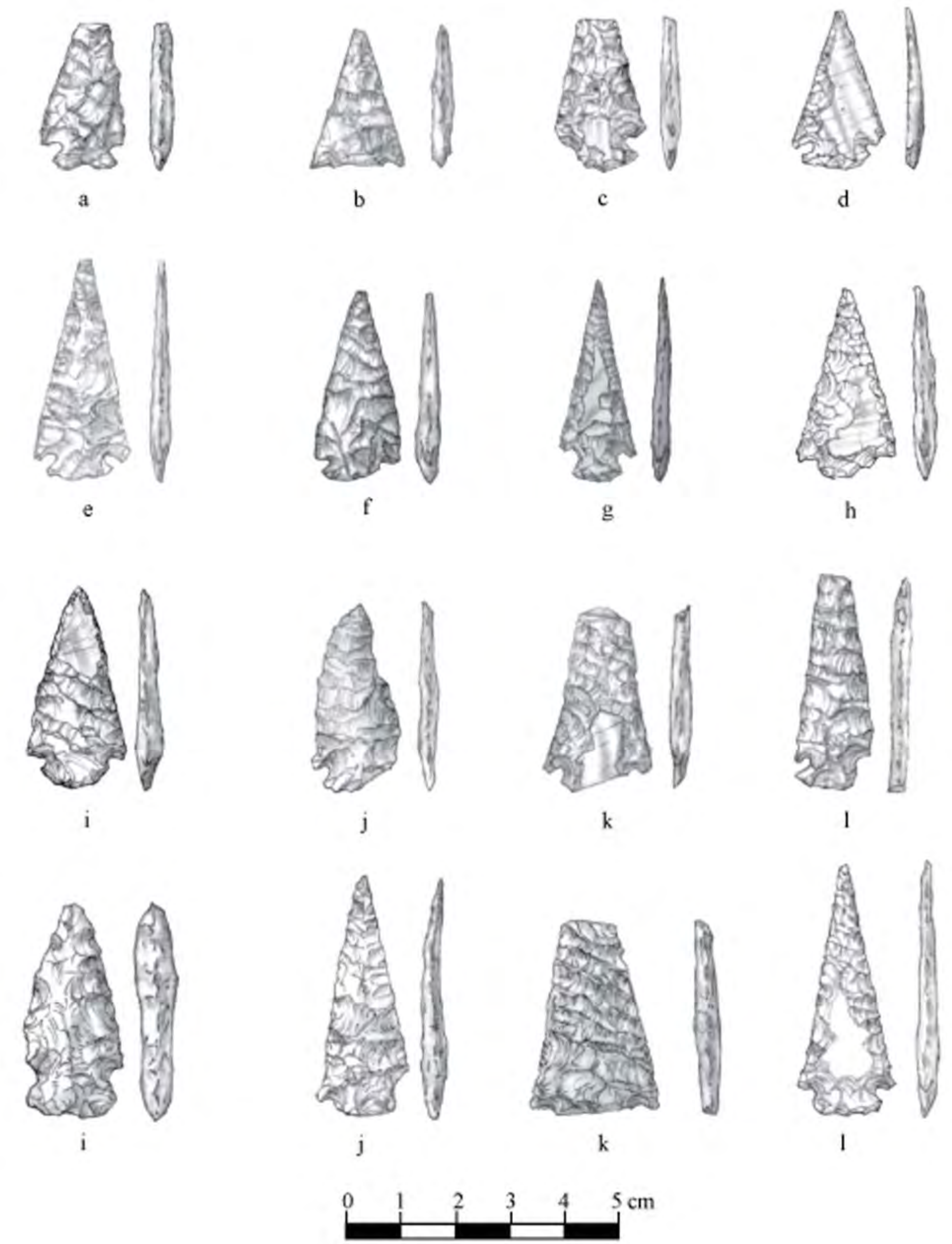

Figure 2. Small corner-notched points.

less variability than shallow arris counts resulting from maintenance. Overall, projectile point arris counts exhibit a low degree of variability.

Qualitative attributes were recorded, such as the presence or absence of a remnant flake blank surface, cortical surface, patina, and thermal fracture. From a total 94 projectile points, 44 (47 percent) specimens possess a remnant flake blank surface, 17 (18 percent) have a cortical surface, 13 (14 percent) exhibit patina, and 1 (1 percent) has thermal fracture. A significant number of points are manufactured from flakes. This may account for the presence of cortical surface on some specimens. Some points exhibit patina, suggesting that older broken dart points and/or bifaces may have been recycled as new arrow points.

Bifaces

A total of 47 bifaces were recovered during the 2013 excavation at CCO-297 (Figures 3 and 4). Bifaces were predominately manufactured from Napa Glass Mountain obsidian. Two specimens were manufactured from Borax Lake obsidian, and four from local chert and chalcedony materials.

While all 47 specimens possess measureable thickness dimensions, only 40 specimens possess measureable width dimensions. Biface thicknesses range from 3.1 to 17.9 mm. The mean thickness of bifaces is 8.7 mm. A moderate degree of variability in biface thickness is documented (standard deviation 3.2 mm). Biface widths exhibit a broad range, from 9.0 to 39.1 mm. The mean width of bifaces is 20.2 mm, with a high standard deviation of 6.2 mm. Overall, bifaces appear to be characterized by a moderate degree of formal variability.

Arris counts were taken for all 47 bifaces. Deep arris counts range from one to four arrises, with a mean of 1.9 arrises and a standard deviation of 0.8 arrises. Shallow arris counts range from one to seven arrises, with a mean of 3.5 arrises and a standard deviation of 1.3 arrises. Similarly to projectile points, deep arris counts associated with initial biface manufacture exhibit less variability than shallow arris counts resulting from maintenance.

