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DURING THE EARLY AND MIDDLE PRECLASSIC.

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LITHIC TECHNOLOGY IN THE BASIN OF MEXICO

DURING THE EARLY AND MIDDLE PRECLASSIC

by

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A dissertation submitted to the Graduate Faculty in Anthropology in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, the City University of New York.

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Abstract

LITHIC TECHNOLOGY IN THE BASIN OF MEXICO

DURING THE EARLY AND MIDDLE PRECLASSIC

by

Martin W. Boksenbaum

This study is an attempt to get information from stone--some 2500 chipped obsidian and 1200 non-obsidian specimens recovered by several of Paul Tolstoy's field projects from several sites with Early and Middle Preclassic components in the Basin of Mexico (El Arbolillo East, El Arbolillo West, Loma de Atoto, Tlapacoya). The information sought is on several levels: descriptive (how is each of the chipped stone items to be interpreted); inferential (what cultural activities produced, distributed, and used these chipped stone items); and explanatory (are these activities referable to evolutionary processes). The answers to each of these questions are significant both for the understanding of archeology as a set of analytic procedures and for the understanding of culture.

First, as for the understanding of archeological procedures, I discuss a number of theoretical and methodological issues.

Regarding description, the archeological dilemma, I argue, is to define relevant units of analysis. Description, to be interpretable, should be based upon theoretical models which specify the significance of the attributes to be measured. To this end, I draw

upon the analytic, comparative, and/or experimental work of others in defining many units relevant for the description of chipped stone. In addition, I define other units not previously considered that are attributable to a nodule-smashing flake production strategy. While others have discussed the presence of nodule-smashing in several present-day societies, I point to a number of attribute states which seem to be archeologically useful indicators of nodule-smashing.

Regarding inference, the archeological dilemma is to reconstruct activities. As framework for such reconstruction, I find it useful to distinguish the "input system" from the "cultural system." The "input system" concept refers to the effects of the various reduction strategies on the stone itself, from the effects of quarrying through the effects of the manufacturing steps that convert stone into culturally usable forms. Further, I divide the input system into blade-core, nodule-smashing, and shaping subsystems. The "cultural system" concept refers to the culture itself, with its economic, sociological, and ideological dimensions. It is the cultural system which produces and/or uses the manufactured chipped stone products. For the reconstruction of aspects of Basin of Mexico cultural systems, I employ "archeological analogy" (i.e., comparison of these assemblages with context-defined assemblages from elsewhere in Mesoamerica) and the clustering of artifact types in order to define manufacturing and use activities.

Regarding explanation, I address the hypothesis that the evolution of cultural complexity in Mesoamerica is comparable to that in the Near East with obsidian-working serving as the functional equivalent of metallurgy in civilizational processes.

The results of each level of archeological procedure provide information useful in understanding culture.

Regarding the evidence considered here of the particular Early and Middle Preclassic cultures in the Basin of Mexico, the description of lithic artifacts indicates a preponderance of debitage referable to crude flake production strategies, most likely that of nodule-smashing. A minor portion of the debitage is referable to the sophisticated blade-core reduction strategy, while only traces of the shaping of such finished forms as projectile points and drills are found. This significantly challenges the generally accepted view that there was only one reduction strategy, namely the blade production strategy. That there were at least two production strategies has a number of implications for the reconstruction of Preclassic cultures.

The inferences (syntheses) produced suggest that the debitage is the refuse of domestic activities, that very few artifacts were hafted (either end or side hafting), that nodule-smashing was probably a local activity, but that blade-making was non-local, blades being imported as finished products. Thus it would appear that local villagers had little stone-working skill and few composite tools/weapons of the type made by hafting chipped stone artifacts. The evidence suggests that the communities considered were unspecialized and that they were at the receiving, consuming terminals of any lithic interaction spheres of which they were part.

On the explanatory level, the small sample of material considered here is insufficient to fully tackle the evolutionary question.

However, it does provide some support for the equivalence of obsidian-working with metallurgy since obsidian was apparently involved in exchange, not only between geologic sources and habitation sites, but, more importantly, between manufacturing (blade producing) and consuming loci, and since specialization of labor, if only part-time initially, is suggested by the non-local blade-core reduction strategy.

