ASPECTS OF ANCIENT MAYA HOUSEHOLD ECONOMY:

VARIATION IN CHIPPED STONE

PRODUCTION AND CONSUMPTION

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INTRODUCTION

Interpretation of regional settlement patterns from the central Maya lowlands (Figure 1) has provided a foundation for understanding the basic subsistence economy of the ancient Maya (Ford 1986, Rice & Rice 1980, Rice 1976, Puleston 1973). Despite our growing understanding of Maya residential land use and its change over time, though, little has been done to understand differentiation among the identified settlements and their residents. What is needed is an examination of the direct evidence on the household economy in order to evaluate variation in production and consumption patterns. In this essay, we look at

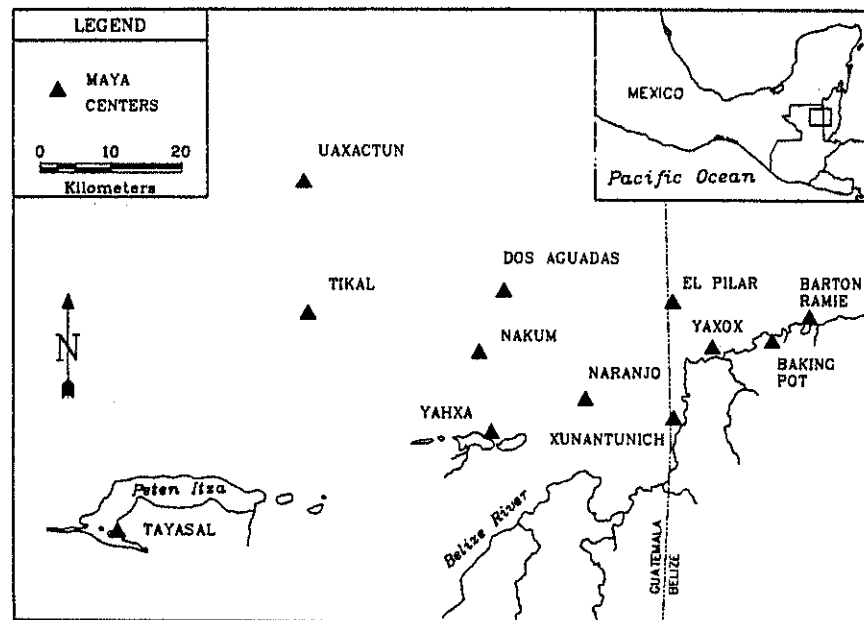*Figure 1.* Central Maya Lowlands

the settlement pattern data from the Belize River area and predict aspects of the relationship of residential patterns to a major constituent of household midden: chert products and production debris.

Settlement patterns of the Belize River Archaeological Settlement Survey (BRASS) area have pointed to provocative organizational differences that are clearly related to variations in the local household economies of the ancient Maya (Ford 1985, n.d.). These variations and implied organizational differences appear to be related to environmental characteristics of the area. Settlements of the interior uplands show distinct hierarchical organization, similar to the core area around Tikal. Settlement in the valley, on the other hand, appears to be fairly undifferentiated and possibly self-sufficient. Analysis of midden constituents at residential units within these zones of the Belize River area will illuminate the local household economies.

Many kinds of household activity by-products are represented in ancient Maya middens, but not all are equally preserved. One household activity that yields well-preserved material remains is chert tool production and consumption. We can describe household-level chert tool activities mainly because there is archaeological evidence pertinent to the reductive stages of chert tool manufacture. The waste products, or debitage, generated during tool production and other, associated stone working activities provide the basic information about chert tool

production at house sites, while the discarded tools monitor chert tool consumption.

To evaluate chert artifact patterning, we describe the BRASS project itself and discuss the nature of the settlement data. Based on assumptions of chert reduction technology, we set up a standard approach to evaluate chert debitage using data from studies of biface, flake-blade, and flake production. This approach involves application of a simple debitage size-sorting procedure in order to elucidate the variable chert production activities and their stages. We compare the results with the BRASS settlement pattern data in order to interpret ancient Maya household chipped stone production activities.

The results of this analysis of chert artifacts in the residential middens provide critical information on the degree of variation in organization of ancient Maya chert tool production in the Belize River area. The identification of patterns of production centralization has significant impact on our interpretations of household-level independence, not only for the local area but for the region as a whole. These patterns can be evaluated with an approach that is expedient and effective. Our approach should have general applicability for any initial inquiry into chipped stone production and could precede more detailed and labor intensive analyses of chert production.

THE UPPER BELIZE RIVER AREA

The upper Belize River area (Figure 2) can be categorized geographically into (1) the open, undulating valley east of the confluence of the eastern and western branches of the Belize River and (2) the valley foothills and uplands to the west (Jenkin et al. 1976, Wright et al. 1959). The center of Baking Pot (described in Bullard & Bullard 1965) and the settlement of Barton Ramie (described in Willey et al. 1965) are only a few kilometers downriver in the open valley area.

Belize River Archaeological Settlement Survey

The BRASS project was designed to investigate settlement-environment relationships in the peripheral upper Belize River area. Because of the lush tropical vegetation, transect surveys were used as the sampling strategy. Each of the survey transects was located to include identified environments of the area and was oriented to crosscut the valley and bisect a local center (see Figure 2).

Most of the survey, undertaken in two 5-month seasons (1983 and 1984), encompassed five major activities: (1) transit mapping of the four centers, (2) establishment of two 5-km baselines and one 10-km baseline to serve as the axes of the transects, (3) settlement survey of 125m on each side of the baseline (500 ha), (4) mapping of all obtrusive cultural remains within the 250m-wide transect (348 residential units), and (5) test excavation in household middens of a 12.5