Qualitative attributes were also observed, such as the presence or absence of a remnant flake blank surface, cortical surface, patina, and thermal fracture. From a total of 47 bifaces, only five specimens (11 percent) possess a remnant flake blank surface; 15 (32 percent), a cortical surface; 23 (49 percent), patina; and two (4 percent), thermal fractures. The frequent occurrence of patina suggests that bifaces were recycled. In addition, a significant number of bifaces possess a cortical surface, indicating some amount of manufacture may have occurred at CCO-297.

Formed Flake Tools

A total of 20 FFTs were recovered during the 2013-2014 excavation at CCO-297. Almost all FFTs were visually sourced as Napa Glass Mountain obsidian, except for one specimen manufactured from a local or nearby chert deposit.

All 20 specimens possess measureable thickness and width dimensions. FFT thickness ranges from 5.5 to 18.7 mm. The mean thickness of FFTs is 10.3 mm. There is moderate variability in the thickness of FFTs (the standard deviation is 3.7 mm). FFT widths range from 7.0 to 52.0 mm. The mean width of FFTs is 27.7 mm, with a high standard deviation of 11.7 mm. Overall, FFTs appear to be characterized by a high degree of formal variability. Deep and shallow arris per cm counts were taken for all 20 FFTs. Deep arris counts range from one to three arrises, with a mean of 1.3 arrises, and a standard deviation of 0.5 arrises. Shallow arris counts range from two to six arrises, with a mean of 3.4 arrises, and a standard deviation of 1.0 arrises. Unlike projectile points and bifaces, deep arris counts associated with initial FFT manufacture exhibit greater variability than shallow arris counts resulting from maintenance.

Qualitative attributes were also observed, such as the presence or absence of a cortical surface, patina, and thermal fracture. A total of 16 flake tools (80 percent) possess a cortical surface, nine (45 percent) exhibit patina, and three (15 percent) have thermal fractures. Nearly all FFTs exhibit a cortical

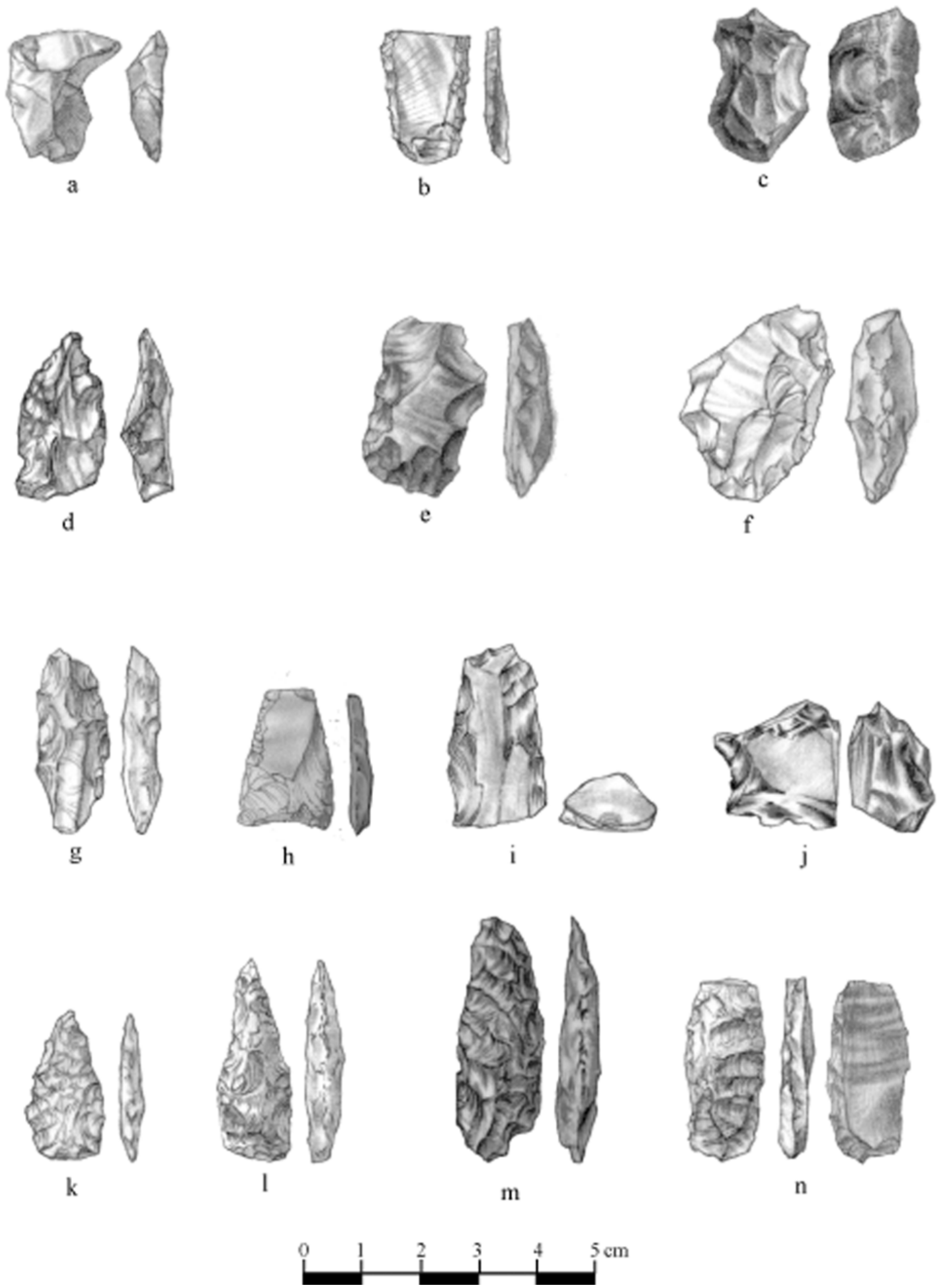

Figure 3. Obsidian bifaces.