ACKNOWLEDGMENTS

Acknowledging the social sources I have drawn upon in developing the theory and practice underlying this dissertation allows me to thank the various people who became involved and provides you, the reader, with information about my intellectual background additional to that provided by the text or the bibliography.

First, regarding my recruitment into anthropology and archeology, I should note that the personal problem I was trying to solve was existential, namely, what was this world I was living in about and how did I want to live in it?

A general materialist framework for answering such questions was provided by the political activism and protest of the 1960s, with a more particular focus on Marxism provided by some of the friends with whom I sought to bring about change. For the stress given to the importance of ideas and thought in any of the materialist equations, I thank Earl Price.

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In the M.A. program at Hunter College (C.U.N.Y.), several professors provided a broad range of material and opportunity for involvement in anthropological work. I thank, in particular: Edward Bendix (anthropological linguistics), Melvin Ember (cross-cultural studies), Lester Firschein (physical anthropology), and especially Annemarie de Waal Malefijt (ethnology) who was advisor for my M.A. Thesis (Colonial Development in Evolutionary Perspective: A Study of Guyana).

In the Ph.D. program at the Graduate Center (C.U.N.Y.), Paul Tolstoy's well-reasoned, thorough, and far-ranging approach to archeology served as model for my archeological studies, while Edward C. Hansen's courses provided a setting for the development of materialist models applicable to the study of contemporary cultures.

Third and finally, regarding the rite of passage of which this dissertation is the major part, I would like to thank those who helped in the research itself, those who helped in the preparation of the manuscript, and those who advised and officiated.

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Chapter 1

INTRODUCTION

This study is an attempt to clarify the nature of the chipped stone industries, particularly the obsidian industries, in existence during the Early and Middle Preclassic in the Basin of Mexico. At present, the structure and function of such industries is only partially undestood, although there is a growing realization that such knowledge could help considerably in understanding the evolution of cultural complexity in Mesoamerica.

In order to understand these industries, it will first be necessary to transform the chipped stone finds into information. That is, the chipped stone must be meaningfully described. To this end, the lengthy history of lithic studies provides much that aids in defining attributes relevant for understanding cultural activities. My work consists of: (1) the presentation of theoretical models or "expectations" against which to measure the lithic finds, the model characterizing nodule-smashing debitage being my contribution to such studies; (2) the descriptive analysis of several thousand chipped stone artifacts from several Preclassic sites (Tlapacoya, Loma de Atoto, El Arbolillo East, and El Arbolillo West, all discussed further in Chapter 4) and the presentation of the resultant data; and (3) the synthesis of such data, thus generating interpretations of several aspects of the various Preclassic cultures from the description of chipped stone finds.

To some "new archeologists," any use of the word "description" raises hackles, at least to those who narrowly define "description" as a sin of the fathers not to be visited on the new generation, that is, as a bypassed procedure of the old school--not problem oriented, not subjectable to hypothesis testing. Everyone would undoubtedly accept the idea that since processual interpretations are based on observations, one must engage in some form of description (measurement). However, there is more of a processual dimension to description than that. Namely, description, in order to help resolve interpretive issues, has to (1) be based on theoretical models which define the relevant variables and (2) be derived from valid operationalizations of the theoretical variables (for example, compare Chapter 2 in Blalock 1960; Chapter 1 in Webb et al. 1966; and Chapter 2 in Brim and Spain 1974). The scale values to be assigned to each characteristic selected for observation are derived from measuring scales constructed for the interpretive purposes of the researcher. Evaluation of some of the alternative descriptions possible requires processual interpretation in the light of the alternative theoretical models. The measuring scales are neither obvious nor unique nor of equal interpretive power. Thus description itself becomes a processual problem, a problem I will deal with in Chapter 2.

For the most part, lithic studies in Mesoamerica have dealt with two classes of well-defined artifacts: (1) prismatic blades, clearly defined by the preformed core reduction strategy, and (2) heavily retouched specimens--points, knives, scrapers, etc.