Figure 2. Belize River Area, Showing Survey Transects
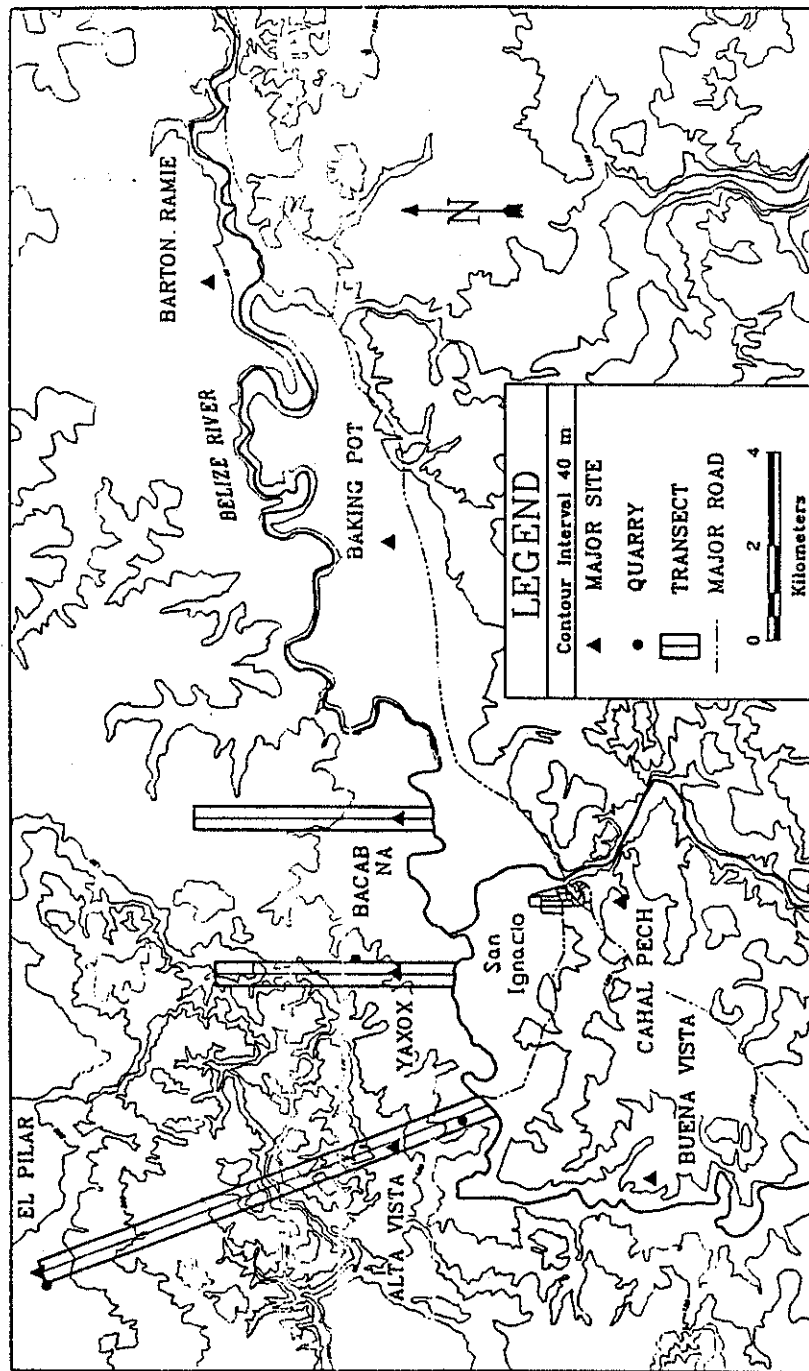
percent random sample of residential units (48 total), stratified by distance from the river. In 1985, a further settlement survey was conducted around the identified obsidian production site of El Latón, 4.5 km south of El Pilar, locating a small center on the hill overlooking the settlement cluster. The 1986 season focused on the centralization process in the area by examining construction sequences exposed in looters' trenches at the four identified centers: El Pilar, Alta Vista, Yaxox, and Bacab Na (see Figure 2). Finally, the 1987 season was designed to cover selected unsurveyed zones, based on soil type and topography, to confirm the interpreted environment-settlement relations identified from the 1983–84 transect surveys.

Residential excavations within the three major transect surveys focused on middens located adjacent to the structures. Middens were located using the posthole-digger method developed during the Tikal Sustaining Area Project (Fry 1972). The densest midden debris, determined by posthole tests, was excavated. All excavated material was screened, and collections retained by $\frac{1}{4}''$ mesh screens were processed and cataloged.

Three chert quarries were identified in the course of the survey (see Figure 2). Two were in the valley foothills, in tributary drainage exposures. The larger of the two, the Yaxox quarry (Ford 1985:14), was located about 2.5 km north of the river at the edge of the Yaxox transect. The Yaxox quarry has chert debitage densities of 1,541,600 pieces/m³. The smaller quarry was located within 1 km of the river on the Pilar transect; this site is referred to as 272–229 and has debitage densities of 6,994/m³. Both quarries are loci of considerable lithic reduction of cobbles mined from local exposures. The last quarry recorded by the BRASS project was adjacent to the large center of El Pilar. This major quarry and reduction site, known as the LDF chert site—after Larry De Forest, who first identified it—is the largest recorded in the area. It displays evidence of biface reduction over a 50m² area approximately 60 cm thick, with debitage averaging 550,000 pieces/m³.

Preliminary Belize River Area Chronology

Archaeologically identified occupation of the BRASS study area begins in the Middle Preclassic Period in both the valley and upland zones and continues through the Postclassic Period (Figure 3). Generally speaking, there is evidence of settlement expansion over time, from the Preclassic through the Classic. The enigmatic decline in the Early Classic settlement expansion may be more a function of our limited knowledge of Early Classic ceramics of the Belize River area (cf. Lincoln 1985) than of any adaptive change (see Ford 1986:80–81). Diagnostic Early Classic ceramics make up only 2.4 percent of the entire collection, and over half of these ceramics are decorated basal-flange bowls.

Seventy-five percent of the diagnostic ceramics collections pertain to the Late Classic Period, when nearly all of the residential sites are occupied. This growth

Figure 3. Percentage of Occupation, by Archaeological Period, in the Valley and Upland Zones of the Belize River Archaeological Settlement Survey (BRASS)
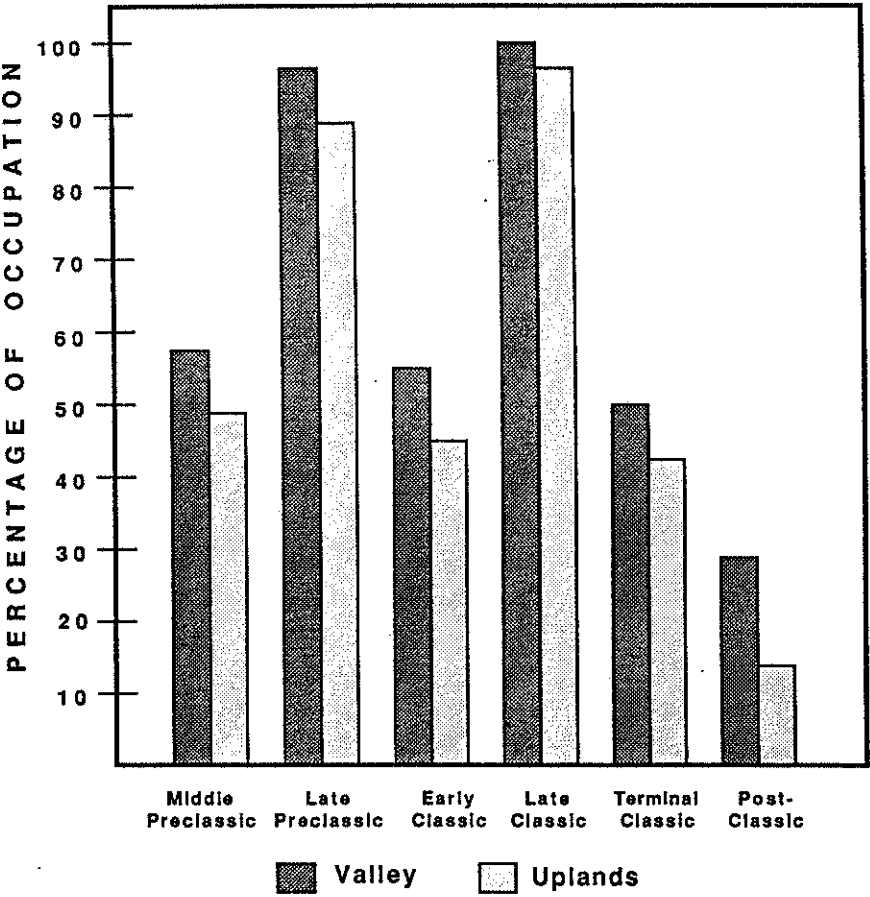
appears to be correlated with the major building activity at centers in the valley (Bullard & Bullard 1965), including large public construction undertakings at all the centers of the BRASS study area. Our current study of the chert artifacts, reported here, focuses on the activities of the Late Classic Period.