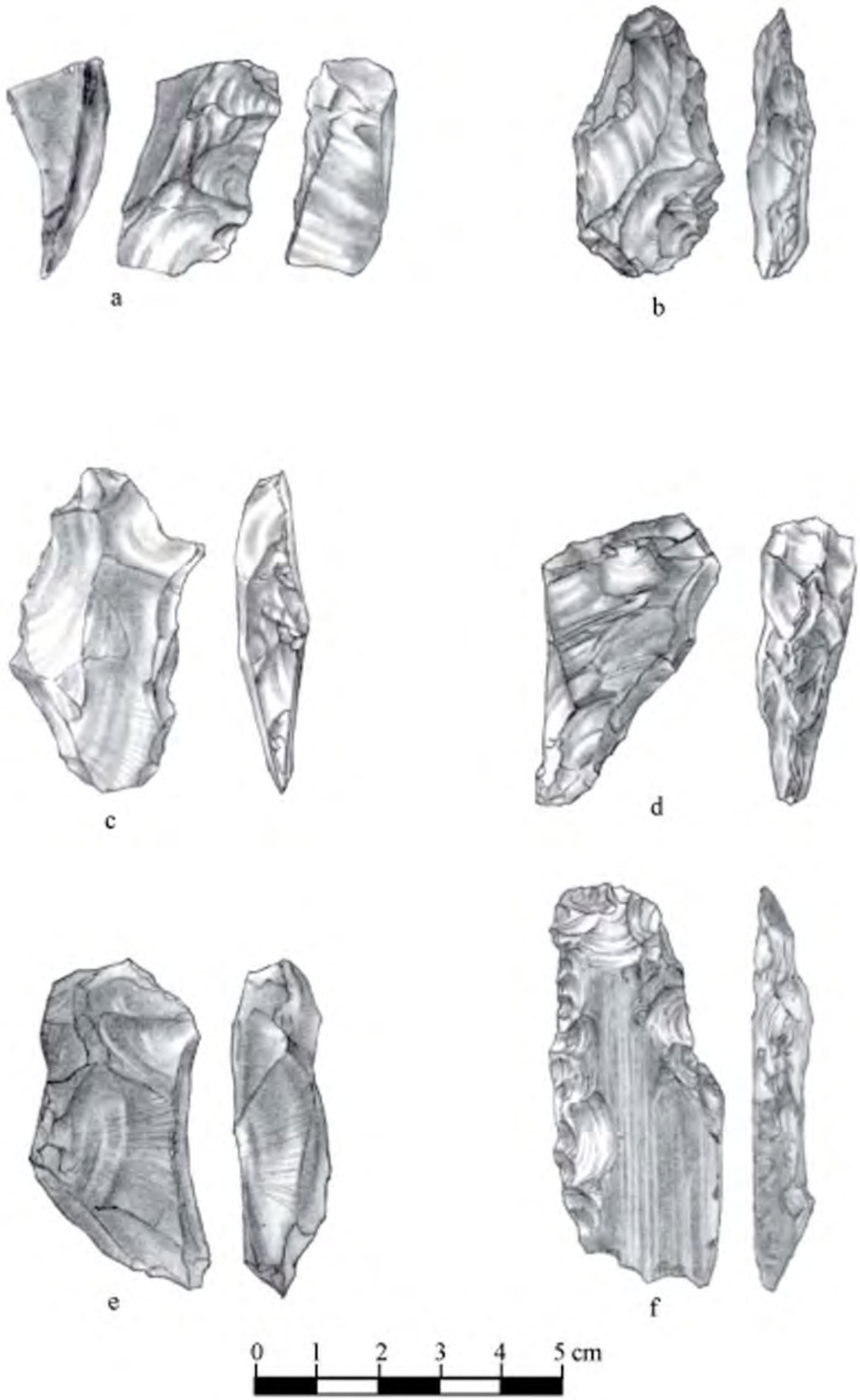

Figure 4. Obsidian bifaces.