(e.g. Holmes 1919; Kidder, Jennings and Shook 1946; Kidder 1947; Crabtree 1968; Spence 1971; Tolstoy 1971). Rather neglected are the ill-defined, irregular, little modified flakes, chunks, and fragments that usually constitute the bulk of Preclassic lithic assemblages. These usually have been assumed to be the "waste flake" discards of the sophisticated reduction strategy used to produce prismatic blades. Indeed, it has been argued that there was only one reduction strategy, centering on blade production, with the irregular flakes and the heavily retouched specimens being spin-offs of it (e.g. Sheets 1972, 1974, 1975). However, while some of the debitage may indeed be waste from such a sophisticated technology (although even this appears unlikely at a number of sites), it appears that a considerable amount of Early and Middle Preclassic village debitage is the result of a distinguishable, autonomous process: that of nodule smashing. The importance of such an alternative strategy is indicated by the following possible implication: that there were at least two Preclassic obsidian industries, one involving craft specialists (to produce the blades and heavily retouched specimens which were imported by villagers) and the other involving non-specialist local villagers (to produce sharp-edged flakes by nodule-smashing as part of local household production). In Chapter 3, I elaborate the theoretical models that relate specifically to such manufacturing systems. I present there the kinds of observations that would allow one to interpret chipped stone manufacturing activities. I also present there some of the expectations that could perhaps help one to gain some insight into the activities in which lithic items were used.

(Note that the expectations generated by the models presented in Chapter 3 will serve as "sensitizers" which open up consideration of many possible relevant observations--however, not all of them will be useful in dealing with the given collections.)

Once having established the theoretical models and having operationalized the variables, my next task is to describe the specimens themselves. Description, itself involving inferences, cannot be set apart from interpretation on the basis that the latter is processual but the former is not. However, as various researchers have done, one can distinguish two different levels of study: one, the analytic, involves the break-down of the subjects under study into the categories (types, modes) used as measures, thus producing the "data"; the second, the synthetic, involves the integration of the data into coherent models that account for ("explain") the data. Chapter 4 will present the analytic level, i.e., the "data." Chapter 5 will present the synthetic level, i.e., the interpretive models which account for the "data."

Chapter 6 will contain summary comments and discussion of an explanatory issue, namely, the problem of the relationship between lithic technology and cultural systems. The summation includes discussion of procedural matters and review of the actual steps utilized in executing the research design. With regard to the explanatory problem, I can perhaps offer some further insights although any final resolution is beyond the scope of this study. Namely, if, as is hoped, this study allows a fuller understanding of Preclassic Mesoamerican "obsidian industries," then it should provide insight into the importance of these industries both to the maintenance of the cultural systems in which they were imbedded and to the evolutionary transformations these cultural systems were undergoing. In particular, I will attempt a more critical evaluation of the suggestion made by a number of researchers (e.g., Childe 1974 [originally 1950]; Cobean et al. 1971; Millon 1973) that there is a causal relationship between obsidian utilization and the evolution of cultural complexity in Mesoamerica.

Chapter 2

THEORETICAL MODELS AND INTERPRETABLE OBSERVATION

> In the absence of a paradigm or some candidate for paradigm, all of the facts that could possibly pertain to the development of a given science are likely to seem equally relevant. As a result, early fact-gathering is a far more nearly random activity than the one that subsequent scientific development makes familiar. Furthermore, in the absence of a reason for seeking some particular form of more recondite information, early fact-gathering is usually restricted to the wealth of data that lie ready to hand. (Kuhn 1970: 15)

> The sets of phenomena selected for observation, from the infinite number of possible observations, are not most profitably determined by the formal structure of the archeological record itself. On the contrary, they are data which we must justify as relevant to the particular propositions advanced and as useful for hypothesis testing. A crucial role is thus given to the development of techniques and to the generation of increasingly accurate analytical units for measuring cultural and environmental variables. (Binford 1968: 25)

Description of the chipped stone remains in the Basin of Mexico collections at hand is a first step in pursuing the materialist strategy of determining "what is produced, how it is produced, and how the products are exchanged" (Engels 1959: 367). In this perspective the archeological task is to analyze the fragmented lithic remains so as to determine what was produced--i.e., definition of artifacts both by form and content (function, use); how they were produced--i.e., the techniques and social relations of manufacture; and how the products were exchanged--i.e., the manner of distribution. The general materialist statements are too global to be guides in specifying or operationalizing variables for lithic analysis. The problem, therefore, is one of determining what to observe.