Belize River Area Settlement Hierarchy

While settlement density in the Belize River area is relatively high for the region as a whole (Table 1), there is significant variation within the area

Table 1. Labor Investment Comparisons between the Belize River Area and the Tikal Area

	Belize River Area[a]	Tikal-Yaxhá Area	Tikal Center
Settlement density (structures per km²)	120	110	200
Average labor investment (labor-days)	997	2,085	2,793
Highest labor investment (labor-days)	6,500	9,000	19,500

[a]These data include the BRASS area and Barton Ramie (as derived from the map in Willey et al. 1965).

(Table 2). These local variations have implications for household organization of production, including chipped stone production activities. We consider residential form, composition, and relative size as indicators of household and community differences. Understanding the variation in settlement patterns and implied organizational correlates within the Belize River area provides a basis for interpreting chert artifact distribution.

Settlement pattern variations within the Belize River area suggest that the dense communities in the uplands were hierarchically organized and focused on El Pilar. Settlements consisted of few large, multi-structure residences and many small, single-structure residences. Communities in the valley, on the other hand, appear to have been medium-sized, single-structure units, scattered in moderate densities (Table 2), suggesting relative self-sufficiency.

The difference between upland and valley zones in residential settlement density, size, and composition, is reflected in the administrative centers recorded and mapped by the BRASS project (Ford 1985). There is little size differentiation among the valley centers of Yaxox, Alta Vista, and Bacab Na (Ford n.d.). All fall within the expected range of the lowest hierarchical levels in Adams & Jones' (1981) ranks of courtyard counts and are consistent with the ranks of other Belize Valley centers (Adams & Jones 1981:Table 1). The upland center of El

Table 2. BRASS Residential Unit Composition, by Transect

	El Pilar Transect	Yaxox Transect	Bacab Na Transect	Barton Ramie Transect
Average structure density	141	123	95	100
Average number of structures per residential unit	1.5	1.4	1.2	1.05
Percent single-structure units	64	64	90	96
Average labor investment (labor-days)	745	749	1,598	1,159

Pilar, with 15 courtyards (Ford 1985), is a dramatic contrast to valley centers and ranks equally with many major centers of the core area around Tikal.

El Pilar is the largest center in the area. Surveys have documented a number of centers within 5–10 km, but all are about a third the size of El Pilar. Residential settlement density and composition in the immediate vicinity of El Pilar have much in common with the Tikal core area. Both areas have comparatively large residential units, averaging 2–3 structures per unit, and fewer than 30 percent of the units are composed of single structures (compare Rice & Puleston 1981:149, and Tourtellot 1983:43). This percentage is significantly lower than that of the El Pilar transect as a whole (Table 2). Furthermore, settlement density around El Pilar is 292 structures/km², more than twice that of the Pilar transect as a whole (see Table 2).

Examination of estimates of cumulative construction labor investments for ancient Maya residential units (Arnold & Ford 1980) provides another basis for evaluating settlement variation in the Belize River area. Estimated labor investment for the construction of ancient Maya residential units is arrived at through a cumulative computation based upon area and height of mapped structural remains (Arnold & Ford 1980, Ford & Arnold 1982). Structures are individually measured and summed together where residential units are composed of several structures. For residential units situated on an artificially raised plaza, the labor investment in the plaza is included in the total labor investment calculation. Residential unit labor investment is a relative estimate of residential value and household wealth (Arnold & Ford 1980; see also McGuire 1983, Netting 1982). The calculated result provides a standard means for comparing residential unit size in the Maya lowlands.

Residential labor investment distribution for the entire upland zone is unequal, with many small residential units and few large residential units (Figure 4). This type of distribution, noted also for the core area near Tikal (Ford & Arnold 1982), reflects heterogeneity among the residential units. This settlement differentiation suggests that some degree of wealth differentiation and hierarchy existed in the local upland zone. Initial examination of soil fertility (Fedick n.d.b) demonstrates that the highest labor investments are concentrated in the fertile soil zones (see also Fedick, this volume).

Valley centers do not appear to be the population nuclei of the surrounding settlement, as seen in the upland zone near the center of El Pilar. The average settlement density in the overall Yaxox, Bacab Na, and Barton Ramie areas corresponds to the density within and beyond 1 km of the center, averaging about 100 structures/km². Lack of settlement aggregation around these valley centers is unlike the core area, where the emergence of centers has been seen to be tied to settlement density (cf. Haviland 1970, Ford 1986:92).

Valley residential size distribution, based on construction labor investment, is fairly equivalent, with many medium-sized units and few small and large residential units (Figure 4). Even though settlement densities are lower in the valley

Figure 4. Percentage of Residential Unit Labor Ranks of the El Pilar, Yaxox, and Bacab Na Transects
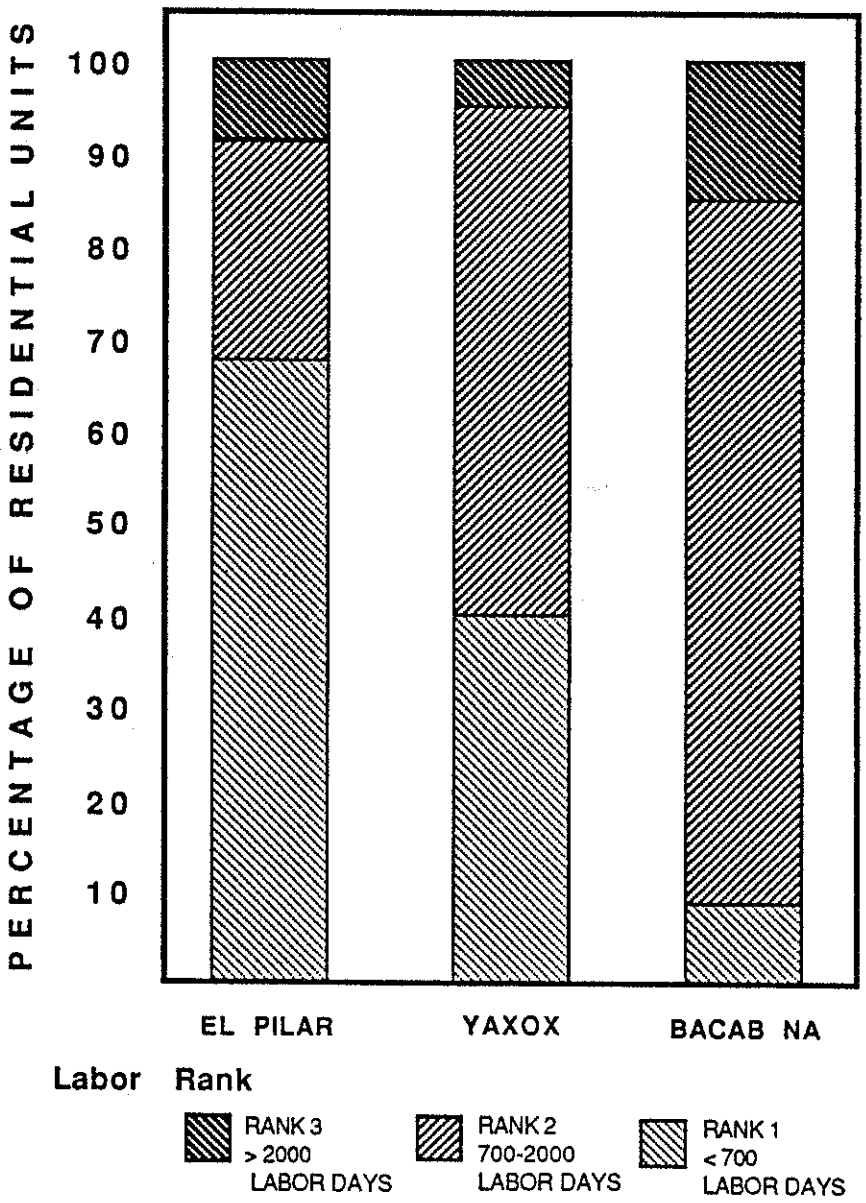
bottom, where the Bacab Na transect and Barton Ramie area are located, labor investments are more evenly distributed (cf. Willey 1956) than in the upland zone around El Pilar. The residential units of the valley reflect a homogeneity in overall size and composition.