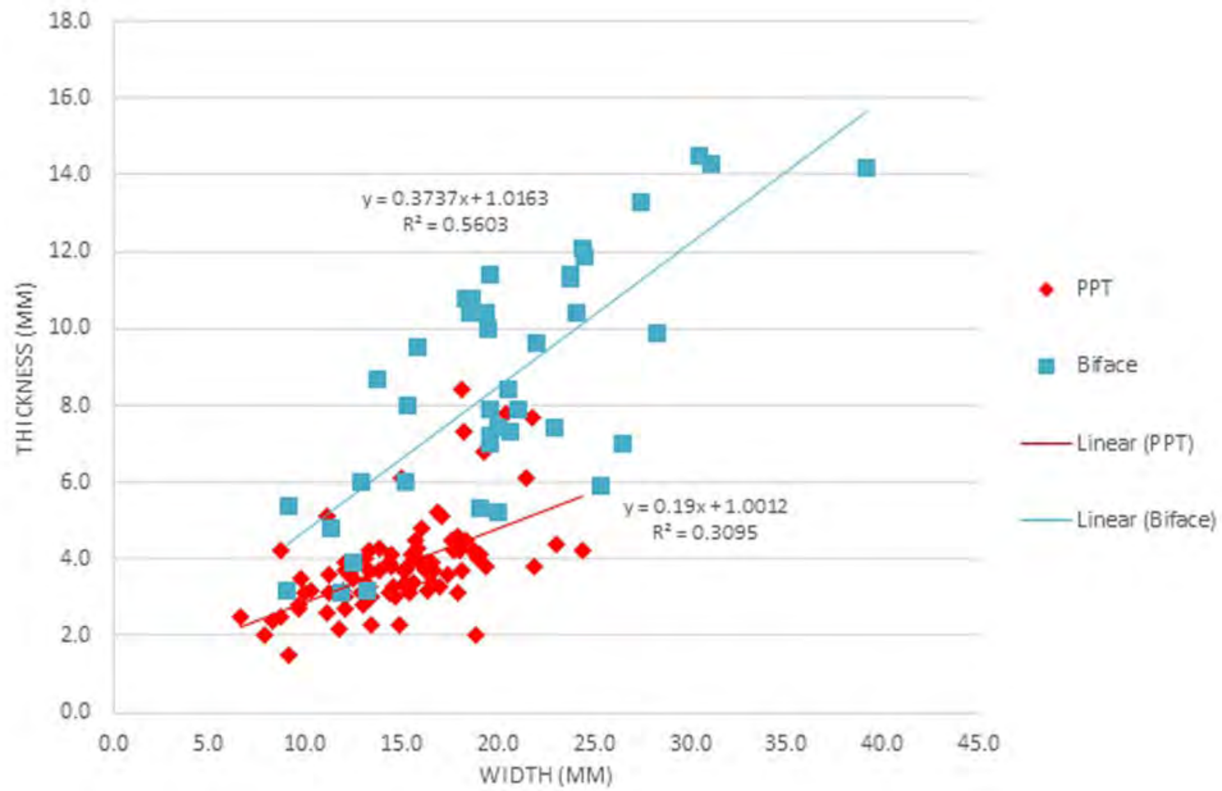

Figure 5. Projectile point and biface width/thickness correlation.

surface, suggesting that they were manufactured on-site. In addition, many FFTs exhibit patina, indicating potential recycling of older tools and/or flakes.

Tool Production Trajectories

The analysis of projectile point and biface width, thickness, and arris counts per cm suggests that these tools existed along two different production trajectories. Bifaces do not appear to have been used to manufacture projectile points. Figure 5 depicts the correlation between width and thickness for projectile points and bifaces. Projectile points form a tight cluster, are thin, and exhibit a high degree of uniformity (R value 0.3095). In comparison, the biface distribution is scattered and appears to overlap (R value 0.5603). This evidence suggests that while projectile point production followed a focused trajectory strongly influenced by thinning and re-sharpening, bifaces existed along an unrelated peripheral trajectory.

Figure 6 depicts the correlation between thickness and arris counts per cm for bifaces and projectile points. Projectile points form a tight cluster, are thin, and have high arris counts. There is a strong correlation between a decrease in thickness and an increase in arris counts. The distribution of bifaces, on the other hand, is scattered, highly variable, and does not overlap the projectile point distribution. This evidence suggests that while projectile point production followed a focused trajectory strongly influenced by thinning and re-sharpening, bifaces existed along a peripheral trajectory, unrelated to projectile point production. Most importantly, these data provide additional evidence that bifaces were not being reduced to produce projectile points. Instead, bifaces and points appear to represent separate and independent behaviors.