Previous lithic studies provide many insights. While there is, as yet, no single, overall paradigm to guide research by specifying which observations will yield information either as to manner of manufacture or as to manner of utilization, partial models have been abstracted from studies of Stone Age industries and from ethnographic and experimental data (e.g., Barnes 1947; Bordaz 1970; Bordes 1961; Bordes and Crabtree 1969; Crabtree 1968; Faulkner 1972; Frison 1968; Gould, Koster, and Sontz 1971; Hayden and Kamminga 1973; Newcomer 1971; Semenov 1964; Sheets 1972, 1974; Speth 1972, 1974; Wilmsen 1967). However, the work done thus far has been only partially successful. Many observations being made in lithic studies do not have clear-cut interpretability while many other interpretable observations that could be made have undoubtedly been missed. It appears that lithic studies are in the process of developing its paradigms (cf. Clarke's 1968 discussion of the inductive-deductive feedback loops that are necessary for generating better models and the quotes by Binford and Kuhn which introduce this section).

The insights provided by past work have resulted from a number of complementary but different approaches which can be discussed using Washburn's (1951) analysis. Although dealing with procedures for isolating interpretable units of observation in physical anthropology, Washburn's typology of methods is useful in considering the different approaches used in archeology. He discusses: (1) comparison and evolution; (2) variation; (3) development; (4) experiment. Contrasts discerned between the various Stone Age industries would come under the heading of "comparison and evolution"; contrasts within an assemblage under "variation"; contrasts between assemblages within the same tradition under "development"; and the various results obtained by knapping and utilization experiments would, obviously, come under the heading of "experiment."

In this study, the methods for isolating interpretable units are based upon discerning contrasts within assemblages (variation) and between sequent assemblages of the same tradition (development). While I have the advantage of being able to use the lenses of the various paradigms already proposed to help me to "see" (Kuhn 1970), these paradigms are tentative and incomplete. To the extent that study of the collections enables me to provide empirical feedback to amend the models themselves, to that extent I am, additionally, helping to generate better models, and to that extent, this study is part of the "time trajectory of the state of shared . . . knowledge" (Holton 1975: 328).

The first step taken in interpretatively "seeing," i.e. in translating the chipped stone artifacts into symbolic data, was to select and operationalize a set of variables. Since these variables were being devised as a set of observations to be made on the collections at hand, operationalization was done in conjunction with examination of specimens. In dealing with these collections, some choices were obvious. "Blade," for example, is one value that has been shown by ethnographic/ethnohistoric (e.g. Bordaz 1969; Holmes 1919), variational (e.g. Barnes 1947; Laughlin and Aigner 1966; Sheets 1972), and experimental (e.g. Crabtree 1968; Bordes and Crabtree 1969) work, to have clear-cut interpretability vis-a-vis manufacturing processes. At the other extreme, some choices were not based on clear-cut interpretability, but were rather exploratory (inductively oriented). That is, using general notions of manufacturing procedures, values were operationalized in the hope that their interpretability could be subsequently demonstrated or that they could be used to isolate more interpretable units. Some choices were intermediate between these extremes of interpretability. All together, this "step" was a somewhat lengthy procedure, involving several amendations of the operational code in light of several attempts to code the actual artifacts. Once the artifacts were coded according to the final version of the operational measuring scales, however, further modification of the code could be accomplished by re-coding existing variables using a "lumping" approach. Also the variables used dealt with either of two classificatory levels, the attribute and artifact levels (cf. Clarke 1968; Deetz 1967).