In summary, the uplands around El Pilar appear to exhibit great wealth concentrations as evidenced not only in the presence of one of the largest local centers but also in residential labor investments. Valley settlement was generally homogeneous and centers were relatively equal in size. While differences between the valley and the uplands are evident through remains of residential units, more evidence is needed to support these interpretations. The examination of midden constituents, specifically, chipped stone artifacts, provides an opportunity to further evaluate these assessments.

THE STUDY OF CHERT ARTIFACTS OF THE BELIZE RIVER AREA

Fundamental settlement pattern differences between the upland and valley zones suggest differences in basic community economic organization which should be evident in aspects of the household economy, especially in artifact inventories. Indeed, an understanding of the distribution of the chipped stone artifacts from household middens will help in the interpretation of organizational differences and similarities that exist within the area.

Chipped Stone Analysis

Chert, used for most chipped stone tools in the lowland Maya region, is readily available in the Belize River area, both in terrace river gravels and in nodule-bearing outcrops in the limestone foothills and uplands. Generally speaking, household utilitarian items such as bifacial choppers and simple utilized flakes would have been derived from local sources, whereas specialized chert artifacts such as large "eccentrics" and specialized bifacial knives may have been procured and produced from outside the local area (e.g., Colha; see McAnany 1989, Hester & Shafer 1984, Shafer & Hester 1983).

Although studies of prehistoric Maya chert artifacts traditionally have been limited to the examination of shaped tools (e.g., Bullard & Bullard 1965:28; Moholy Nagy 1976; Willey et al. 1965:410–452), attention has been devoted recently to debris associated with chert tool manufacture (Hester 1976, Shafer 1985) or tool refurbishing (Shafer 1983, McAnany 1989). A number of massive biface and blade production loci have been the subject of detailed debitage analyses (Michaels, this volume; Roemer 1984). What these and similar efforts have amply demonstrated is that each chipped stone endproduct is associated with a specific debitage pattern.

Analysis of chert products and debitage can provide important information on procurement, production, and consumption of the chipped stone tools (cf. Bamforth et al. 1984, Ericson 1984, Fedick n.d.a, McAnany 1989, Runnels 1985, Torrence 1984). After production, tools will be distributed for use, while the debitage normally is left near the place where the tools have been made (Shafer 1985:293, Torrence 1984:58). To obtain the most accurate and complete technological picture of chert tool production at the residential level, one must look at all stages of the process (Ericson 1984). Chert tool reduction stages include: (1) quarrying the source material, (2) decortication (flake removal of outer cortex), (3) secondary preforming, (4) shaping and thinning, and (5) finishing the tool (Crabtree 1972, Callahan 1979, Shafer 1985:281–282). As all these activities produce distinctive debitage associations (see McAnany 1989), debitage studies can provide information on the kinds of chert products that were being produced in a specific area as well as the intensity at which they were being produced.

Primary Classification

Collections of chert artifacts from the BRASS test excavation units include materials $\frac{1}{4}''$ (the minimum size of excavation screenings) or larger. Pieces of chert were classified as flakes, angular debris (chunks), cores, or tools. Flakes have an identifiable set of characteristics: bulb of percussion, eraillure scars (on bulb), force rings increasing in diameter away from the platform, radiating lines close to the platform, dorsal flake scars or cortex, and the platform and its specific features (see Crabtree 1972, Bamforth n.d.). Angular debris, or shattered chunks, are pieces of chert related to production but which have no identifiable flake or core characteristics. Cores are chert nodules or cobbles from which flakes have been struck and are often the by-products of flake production. Shaped tools in the Belize River area mainly consist of fragmentary and complete bifacial and shaped-flake tools.

The BRASS chert artifacts are associated with excavated subsurface levels of variable depths. The excavated volume of each unit was calculated individually. Unit frequencies of excavated chert artifacts were converted to density/m³ (Table 3) in order to have comparable data for interunit comparisons.

Variability in chert debitage densities was immediately apparent among the residential units (Table 3). Considering all residences in the Belize River area, the debitage density mean is 430/m³, with a range of 13–6,994. The debitage densities of BRASS residential units are quite high when compared to densities in the Copan valley, where all chipped stone (chert and obsidian) had a mean density of 97/m³ and a range of 3–482/m³ (Mallory 1984:229). The BRASS residential densities are low, however, when compared with the specialized chert production site of Colha, where densities are some 1,000,000–5,000,000/m³ in workshop areas (Roemer 1984, Shafer & Hester 1986). Specialized sites of chert reduction and tool production recorded in the BRASS survey (the LDF chert site

Table 3. Mean Chert Artifact Density in the Belize River Area, by Transect and Residential Unit

Residential Unit No.	Density per m³				Distance (km) from river
	Debitage	Chunks	Cores	Tools	
El Pilar Transect (272)					
237	71	4	0	4	0-1
229	6,994	9	8	18[a,b]	1-2
220	164	12	0	3[b]	1-2
219	143	10	0	2	1-2
210	462	20	0	6	2-3
198	413	17	0	6[a]	2-3
192	53	4	0	5[a]	2-3
182	313	29	0	11[a,b]	2-3
179	459	15	0	4	2-3
168	191	5	0	11[a,b]	3-4
162	51	7	0	4	4-5
152	64	3	0	0	5-6
145	218	8	1	8	5-6
136	1,231	12	27	487[a]	5-6
129	170	25	5	30[b]	5-6
118	13	1	0	0	5-6
110	60	1	1	0	6-7
108	57	0	0	1[b]	6-7
94	73	1	0	4[b]	7-8
90	238	1	2	0	7-8
78	168	6	0	1	7-8
71	305	7	4	29[a,b]	7-8
68	73	15	0	6	7-8
60	287	16	0	10[a]	8-9
46	168	6	1	1[b]	9-10
39	115	7	1	1	9-10
32	305	12	0	4	9-10
25	63	5	0	3[b]	9-10
Yaxox Transect (278)					
26	368	16	4	5[b]	0-1
31	496	11	0	5[b]	0-1
40	512	10	5	2	1-2
46	987	29	15	49[a]	1-2
55	205	12	3	8[b]	1-2
56	585	28	17	14[b]	1-2
66	1913	20	22	36[a,b]	2-3
77	342	36	2	28[a]	2-3
82	160	11	2	2[b]	3-4
89	796	28	13	7	4-5
92	115	6	0	7[a,b]	4-5
98	94	9	1	1[b]	4-5
105	203	10	0	0	4-5