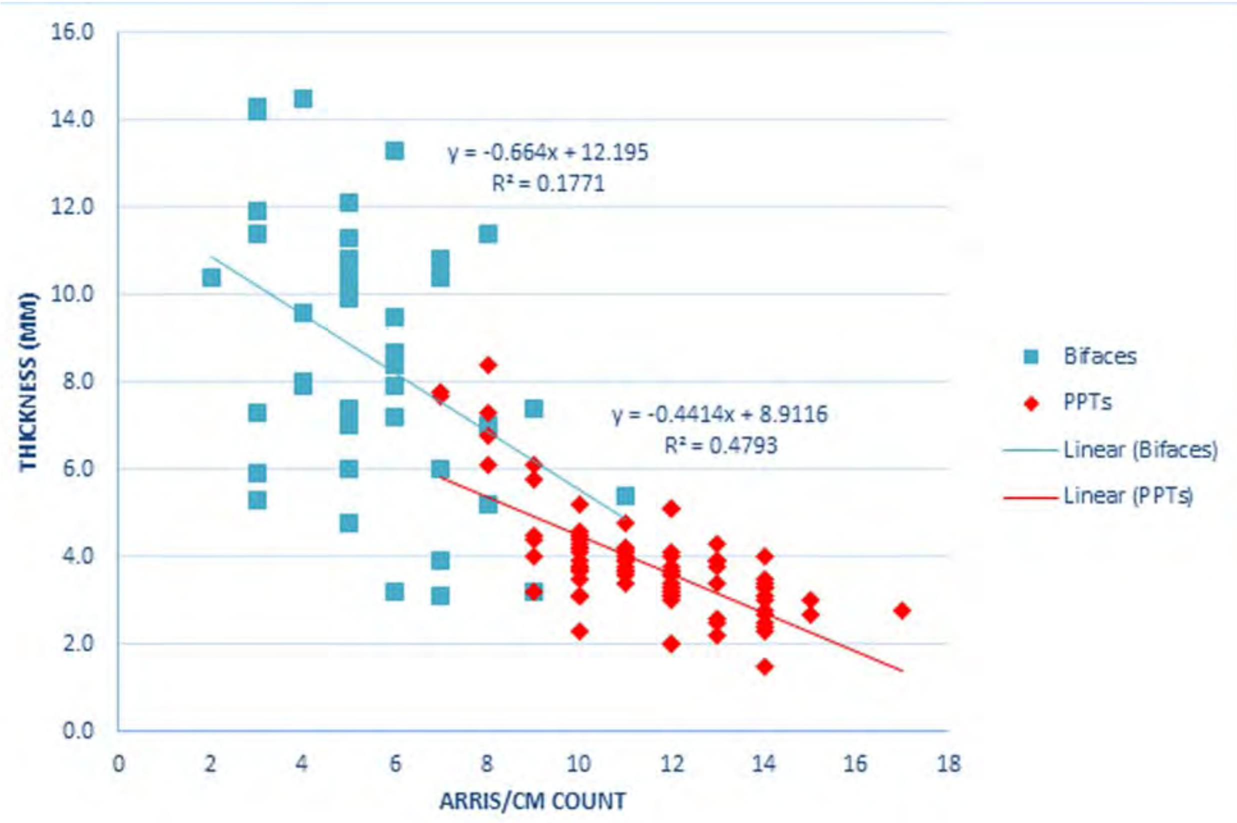

Figure 6. Biface and projectile point thickness/arris count correlation.

Cores

A total of 23 cores were recovered during the 2013-2014 excavation at CCO-297. Fifteen cores are visually sourced as Napa Glass Mountain obsidian, while only six cores were derived from local chert deposits. The remaining two cores were manufactured from feldspar and quartz materials. Eight cores exhibit edge morphology indicative of core tools.

Twenty-two specimens possess measureable height dimensions, while 19 possess measureable diameter dimensions. Obsidian core height ranges from 9.5 to 22.2 mm. Mean obsidian core height is 14.6 mm. There is moderate variability in the height of cores (standard deviation 3.8 mm). Obsidian core diameter ranges from 13.6 to 43.2 mm, with a mean diameter of 26.6 mm, and a high standard deviation of 8.0 mm. Overall, obsidian cores tend to be small and exhibit a moderate/high degree of formal variability.

Chert, quartz, and feldspar core height ranges from 14.8 to 34.5 mm, with a mean height of 25.4 mm, and a standard deviation of 5.8 mm. Core diameter ranges from 42.0 to 91.5 mm, with a mean diameter of 59.7 mm, and a standard deviation of 19.7 mm. In relation to obsidian cores, chert, feldspar, and quartz cores are significantly larger and exhibit a much higher degree of formal variability.

Qualitative attributes were also observed, such as the presence or absence of a cortical surface, patina, thermal fracture, multiple platforms, and bipolar reduction. From a total 23 cores, 21 (91 percent) possess a cortical surface, one (4 percent) exhibits patina, and four (17 percent) show thermal fractures. Twelve cores (52 percent) possess multiple platforms, and five (22 percent) exhibit evidence of bipolar reduction.

Table 3. Obsidian debitage analysis.

FLAKE TYPE	FLAKE SIZE							TOTAL
	< 1 CM	< 2 CM	< 3 CM	< 4 CM	< 5 CM	< 6 CM	< 7 CM	
Biface Reduction	82	61	11	--	--	--	--	154
Primary Cortical	--	1	--	--	--	--	--	1
Secondary Cortical	7	20	4	--	--	--	--	31
Interior	75	40	7	--	--	--	--	122
Core Reduction	81	207	65	13	1	1	1	369
Primary Cortical	9	28	12	7	1	--	1	58
Secondary Cortical	19	97	38	5	--	1	--	160
Interior	53	82	15	1	--	--	--	151
Unidentifiable	31	33	6	2	1	--	--	73
Primary Cortical	4	3	1	--	--	--	--	8
Secondary Cortical	2	6	1	--	1	--	--	10
Interior	25	24	4	2	--	--	--	55
Shatter	15	15	4	--	--	--	--	34
Primary Cortical	2	2	2	--	--	--	--	6
Secondary Cortical	3	9	2	--	--	--	--	14
Interior	10	4	--	--	--	--	--	14
Total	209	316	86	15	2	1	1	630

On average, obsidian cores are smaller and more frequent in the assemblage than chert, feldspar, and quartz cores. They also exhibit greater uniformity in size. This pattern suggests that obsidian core reduction was more intensive and exhaustive than core reduction of locally available lithic material. Interestingly, most obsidian cores possess a cortical surface, suggesting obsidian raw materials may have arrived at the site in an unprepared nodule form.

Debitage

A total of 703 individual pieces of debitage were recovered during the 2013-2014 excavation at CCO-297. Visual sourcing indicates that 90 percent (n = 630) of all debitage is derived from Napa Glass Mountain obsidian, while 10 percent (n = 73) is from local to nearby chert, schist, and serpentine deposits. Table 3 shows the distribution of obsidian debitage by flake type, amount of cortex, and flake diameter. Obsidian debitage is dominated by small biface and core reduction flakes less than 3 cm in diameter. Within this size range, 49 percent (n = 75) of a total of 154 biface reduction flakes are interior flakes less than 1 cm in diameter. Core reduction flakes account for 59 percent (n = 207) of a total 353 flakes less than 3 cm in diameter and are mostly secondary cortical and interior flakes. The majority of unidentifiable flakes and shatter are also secondary cortical and interior flakes less than 3 cm in diameter. In general, obsidian flakes are small and appear to have been either derived through production of finished bifaces or reduction of small interior cores and partially prepared nodules.