It should be pointed out that the phrase "chipped stone artifacts" includes not only the items intended for use--points, scrapers, and so on--but the waste material produced in the manufacturing process as well. Waste flakes can provide information both as to manufacturing and use. For example, sharpening (rejuvenation) flakes can yield information both as to techniques for sharpening dulled tools as well as to the characteristics of dulled edges (Frison 1968; Shafer 1970). Also, waste flakes used in the original shaping of tools can provide information about the steps in manufacturing (even if one does not go so far as to reconstruct the nodule and/or manufactured item from the debitage, as have Laughlin and Aigner 1966).

Two approaches to classification (i.e., to operationalizing variables) have been discussed in the literature. One is a "subdivisive" approach (or "tree-type" or "artifact group" approach--cf. Sackett 1966, Whallon 1972), whereby the collection of chipped stone artifacts is partitioned into contrasting groups of artifacts. Artifact "types" result from such partitioning, with the artifact being the unit of analysis. For example, in my work, coding artifacts according to the variable "BASIS1" categorizes artifacts according to the manufacturing process which produced the piece (regardless of subsequent retouch). This variable has several alternative values. One value is the aforementioned "blade" (which is defined by a number of criteria that set it apart from other values of the variable "BASIS1," such other values as "ridged flake," "thin flake," etc.). As already mentioned, some of these categories or "types" have been shown to be interpretable, while some, at least at the start, were little more than arbitrary or "convenient" constructs (Hole and Heizer 1973: 204).

The other approach to classification is an "agglomerative" or an "attribute clustering" approach (cf. Sackett 1966; Whallon 1972). Its primary unit of formal analysis is the attribute, an element of form of an allegedly "logically irreducible character of two or more states" (Clarke 1968: 665). Artifact types are built up, so to speak, by clustering techniques. Artifact types are then defined on the basis of co-occurrence of attribute values (states).

Both approaches indicate a close connection between attribute and artifact levels of analysis. Attributes do not exist in isolation but are attributes of something--namely artifacts. Conversely, as Deetz has discussed the matter, artifacts embody the manner in which attributes are combined (1967: 108 ff.).

In this dissertation, I am using the attribute approach to complement the artifact approach in the sense that the attributes provide a means of considering variation within the artifact types. For example, I can use the attribute "XSECT," cross-section of blade, as a measure of the variability within the category "BLADE," thus providing a way of distinguishing "fine" and "crude" blades. Or I can use "W," width of blade, to provide a measure of variation in the size of blades found at one site with those found at another site.

Even those who pursue an "attribute" approach in contrast to an "artifact" approach, do their attribute analysis within the bounds of particular artifact types. For example, Sackett (1966) suggests that the old approach to typology was to group like artifacts and then to introspect--i.e., figure out what attributes one had used as the underlying similarities in establishing each group (as, for example, Rouse 1939: 11, 25, had done). On the other hand, the new approach allegedly starts with the attributes, and by means of statistical clustering techniques (Sackett uses χ^2 following Spaulding 1953, 1960) discovers types. Yet in his attribute analysis, Sackett confines himself to Upper Paleolithic end-scrapers and is dealing with subtypes of end-scrapers. Thus, while ostensibly arguing for the "clustering" approach in contrast to the "subdivisive" approach, and while ostensibly "discovering" artifact types in the manner of Spaulding, Sackett's approach can be viewed as a way of measuring variability within the category of Upper Paleolithic end-scrapers. Clearly, there is not as much opposition between the approaches as some have suggested.

Another example of the use of attributes to measure artifact variation within artifact types is provided by the numerous instances in which different attribute codes are used within the different artifact categories. Thus, for example, there are a number of differences in the attributes considered in coding blades from those used in coding bifacially worked points. In devising codes for attributes within different categories, I am, in effect, refining nominal scale classification by subdividing categories, and this results in an hierarchical classification (Read 1974). Considering the data which is being analyzed in archeological classification it is inconvenient and involuted to use a "paradigmatic" approach, i.e., such that the subdivision within a category on one level can be applied across the board to all categories. A "tree-type" classification with different subdivision rules as are appropriate for a given category is to be expected (Whallon 1972; Read 1974; also cf. the hierarchical classification presented by Laughlin and Aigner 1966). Thus, it is apparent that a classification being used to devise categories relating to manufacturing procedures and/or uses and that has such different categories as "blades" and "points" as contrasting values on one level would be unnecessarily complicated in the extreme if categories on one level were to be divided using all the same rules for subdivision in order to produce more refined categories on the next level.