(continued)

Table 3. (Continued)

Residential Unit No.	Density per m³				Distance (km) from river
	Debitage	Chunks	Cores	Tools	
Yaxox Transect (278) (continued)					
116	99	5	0	1	4-5
126	93	0	1	7	4-5
Bacab Na Transect (281)					
21	117	7	1	0	0-1
24	254	18	10	16	0-1
27	235	20	2	3	0-1
33	128	7	1	3	0-1
34	300	13	4	13[a]	0-1

[a]Sites with hammerstones.
[b]Sites with biface failures.

at El Pilar and the Yaxox quarry north of Yaxox) exhibit densities approaching a million flakes/m³, comparable to those at Colha. Clearly, the intensity of chert tool production at households is of an entirely different scale than at specialized production sites.

Because flake size has been shown to be indicative of production stages of lithic tool reduction (Callahan 1979:9–10, 18; Fedick n.d.a:13; Roemer 1984; Michaels 1987), all unutilized flakes from the BRASS residential units were screened through $1''$, $\frac{1}{2}''$, and $\frac{1}{4}''$ mesh to separate them into gross size categories. These categories of large ($>1''$), medium ($1''-\frac{1}{2}''$), and small ($\frac{1}{2}''-\frac{1}{4}''$) flakes were then counted, weighed, and recorded for the analysis. At the same time, 20 percent samples of each size group (one in five counted pieces) were drawn for further attribute analysis focusing on the specific characteristics of flake mass, presence of cortex and dorsal flake scars, as well as platform properties. The SYSTAT program, run on an IBM microcomputer, was used to analyze the large data set (42,966 flakes) from the 48 BRASS residential units.

Setting Up a Standard for Comparison

As different chert production technologies will be reflected in their chert debitage patterns, we established an initial means of distinguishing these patterns using flake density and size. Several data sets pertaining to different types of chert tool production were chosen as standards against which the BRASS data would be compared. These standards are from a wide variety of sources, including experimental materials of Monterey chert from Vandenberg, California, and archaeological materials from Mojave, California, and Colha, Belize. We contend that lithic reduction techniques are sufficiently standardized to make these

comparisons relevant. That is, despite local differences in raw materials, sub-sistence strategies, and technical skills, the objectives of lithic reduction are shared and held in common by all stone-age technologists (Shafer, per. comm., 1988).

The first comparative data set was from the experimental manufacture of two bifacial tools produced by a moderately accomplished lithic technologist (Marcel Kornfeld) at the University of California, Santa Barbara.[1] This data set consists of all pieces of chert from manufacture (including flakes, shatter, and detritus over $\frac{1}{4}''$ in size). The identified debitage flakes were sorted into large, medium, and small size categories, comparable to the BRASS classification scheme. Within these general size categories, information was collected on flake frequency and average flake weight as well as platform angle (see Raab et al. 1979). Importantly, this data set provides flake percentages by size that are clearly representative of bifacial tool production (Table 4).

The second standard data set comes from Colha (Roemer 1984). The Colha material provides standards for two distinctive stone tool technologies that have been identified at this large chert tool production site: bifacial and flake-blade tool production. Roemer (1984:222–223) separates biface and flake-blade debitage and provides weight by flakes size categories for the excavation units. Using the weight per frequency data derived from the experimental biface data mentioned above, Roemer's weights were converted to frequencies for use in this analysis. Both the blade and the biface debitage weights were converted in this manner (Table 4).

The last standard data set is derived from the Mojave desert (Bamforth et al. 1984) and gives us our standard for the debitage of flake-tool production. Flake size distribution from four sites is given in a graph by Bamforth et al. (1984:180). Our compilation of these data for flake production is shown in Table 4.

The comparative percentage standards provide a set of expectations for distinguishing between the debitage patterns associated with biface, flake, and flake-blade production. These standards indicate that biface reduction stages include low percentages of large flakes and high percentages of small flakes. This pattern is expected, since bifacial production involves a great amount finish flaking (Callahan 1979:17; Patterson & Sollberger 1977). Flake-blade technology involves fairly equal percentages of large, medium, and small flakes, indicating that the production of large blades involves some degree of core preparation and little fine finishing. Flake production, with an emphasis on the primary reduction stage (Bamforth et al. 1984:215, 234), is focused on large flakes, since the objective of this production technology is to make flakes suitable for handling. The result is a high percentage of large flakes and a low percentage of small flakes.

Each standard representation of chert production technology was plotted on a tripolar graph (Figure 5A). Each axis of the tripolar graph denotes the percentage

Table 4. Percentages of Size-Sorted Flakes of $>1''$, $1''-\frac{1}{2}''$, and $\frac{1}{2}''-\frac{1}{4}''$ Used for the Comparative Analysis

FLAKE SIZE	EXPERIMENTAL[a]	COLHA[b]		EL PILAR[c]			MOJAVE DESERT[d]
		Biface	Flake-Blade	3N1W	1N1W	Mean	
$1''$	4	8	24	2	4	3	78
$1''-\frac{1}{2}''$	28	29	29	22	30	26	18
$\frac{1}{2}''-\frac{1}{4}''$	68	63	47	76	66	71	4

[a] Biface production debitage of Monterey Chert knapped by Marcel Kornfeld. Data curated in the Department of Anthropology, UCSB.
[b] Production Workshop data from Roemer 1984.
[c] El Pilar LDF biface production site, BRASS project. Data available in the Department of Anthropology, UCSB.
[d] Flake Production debitage from the Mojave Desert (Bamforth et al. 1984).