A total of 71 individual pieces of debitage were derived from local to nearby chert deposits. Core reduction flakes ranging from less than 2 to less than 5 cm in diameter account for 75 percent (n = 53) of all chert debitage. Within this size range, 75 percent (n = 40) are secondary cortical flakes. On average, chert flakes are larger than obsidian flakes, are less frequent in the debitage assemblage, and were most likely derived from partially prepared cobble cores.

Edge-Modified Flakes

Fifty-nine pieces of debitage exhibit edge modification. Visual sourcing indicates that 81 percent (n = 48) of all edge-modified flakes (EMFs) were derived from Napa Glass Mountain obsidian, while 19 percent (n = 11) were derived from local to nearby chert, schist, and serpentine deposits. Primary cortical, secondary cortical, and interior core reduction flakes ranging from greater than 1 to less than 7 cm in diameter account for 71 percent (n = 34) of all obsidian EMFs, while interior biface reduction flakes ranging from less than 2 to less than 3 cm in diameter only account for 8 percent (n = 4).

Table 4: Projectile point and biface parts.

FRAGMENT TYPE	CLASS	FRACTURE TYPE					TOTAL
		BENDING	SNAP	IMPACT	INDETERMINATE	NO FRACTURE	
Tip	Projectile Point	5	2	--	--	--	7
Margin	Biface	2	1	--	3	--	6
Midsection	Projectile Point	1	1	7	1	--	10
	Biface	1	2	--	--	--	3
Base	Projectile Point	10	3	15	15	--	43
End	Biface	13	4	--	6	--	23
Complete	Projectile Point	--	--	--	--	34	34
	Biface	--	--	--	--	15	15
Total Projectile Point		16	6	22	16	34	94
Total Biface		16	7	--	9	15	47
Grand Total		32	13	22	25	49	141

A total of 10 chert EMFs range in diameter from greater than 2 to less than 6 cm; nine are secondary cortical core reduction flakes. One large (>7 cm) serpentine primary cortical core reduction EMF is present. In general, EMFs are small and derived from obsidian core reduction. On average, EMFs derived from locally available material are larger in size and less frequent in the assemblage.

Formal Tool Parts

Analysis included a study of the distribution of fragment and fracture types within the projectile point, biface, and FFT assemblage. Table 4 shows the distribution of projectile point and biface fragment types by fracture type. Complete specimens without fractures account for 35 percent (n = 49) of the total assemblage. Bending fractures, associated with either tool manufacture or maintenance, account for 23 percent (n = 32) of the total assemblage. The majority of bending fractures occurred on projectile point base and biface end fragments. Snap fractures, associated with use-related pressure, account for 9 percent (n = 13) of the total assemblage. Impact fractures are only observable on projectile points and account for 23 percent (n = 22) of the projectile point assemblage.

Indeterminate fractures are either unidentifiable or associated with recent breakage. Recent breaks caused by taphonomic damage are observed on eight projectile point base fragments and an additional eight complete projectile points. The majority of these breaks occurred at the tip and/or along the hafting element, the thinnest and most fragile parts of the point.

Fracture types were also analyzed for the entire FFT assemblage (n = 20). Complete specimens without fractures account for 60 percent (n = 12) of the total assemblage. Seven end fragments and one margin fragment are present. Five end fragments exhibit snap fractures associated with use-related pressure. Snap fractures account for 30 percent (n = 6) of the total assemblage. One bending fracture associated with either tool manufacture or maintenance and one indeterminate fracture, most likely associated with thermal fracture, were also present.

The majority of formal tools are complete. Broken tool parts are most often end fragments, rather than midsections or margins, and exhibit a relatively even distribution of use-related and manufacture- and/or maintenance-related fractures.

Tool Edge Morphology

A total of 242 specimens, including all tool classes (points, bifaces, FFTs, EMFs, and cores) were inspected for evidence of edge morphology. Edge morphology was observed on 118 specimens (49 percent) within the entire stone tool assemblage. Edge morphology can be divided into two categories: formal and informal. Formal edges exhibit morphology consisting of invasive flaking and shaping, either as a result of intensive use or rejuvenation and reuse of tool edges. Informal edges exhibit morphology consisting of non-invasive flaking, as a result of casual or expedient use of tool edges (Andrefsky

Table 5. Tool edge morphology.

Tool Class	Frequency	Reduction	Edge Type: Burin	Bevel	Drill	Spokeshave	Battering	Informal	Total (Edge Units)
Projectile Point	9	Bifacial	--	--	9	--	--	--	9
Biface	22	Unifacial	9	3	--	1	--	22	35
		Bifacial	6	--	1	--	3	3	13
Formed Flake Tool	20	Unifacial	6	3	--	1	--	15	25
		Bifacial	7	--	--	--	6	1	14
Edge-modified Flake	59	Unifacial	--	--	--	6	--	64	70
		Bifacial	--	--	1	--	1	2	4
Core Tool	8	Unifacial	1	2	--	--	--	3	6
		Bifacial	1	--	--	--	4	--	5
Total (Edge Units)			30	8	11	8	14	110	181

1994:22). Tool edges can be categorized by type and quantified by edge unit. Tools can possess multiple edge units of different types, distinguishable by location and/or morphology. Table 5 shows the distribution of tool edge morphology by type, tool class, and reduction technology, quantified by edge units.

Formal tool morphologies are present on 39 percent (n = 71) of all identifiable edge units. Forty-two percent (n = 30) of all formal edge units exhibit burin morphology. The majority of burins are found along biface and FFT edges. Only two burins are present along core tool edges. Bifacial rejuvenation is present on 47 percent (n = 13) of all identifiable burin edge units; the remainder of these edge units exhibit unifacial flaking most likely associated with initial manufacture. Not only are burins the most frequent type of formal edge unit, they were also used and reused intensively.