Since, in choosing and operationalizing variables, I have had in mind their information potentialities as clues to various manufacturing procedures and/or uses, it is important to consider, if sketchily, some of the models that have been shaping my perceptions.

As a general orienting framework, I distinguish the "input system" of the culture from the "cultural system" itself. Thus the "input system" (cf. Berrien 1968) refers to the raw materials coming into the culture and the transformation of these raw materials into culturally usable items. It can be viewed as a sequence of stages in the "life-cycle" of material from "natural" to "cultural" states (see Laughlin and Aigner 1966; Clarke 1968; Schiffer 1972; Collins 1975). Usually, when researchers diagram steps in manufacturing, their flowcharts show what is happening to the materials being processed. They indicate the initial nodule, the results of initial shaping and the further modifications that result in finished artifacts. They may also indicate the waste products of each manufacturing step. This focus on what happens to the material coming into the culture (being ingested, digested and assimilated as it were) is a focus on the "input system."

The "cultural system," on the other hand, is concerned with the organization of activities (see Berrien 1968 regarding his "maintenance system" concept). Two sets of activities are directly relevant to the study of chipped stone artifacts; the set of activities that produce chipped stone artifacts; the set that uses chipped stone artifacts. With regard to the production of chipped stone artifacts, we are looking at the stages in manufacturing again, but from a different standpoint than is used in the "input system" analysis. Now the concern is with how the culture is organized to carry out the procuring and manufacturing tasks, not with the results of such activities on the materials being processed.

In short, I will be considering two aspects of the input system and two aspects of the cultural system:

I. Input System

A. Selection and Procurement

B. Manufacturing Transformations

II. Cultural System

A. Contexts of Lithic Manufacturing

B. Lithic Items Used in Processing Other Cultural Elements.

In the following schematic discussion, a questioning format is used in the sections dealing with the cultural context in order to focus on interpretive goals, namely the consideration of how past cultural systems might have been functioning. Suggestions as to the kind of data that would provide answers are discussed in the sections dealing with archeological context in order to focus on research strategy.

I. The Input System

A. Selection and procurement

1. Cultural context

What materials are being selected/procured and in what forms are these ingested items first apprehended? Did members of the community acquire lumps of raw materials, or "blanks" that were to be worked into specific items, or finished items ready to be used? What were the sources of these items? Were they acquiring them from quarries or from other communities? What were the dimensions of inflow--in what bulk, at what rate, with what regularity?

2. Archeological context

The manufacturing of artifacts with hard, sharp edges by using the principles of conchoidal fracture to control the process requires suitable raw materials. Faulkner (1972: 7-10) states that such materials should be: homogeneous; isotropic ("having uniform susceptibility to fracture in all directions"); hard ("highly resistant to . . . mechanical abrasion"); inert ("highly resistant to . . . chemical deterioration"); elastic ("recover completely from deformation when applied constraints are removed"--i.e., not plastic); rigidity ("the degree of deformation necessary to produce fracture must be slight"); brittle ("deformation . . . is temporary, with no plastic flow prior to fracture"). Rocks and minerals that are noncrystalline or cryptocrystalline most closely exhibit these characteristics, with obsidian, the volcanic glass, the natural material par excellence.

Superficial examination was used to distinguish the various kinds of rocks that had been used. Specimens of obsidian could generally be distinguished by their glass-shiny surfaces and the fine conchoidal fracture exhibited. Within the obsidian category, varieties were distinguished on the basis of various coloring, opacity, and textural differences (see Table 4.1).

Curt Gorman, then an advanced geology student at Queens College, classified the various non-obsidian materials, getting additional advice from faculty in the Geology Department for uncertain specimens. While such superficial identification is not as reliable as would result from more detailed analysis (e.g. thin-section analysis), it is sufficiently accurate for the present needs.