Figure 5. Range Triangles: A, Standard Chert Production Technologies; B, BRASS Residential Unit Percentage Sets
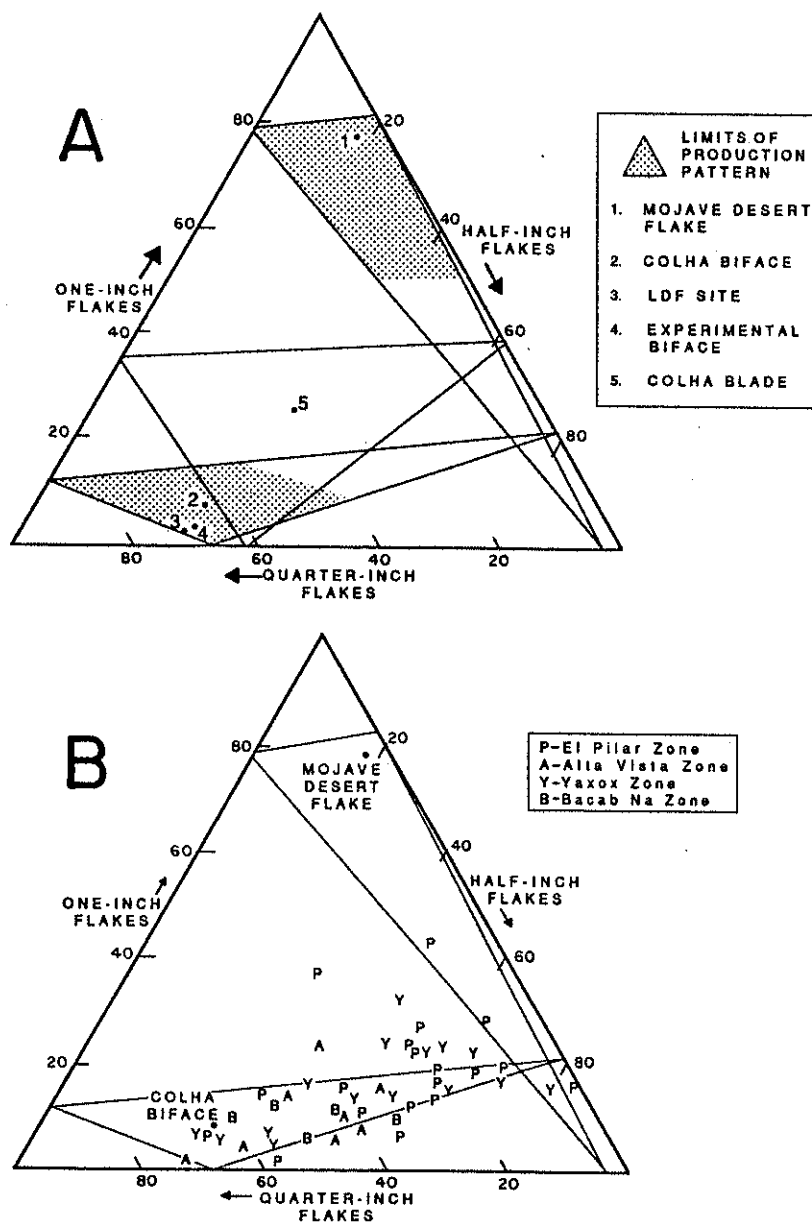
of each screen size of flakes (1″, ½″, ¼″). The plotted data points of the different standard chert reduction strategies represent all by-products of each specific strategy.

While each point provides us with a standard for specialized production debitage patterns, the actual households likely represent a range of production activities. To aid in determining the degree to with each of the identified technologies (i.e., flake, blade, biface) was employed, range triangles were generated around each standard point. Since each size category represents, in a general sense, a stage in the reduction sequence, the elimination of one size category from the calculated percentage would, essentially, eliminate one reduction stage. To accomplish this objective, each size category was eliminated in turn by setting its percentage to 0 and proportionately distributing the values in the other two categories. For example, if the large flakes were eliminated from the Colha data set, the relationship between the small and medium flakes would be 67 percent to 33 percent. The resultant point (67:33:0, in the example) represents the extreme ends of each size category and, by inference, each stage of reduction. By connecting these extreme points, a triangular area is formed that represents the broadest range of each chert production technology.

Range triangles were constructed for flake, flake-blade, and biface technologies (see Figure 5A), providing a basis for interpreting the BRASS residential units. While a range triangle was constructed for the flake-blade technology identified at Colha, no such artifacts were identified in the BRASS assemblage. Therefore, the BRASS data points were evaluated in terms of the biface and flake technologies only (Figure 5B).

Data points centrally located around the region of the standard points would be evaluated as fitting the production pattern of the standard reference point (e.g., flake vs. biface). Deviations from the standard reference point should be evaluated in terms of relative flake size proportions and density. For example, we may suggest that biface production was the predominant strategy at a particular residential unit with moderate flake density, if a data point falls into a central area where small flakes comprise no less than 40 percent and large flakes comprised no greater than 15 percent of the debitage (see Figure 5A). Likewise, we may suggest that early stage core reduction and, possibly, flake production was practiced at a residential unit where a data point fell into a central area where small flakes comprised no more than 15 percent and large flakes no less than 50 percent of the debitage. Location of data points on extreme ends of the range triangle (opposite of the central area) implies the absence of a particular production pattern. For points located beyond these basic limits, alternate conclusions must be drawn. Such alternatives may include mixed strategies of flake and biface production or the presence/absence of single stages of the reduction/production sequence. Thus, these range triangles provide the standard reference by which we are able to analyze the BRASS chert data (Figure 5B).

Application of Standards to BRASS Data

In order to evaluate the BRASS chert data, we had to organize them for proportional comparison with the standards. The BRASS data represent chert frequencies of each size category for all tested residential units. These data were combined with excavated volume to yield the chert artifact density, important in comparisons among residential units. The screen size frequencies of flakes/m³ were converted into percentages representative of each flake size category present in the residential middens. The composition of the three flake size categories, representing household chert production at each residential unit, makes up a percentage set.

Each percentage set, representing a BRASS residential unit, was plotted on a tripolar graph (see Figure 5B). The triangular standards were then made into template overlays for visual analysis of the BRASS data. The BRASS data points lay largely within the biface and, to a much lesser extent, within the flake production areas denoted by the triangles.

The BRASS data were broken down into parts for separate analysis. Each basic transect area was considered separately as a representative of a local zone (Bacab Na, Yaxox, Alta Vista, or El Pilar). In order to further interpret the relative significance of the BRASS data points, we also considered flake debitage density (see Table 3). The total frequencies of flakes/m³ for each residential unit were plotted as a histogram and, based on the overall distribution, were divided into low (0–230 flakes/m³), medium (230–520 flakes/m³), and high (520–above/m³) density groupings. These density groupings were plotted against the range triangles in Figure 6.

The upland El Pilar zone shows a wide scattering of points and no obvious pattern towards either biface or flake production. This lack of patterning is also seen in the evidence of low chert densities at the majority (80%) of residential units (see Figure 6C). Even sites with medium density display no pattern congruent with either biface or flake production (Figure 6B), although the residents were using such artifacts (Table 3). Only one residential unit shows high flake density (Figure 6A). This site, 272–136, is notable in its high tool density (Table 3). It is the location of a specialized workshop utilizing an enormous quantity of specialized chert engravers and wedges which were largely produced at the site. In addition to high tool densities, 272–136 has elevated densities of other chert production by-products, including chunks, cores and hammerstones (see Table 3).

Within the immediate vicinity of the upland center of El Pilar, sites show markedly low debitage densities (mean = 130 flakes/m³). Clearly, neither consistent biface nor consistent flake production occurred at any household directly around the center, since even the moderate density points lie near the periphery of both the biface and flake range triangles. Thus, we must conclude that chert production was an irregular activity at the household level in the uplands. This conclusion is complemented by the data from the LDF chert tool production site,

adjacent to the center of El Pilar, which has chert densities and size proportions (Table 4) comparable to Colha and is not associated with any single residential unit.

The residential data points around the valley foothill center of Alta Vista roughly cluster together within the biface range triangle (Figure 6A–C). All of the units having medium densities of debitage (mean = 340 flakes/m³) and the presence of hammerstones are grouped immediately around the center of Alta Vista. These units fall within and at the margin of the central area of the biface triangle (Figure 6B), suggesting mixed chert reduction strategies, emphasizing biface over flake production. This preponderance of residential units with medium chert densities around Alta Vista suggests a tendency towards multiple residential production/consumption units rather than a single, high-density production site.