Battered bifacial edges represent 20 percent (n = 14) of all formal tool edge units. Nearly all classes except for projectile points possess edge units which exhibit battering. Fifteen percent (n = 11) of all formal tool edge units exhibit drill-wear morphology. The majority of drill wear is found along the edges of projectile point tips. Beveled edge units are also present and account for 11 percent (n = 8) of all formal tool edge units. Similar to burins, beveled edges are found along biface, FFT, and core tool edges. Beveled edges only exhibit unifacial flaking. Spokeshaves are present on 15 percent (n = 11) of all formal tool edge units. The majority of spokeshaves are found on EMFs.

Informal edge units account for 61 percent (n = 110) of all identifiable edge units. EMFs possess 60 percent (n = 66) of all informal edges, while the remainder are found on bifaces, FFTs, and core tools. Projectile points do not exhibit any informal edge morphology.

The CCO-297 stone tool assemblage exhibits a variety of tool edge morphologies distributed across all tool classes. This distribution is not evenly represented among different tool types. Edge units are infrequent among projectile points. When present, they are identifiable as drill-wear. EMFs, on the other hand, exhibit the highest frequency of edge units, yet informal edges are the most abundant. Core tools are the least frequently represented tool class; nevertheless formal tool edges, especially battered edge units, predominate. In comparison to all other tool classes, bifaces and FFTs appear to have been the most intensively used and reused tools. Although informal and formal tool use appears evenly distributed, formal tool use seems highly variable, emphasizing that bifaces and FFTs were multifunctional tools. The remarkably high frequency of unifacial and bifacially rejuvenated burin edge units suggests an intensive reliance on tools used to cut, incise, or inscribe.

Analysis of the CCO-297 flaked stone assemblage reveals distinctive patterns related to lithic raw material procurement and reduction, stone tool production, and function. The following section provides a preliminary interpretation of findings, as they relate to flake stone tool procurement, manufacture, and use at the Stege Mound.

FINDINGS

Trade

At the Stege Mound, projectile points appear to have arrived at the site as finished objects. The majority of projectile points are complete. A relatively low frequency of fragmented specimens is present. Use-related breaks and fractures resulting from manufacture and/or maintenance are evenly represented. One-half of fragmented point specimens display impact or snap fractures. Impact and snap fractures likely resulted from use. The other half of the broken points exhibit bending breaks, likely resulting from maintenance activities. The abundance of small bifacial thinning flakes and pressure flakes lacking cortical surfaces also suggests that point maintenance activities were important and carried out on-site. There is little evidence indicating the initial production of points at the site. Early biface thinning flakes are relatively absent, and the assemblage lacks a large quantity of broken projectile point parts with bending breaks. While evidence of projectile point maintenance is present in abundance, point manufacture is noticeably absent. Previous investigators argued that

> finished obsidian implements were manufactured by specialists elsewhere and [the specialists] were successful enough in promoting their industry to be able to establish a sole-source relationship to Bay Area traders, to the extent that local materials had little value vis-à-vis the preference placed on the well-made Napa obsidian implements. Their thinness, symmetry and complex notching must have increased their value since their production in quantity would require highly specialized skills applied to high quality raw materials, requirements that were not locally available [Banks and Orlins 1981:8.94].

At the Stege Mound, projectile points appear to have arrived on-site as complete weaponry (i.e., site inhabitants were acquiring the entire package: bows, arrows, and arrowheads). There is no supporting evidence for the manufacture of bows and arrows at the site. Although large chopper-like core tools were recovered, their presence is inadequate evidence of an industry to support bow production. Shaft straighteners or smoothers used to produce arrows are also absent.

We suggest that obsidian raw materials were acquired primarily through trade and exchange systems, and the site inhabitants do not appear to have had direct access to the obsidian source. At the Stege Mound, the majority of core reduction flakes are small, less than 3 cm in diameter. Within this size range, roughly 90 percent of core reduction debris is secondary and interior flakes. Primary cortical flakes make up just 10 percent of core reduction debitage. Flaking debris tends to be small and intensively reduced.

Obsidian cores are also small, having a mean diameter of less than 3 cm. The majority of cores possess more than one platform and appear to have been reduced until exhausted. In addition, one-third exhibit evidence of bipolar reduction. An unusually high number of obsidian cores (86 percent) have cortex, most often present on the area of the platform. It is likely that obsidian raw materials arrived at the site in the form of small nodules, either partially reduced or unmodified.

There are no large unmodified obsidian flakes present in the assemblage. On average, FFTs produced from obsidian are larger than obsidian debitage, having a mean diameter of less than 4 cm. The majority of FFTs (80 percent) possess a cortical surface, indicating that these items were produced following the initial reduction of nodules and/or cores.

Obsidian projectile points, bifaces, and FFTs appear to have been on different tool production trajectories. Bifaces were not used to produce projectile points. Remnant ventral surfaces are present on about half of the projectile points, indicating that points were generally manufactured from large flakes. Comparisons of thickness, width, and arris counts among bifaces and projectile points reveal significant differences. Projectile points tend to be very uniform, having a high number of arrises and small thickness. Bifaces appear generalized and highly variable. They have a greater range of thickness and far fewer arrises. Figures 5 and 6 depict scatter plots comparing the width, thickness, and arris counts for bifaces, projectile points, and FFTs. Points are thin, have high arris counts, and occur in a tight cluster. These traits indicate a high level of uniformity. Conversely, bifaces and FFTs are highly variable and scattered. Bifaces generally do not overlap with the small, uniform size range demonstrated among projectile points. Projectile points follow a thinning process associated with re-sharpening of a blade element. Bifaces are more generalized and do not appear to be on a specific production trajectory, indicating that bifaces were not retouched to produce projectile points.