Several measures of the range of variation of the chipped stone materials found may provide information regarding the form in which it was acquired by the community. A first measure is based upon consideration of the kinds of debitage that one would expect to find if the artifacts had been manufactured there. If the debitage found does not conform to expectations, then it would tend to support an hypothesis that the type of artifact was acquired in finished form. Inversely, if debitage does conform to expectations, support would be for local manufacturing. For example, the manufacturing steps resulting in blade artifacts suggest that one would find: (1) blade cores; (2) core tablets--resulting from the rejuvenation of cores by creating a fresh striking platform; (3) ridged or crested flakes (*lames à crête*)--indicating the first flakes removed from a prospective blade core and which establish the "flutes" and ridges for removing true blades (cf. Barnes 1947; Bordaz 1970; Bordes 1969). Therefore, one variable to consider would be type of debitage.

A second measure is based upon the range of variation within some of the types of artifacts. Again, using blades as an example, it has been proposed (e.g. Sheets 1972, 1975) that as a Mesoamerican blade core is used, the blades detached from it are smaller (both narrower and shorter) than ones earlier detached. Therefore, in this instance, a limited range of sizes would tend to support an hypothesis that a particular size of blade was being "imported." Here, the relevant variable relates to metric variation within an artifact category. For blades, width is a suitable measure of size since it is applicable to fragments as well as to whole blades.

A third measure is based upon patterning, that is, the application of comparable manufacturing techniques to other artifact categories. Pursuing the blade example, if local manufacturers applied the principle of blade production to other than blade cores, they would produce various kinds of ridged flakes, as was proposed for the Anangula material by Laughlin and Aigner (1966). Again a relevant variable deals with types of artifacts.

Additional measures that would enable one to determine the form of the material when acquired by the community can be based upon other kinds of variation within the debitage. For one, if weathered nodules rather than quarried materials were used as cores, flakes should be found that have cortex surfaces. In addition, the number of cortex surfaces on a "waste" flake may indicate either than a natural angle was used as a starting ridge or that rather small nodules were being used. Another possible measure is based upon the quantity of flakes with multi-facetted dorsal surfaces, for if bifacial tools were being made locally, there would be much debitage of this sort (see Newcomer 1971). A third possible measure is based upon comparison of the kind of material that "waste" is composed of as compared with the various finished artifacts, e.g. blades and shaped artifacts (see Kidder quote below).

While the measures here are being made explicit so as to focus research design decisions, these kinds of concerns are not new. For example, Kidder (1947: 11), in the midst of much descriptive detail, noted:

> Although all obsidian must have been brought to Uaxactun in trade, we do not know in what form it arrived. The presence, there, of cores attenuated beyond further serviceability for the striking-off of flake-blades indicates that the making of the latter implements, at least, was carried on locally. And the abundance of small chips (as distinguished from flake-blades) also points toward the local working of obsidian. Large, ready-shaped cores for the production of flake-blades and 'blanks' for the manufacture of chipped implements could have been transported conveniently, and it is likely that most obsidian reached Uaxactun in those forms. Whether or not any finished tools were imported is uncertain; possibly those of green stone were, as no cores or chips . . . of this color were found . . .

As to the sources of the ingested material, two theoretical dimensions are distinguishable: (1) the geologic source; (2) the extra-community cultural source--the "middle-men"--if such were involved. With regard to "sourcing" obsidian, much has been written. It has generally been agreed that the observable visual differences between obsidians (especially color) are poor demarcators of geologic sources. However, some visual distinctions are usable. In particular, in Mesoamerica, high quality green obsidian is most probably from the southern Hidalgo sources variously labeled Pachuca, Cerro de las Navajas, Cruz del Milagro (e.g., see Spence and Parsons 1972)--although there may be other sources of green obsidian (e.g. Pires-Ferreira 1973 has reported a source of perhaps poorer quality green obsidian in Oaxaca).