The only high chert density residential unit, 272–229, falls on the edge of the central area of the range triangle (Figure 6A) and implies biface production. This site, immediately adjacent to a small chert exposure and quarry near the river and about 2 km south of Alta Vista, most likely represents a specialized procurement/production site that takes advantage of the local availability of the chert. The site exhibits a high density of chipped stone tools (largely unfinished biface production failures) and has evidence of hammerstones (see Table 3). The fact that this rural locus is the site of regular and systematic chert production, and that sites in the vicinity of Alta Vista appear to be individual production and consumption units, implies a degree of production independence in this area as contrasted with the uplands.

Yaxox, the largest valley center, shows variations representing more than simple biface production, as the range of the data points is much wider than the biface production triangle (Figure 6A–C). This transect has the most high- and medium-density units of the Belize River area—53 percent of all residential units in the transect (Figure 5). Units with high densities are clustered towards the periphery of the range triangles. All these sites are located within 250m of the major Yaxox quarry site and all deviate from the biface production standards. Given their proximity to a quarry, however, they probably represent early stages of biface manufacture. Emphasis on early stages of production, including decortication and primary shaping, would inflate the proportions of the larger flakes and deflate the contribution of small flakes at a site. Let us note that most of these units (278–46, –55, –56, –66, and –77; see Table 3) have hammerstones and/or biface failures present. Future analysis of flake characteristics will clarify whether or not they were all involved in biface production.

Chert tool production activities often are staged from quarry procurement to ultimate consumer use. Higher percentages of small flakes could indicate that finishing was taking place at locales away from the quarries (see Ericson 1984). Most of the medium-density sites (mean = 458 flakes/m³) are centrally located within the biface range triangle (Figure 6B) and spatially in the vicinity of the

Figure 6. Range Triangles and BRASS Residential Units Percentage Sets by Zone: A, High Debitage Density (>520/m³); B, Medium Debitage Density (230–520/m³); C, Low Debitage Density (<230). (P = El Pilar Zone, A = Alta Vista Zone, Y = Yaxox Zone, B = Bacab Na Zone)
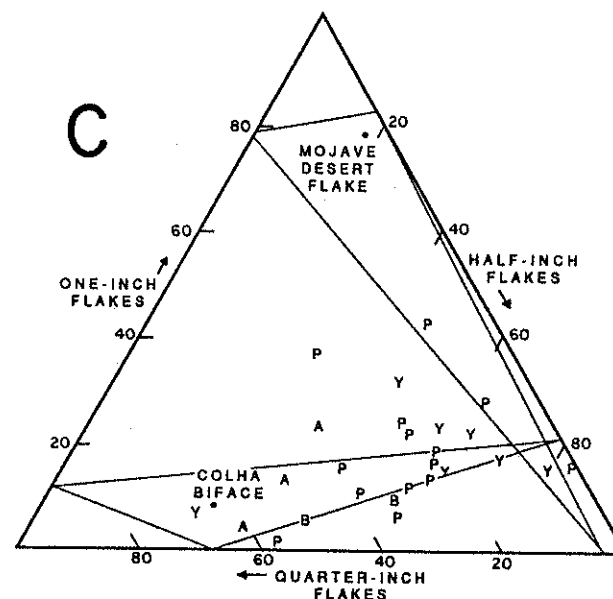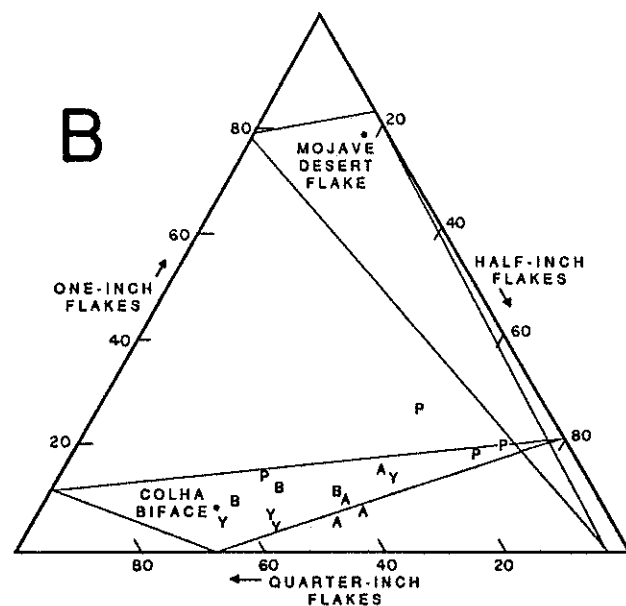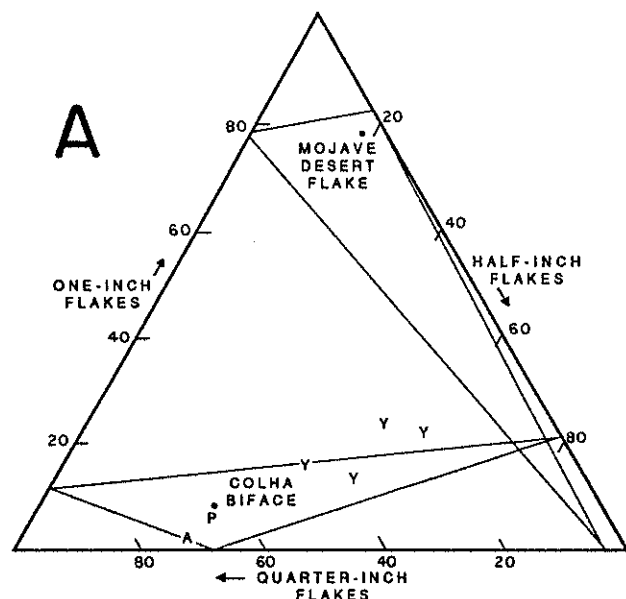
center of Yaxox, a pattern similar to the one seen around Alta Vista. These sites have higher percentages of small flakes, suggesting greater involvement in finishing activities, than do the quarry sites to the north (see Figure 6A). This higher percentage of small flakes appears to indicate that some division of production activities was occurring in the area. The few sites with low chert density within the Yaxox transect area are generally located at the extreme periphery or outside the biface range triangles (Figure 6C). These sites were not significantly involved in chert production.

While some division of labor in tool production is evident in the Yaxox transect, specifically with regard to the initial stages of reduction (as discussed above), all these sites were involved in using shaped tools. Given the moderate to high densities of chert debitage, the local units were doubtlessly involved in making the chert products which they were also consuming. Furthermore, there is no monopoly of the quarry area, as many sites had access to raw materials.

The Bacab Na residential cluster appears similar to those of the Alta Vista and Yaxox vicinities. All the points, whether medium or low density (Figure 5B–C), cluster together in a small, exclusive group of primarily biface producing units. While the majority (60%) have medium densities (Figure 6B) of chert debitage (mean = 206 flakes/m³), none have high densities.

There is a degree of homogeneity in the chert artifacts among these sites

(Table 3). All medium-density sites fall centrally within the range of biface production, implying that tools were produced locally and that flake production was a minimal component of production. These sites all have cores and chunks in their middens. All data suggest that households around Bacab Na were, to varying degrees, basic chert production and consumption units.