Mobility

The organization of tool kits associated with different types of mobility can be characterized as either anticipatory or situational (Binford 1979). Anticipatory gear is organized to accomplish multiple tasks and is linked to a variety of situations. Tools tend to be highly curated. Anticipatory gear is often associated with mobile groups. This takes the form of a generalized tool assemblage or multifunctional tool kit.

Situational gear, unlike anticipatory gear, is responsive and task-specific. Situational gear is "gathered, produced, and drafted into use for purposes of carrying out specific activities" (Binford 1979:264). The activities are usually not known in advance, and the technology is organized to be responsive to the task at hand. Situational gear tends to be expedient in nature, such as the production of simple flake tools, which are made to address a specific purpose.

In his discussion of curated technologies, Binford makes the following generalizations:

> Basic "reduction strategies" for naturally occurring materials are highly variable in "situational" contexts. If only very small pebble materials are immediately available for instance, "bipolar' techniques may be used, whereas given larger materials, hand-held percussion techniques may be used. In contrast, one would expect that with "residential locations", where personal and household gear was frequently manufactured and maintained, only larger, higher quality materials would be commonly used, and reduction strategies would be less variable from one site to the next. [Binford 1979:263]

At CCO-297, the initial production of projectile points does not appear to have been conducted by local inhabitants. Instead, these objects were manufactured elsewhere and acquired through exchange as fully finished implements. In the flaked stone assemblage, projectile points are both the most frequent tool and exhibit the least amount of morphological variability. In addition, points exhibit impact fractures resulting from use. Points also appear to have been heavily curated, resulting in an overwhelmingly high frequency of complete specimens. Collectively, these attributes suggest that projectile points served a specific and limited range of functions. The acquisition of weaponry is associated with anticipated use for hunting purposes and/or in defense against external threats. This pattern indicates that not only was there a need for projectile points, but that the need was known in advance and anticipated, and the objects fulfilled very specific purpose(s) (Binford 1979:263).

Conversely, the organization of biface and core technologies appears responsive to "situational" tasks performed on-site (Binford 1979:263). These reduction technologies likely supported local modes of tool production associated with intensive marine resource extraction, including the harvesting of fish, fowl, and sea otters. Tools within this production trajectory also appear to have supported the manufacture and maintenance of bone implements, such as awls, tubes, flutes, whistles, fish spears, and harpoons. The processing of organic materials for fabricating textiles, basketry, or nets also appears to have been an important site activity. Analytical evidence suggests that unifacial and bifacial tools with formal edges, such as burins, spokeshaves, and beveled scrapers, were used to perform these necessary functions. Burins occur in relatively high frequencies and appear to have been manufactured, maintained, and discarded on-site. Burins tend to be used to cut, incise, or inscribe materials such as bone, shell, or stone. Spokeshaves are often used to process raw materials such as plants or wood. EMFs are abundant, but exhibit a high frequency of informal use, such as non-invasive flaking or "nibbling," likely associated with expedient cutting and scraping activities.

CONCLUSION

The CCO-297 flaked stone assemblage exhibits evidence of tool kits organized to either anticipate or respond to distinctly different situations. Projectile points appear to be end-user or consumer items that were acquired from outside groups as complete, fully fashioned tools and served a limited range of functions. These specialized tools operated primarily as weaponry for hunting and defense. Equally, production of bifaces, FFTs, EMFs, and core tools appears generalized and designed to support a variety of tasks performed on-site. Obsidian raw materials appear to have been arriving on-site as flake blanks or nodules. Obsidian raw material was necessary to address a range of situational tasks. A variety of expedient formal and informal tools were manufactured on-site to support tool manufacture, subsistence, and economic production behaviors. Expedient flake tools are not end products; instead, they represent tools used to make other tools (e.g., a burin is used to inscribe a bird bone tube to manufacture a whistle). Given the large assemblage of bone awls recovered from the site and corresponding evidence for their manufacture, it is likely that these stone tools supported the production of the worked bone tool kit, as well as local subsistence-related activities.

Present evidence indicates that site inhabitants did not have direct access to the obsidian material source. Instead, obsidian arrived on-site in the form of complete, fabricated projectile points or as small, partially reduced cores and unmodified nodules. The pattern of obsidian reduction at the site implies that these items represent indirect procurement. We suggest that obsidian was procured through trade with outside groups, as either formal tools or raw material. These items served as important commodities in an elaborate system of regional exchange.

When archaeologists study lithic artifacts at a site, we tend to use them to explore topics like mobility and settlement. In general, lithic analysts assume direct access to the raw material source. Tools were procured, manufactured, used, maintained, and discarded by the site inhabitants. We adopt an alternative perspective: that the inaccessibility of key resources, due to well-developed territorial systems, resulted in a lack of direct access to raw materials. This scenario was largely responsible for shaping the behavioral strategies evident in the organization of technologies at CCO-297. The types of objects arriving at the site were largely dictated by the nature of trade relationships.

In central California, the Late period is characterized by elaborate exchanges systems (Bennyhoff and Fredrickson 1994). Trade was a critical element of a cultural pattern that satisfied various economic, sociopolitical, ceremonial, religious, and subsistence needs. The timing and availability of certain resources was facilitated through exchange. Analysis of the Stege Mound flaked stone assemblage indicates that the site inhabitants did not have direct access to the obsidian raw material source. During the Late period, important resources such as obsidian projectile points and nodules appear to have been increasingly commoditized, serving as products within a complex exchange system. We recognize the importance of trade in structuring the overall organization of technology.

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