INTERPRETATIONS

A number of conclusions may be drawn from the BRASS chert data. Chert production at the household level was variable. For the most part, mixed strategies including biface and flake production can be seen. Nevertheless, there is a distinct emphasis on biface production over flake production and no clear evidence of primary flake production. This production pattern is not surprising, since over one-third of the shaped tools are large bifaces (excluding the special tool kit of 272–136).

Another factor contributing to flake size proportions is the original nodule size. Data from Pulltrouser Swamp provide an interesting comparison on this point. While the bifacial tools used in the area were made outside it, flake tools were made from small, fist-sized local "chalcedony" nodules, rarely larger than 12 cm in diameter (McAnany 1989). Examining the proportions of flake sizes in the data provided by P. McAnany, Boston University, we found 20 percent small, 38 percent medium, and 42 percent large flakes. This size distribution demonstrates that, the smaller the nodule size, the greater the proportion of small and medium-sized flakes there will be in relation to large flakes. The situation at Pulltrouser Swamp is very different from that of the Belize River area, in that the Pulltrouser area lacks local materials suitable for biface production.

Imported Colha bifacial tools were used and refurbished in the Pulltrouser area. The debitage from this refurbishing (provided by P. McAnany) was grouped by the sizes used in this analysis in order to arrive at information on tool maintenance patterns. We found the proportions of small:medium:large Colha flakes from Pulltrouser Swamp to be 26:48:26. A range triangle around this point would include the area between the extremes of the flake and biface triangles. Where flake production aims for large, handleable flakes and biface production emphasizes the detailed finishing flakes, tool maintenance appears to focus on the medium-sized flakes. This is logical because such flakes are a size sufficient to create a new edge but not so large as to lose too much of the tool size. These data for tool refurbishing are distinct from the other production patterns. Refurbishing activities were likely a regular part of household activities and will influence flake proportions at residential units performing a broad range of tasks. These Pulltrouser data on tool refurbishing provide an important standard of this activity.

Bifacial tools are the main product of the Belize River area. Most residential units of the area were involved in some consumption activities. Eighty percent of the residential units used and discarded shaped tools, while more than half (55%) had such low debitage densities that the tools could not have been produced at the household (see, e.g., 272–168 in Table 3). Bearing in mind the refurbishing data from Pulltrouser Swamp, where medium-sized flakes were emphasized, we can infer that sites which could not have been involved in production may have been involved in tool refurbishing alone (see Figure 6C). Clearly, there was some differentiation of lithic production at the residential level within the Belize River area. These production differences were more obvious in some zones (e.g., Yaxox) and more subtle in others.

There are also some distinct variations associated with the settlement patterns in the area. In the uplands around the center of El Pilar, there was great heterogeneity of the lithic midden composition, with little emphasis on tool production, and overall low debitage density (see Figure 6C). Only 20 percent of all units had moderate to high densities, suggesting that tool production at the residence was not the norm. Further, neither specialization nor household production of chert tools was found occurring at any of the residential sites around the center of El Pilar. This evidence is complemented by the presence of the LDF chert site at El Pilar, one of the specialized biface reduction/production sites that must have served the area's consumers.

The chert analysis of the valley zones provides much evidence to support the view that the valley households were homogeneous and self-sufficient, with relatively equal access to basic resources for local production and consumption. Some 50–60 percent of all sites had moderate to high chert debitage densities, implying that the majority were involved in some basic tool production activities. Deviations from the norm occur where access to specific chert resource zones was differential. In such cases, there is evidence of specialized activities either in production specialization of complete biface tools, as with 272–229, or in the sequential staging of production activities, as with the large Yaxox quarry.

The highest densities of flakes were found regularly at residential units around chert quarries that were distant from centers. The individual manufacturer could much more easily have begun primary reduction close to the chert source; thus, large nodules of chert would not have to be transported long distances to secondary manufacturing sites. Moderately elevated debitage densities at residential units around centers suggest the aggregation of basic production and consumption units in central places. These elevated densities suggest that some chert tool production, including finishing (represented by the small-sized flakes), occurred at these sites. Apparently, most of the residential units around centers were producing completed chert bifacial tools and, to a lesser degree, flakes for individual residential use. Nevertheless, based on size sorting, there appears to be some sequencing of tool production between areas near quarries and those in more distant locales. A number of areas near quarries appear involved in primary reduction, and no single locus was responsible for major chert tool production in

the zone. These data demonstrate an absence of centralized production of chert tools in the valley foothills and bottomlands.

The same dichotomy between the valley and the uplands observed in settlement pattern data is evident in the BRASS chert debitage data. The greatest variation in flake densities and size proportions occurs in the households of the El Pilar uplands. From this pattern, coupled with the presence of the LDF quarry/ production site, we can suggest that chert tool production was centralized in the uplands. Such centralization correlates with the greater degree of hierarchical organization and wealth differentiation around El Pilar. The valley zones, with smaller centers, show relatively more homogeneous households in form, composition, and distribution. The chert artifact data demonstrate that the majority of households were involved in chert tool production, and there is no evidence of production specialists on the scale of the LDF chert site at El Pilar. Chert production was an opportunistic enterprise in this area. Chert resource zones appear as loci of primary reduction, while households around centers were involved in general tool production and consumption.

The centralization of chert tool production at the major center of El Pilar and the lack of such centralization around the valley centers suggest patterns of manufacture of other basic household utility items. For example, pottery, like chert tools, is widely used as a basic household item but does not leave the same kind of production debris in the Maya area. While the ancient Maya clearly produced and consumed pottery, virtually no direct evidence of its production has been identified archaeologically. Nevertheless, inferences about pottery production have been presented (Fry 1969, 1980; Rands & Bishop 1980; Rice 1980) and have led to some conclusions regarding changes in pottery production over time and in space.

The current analysis of debitage in the Belize River area provides a framework for proposing similar organizational differences between the uplands and valley zones of the Belize River area in production of pottery. If chert tool production is primarily a household activity in the valley, we may propose that this was so with pottery production. Conversely, the presence of the chert tool production site at El Pilar, coupled with the lack of evidence of chert production at the neighboring households, leads us to propose pottery specialization in the vicinity of El Pilar. Formal attribute analysis of specific Late Classic vessels of the area could test this proposal. Production specialization may be also evident in the distribution of other artifact types. For example, groundstone occurs at all sites around Bacab Na and most sites in other valley zones but at no sites around El Pilar. Further examination of the residential midden constituents will clarify these matters.

Much of the variation in the tripolar plots of the BRASS residential units is still unexplained. Our explanations of the debitage patterns need to be verified through the examination of the specific flake attributes. Initial examination of the debitage attributes confirms general assumptions about flake size (length, width, mass) and stage of biface production (dorsal flake scars, platform angle, percent

cortex), supporting the general interpretations presented here. If, however, we are proposing a mixed production strategy emphasizing biface production for the majority of moderate- to high-density debitage households, we need to pursue the detailed and thorough analysis of the flakes attributes. This is the next step in our research.

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NOTE

1.   These tools are considered preforms in California, but they resemble most choppers used in the Maya area. The collections are curated by the Department of Anthropology, University of California at Santa Barbara.

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