On a more positive note, it is generally agreed that analysis of the chemical constituents (the minor and trace elements) can be used to "fingerprint" sources. Analyzing the chemical composition of obsidian artifacts so as to match them with the geologic source from which they were derived has been carried out, using various techniques, in several areas; e.g., the work by Renfrew and Wright in the Mediterranean and the Near East; the work by Jack, Heizer and Hester, by Cobean, and by Pires-Ferreira in Mesoamerica. But even here, operationalization and measurement differences have detracted seriously from the reliability of such studies. One indication of the extent and seriousness of the problem is provided by the differences in sourcing the same material that result from the analysis of different laboratories. Pires-Ferreira presents a table (1973: Table 13, p. 79) comparing the results of the analysis of 8 specimens carried out by both the Michigan and Yale laboratories; they agree on only 3 of the 8. One reason for the discrepancies may be that different elements are chosen for measurement. In considering Mesoamerican materials, the University of Michigan's laboratories may simply deal with Mn and Na while Yale laboratories may measure amounts of Mn, Rb, Sr, and Zr, but not Na--and other laboratories may measure different elements. Another difference relates to failure to standardize measurement (there are calibration differences)--between laboratory measurements of the same trace element for obsidian from the same geologic source may be different because of differences in the unit of measurement. Indeed, Cobean (personal communication) has indicated that consistency can be troublesome even within the same laboratory. Recognition of such problems has given rise to a number of papers calling for steps to minimize the sources of error. For example, the problems of choice of trace elements, calibration and the production of consistent, replicable results in chemical analyses were discussed as a symposium at the 1974 SAA meetings in Washington (see Meyers 1974).

A project with which I am associated (NSF grant BNS76-80055, Paul Tolstoy, principal investigator) has, of necessity, been addressing these problems in order to tackle the project's central goal, that of interpreting early exchange networks in the Basin of Mexico. Jerome Kimberlin, neutron activation analyst on the project, has been confronting such problems by using a large number of trace elements, a large number of source materials, and strict calibration requirements, in the facilities of the Brookhaven National Laboratories. The results of the project should help considerably in making such efforts standard, reliable, and replicable.

Regarding the extra-community cultural source, the concern is whether the community was acquiring the material directly from the geologic source, e.g. by expeditions and organized quarrying activities, or from people from other communities (whether of the same or different "cultures"). Some information is provided by consideration of the form in which the material is acquired, but this information is not definitive. For example, if blades are brought to the site, it is clear that manufacturing took place elsewhere, but still unresolved is the matter of whether people from the community did the manufacturing at the quarry or some other workshop site, or whether other communities were the suppliers of obsidian blades in a social field (interaction sphere) involving regional specialization. While discussion of the social organization involved is reserved for a subsequent section dealing with "cultural systems," the routing of material is properly discussed here. Consideration of "routing" involves analysis of the spatial arrangement of manufacturing activities: if there were quarry sites, what manufacturing steps were carried on there; if there were workshop sites, what manufacturing steps were carried on there; and what of other habitation sites and the habitation site where the material was found? Clearly, such questions require, at minimum, a regional perspective involving settlement pattern considerations. The data available from lithic analysis would enable one to locate the manufacturing activities. However, supplemental data as to type of site and as to contemporaneity of sites would be necessary.

Flow dimensions, such as quantity, rate, regularity, are not available from lithic analysis alone, but would require data from other kinds of analyses. Since archeologically recovered materials are only samples of past activities, one would need, for estimation purposes, a proportional measure of obsidian utilization, such as the amount of obsidian per person (or household) per unit of time. Determination of such indices involves many difficulties. Sidrys (1973) has suggested an index that attempts to standardize between-site comparisons of differentially excavated sites. The index involves consideration of the amount of obsidian in relation to the amount of earth excavated at each site. However, his index does not control for time, as was pointed out by James B. Griffin from the floor during discussion of Sidrys' paper. Some variables that might be used are: fine-grained seriational ceramic information for time control; number of metates as a measure of number of households; relative proportion of obsidian and various ceramic types to control for activity variation showing up in midden material. The quantity of ceramic material is problematic for interpreting population size since we are not clear about such factors as longevity of the various kinds of vessels, the number of vessels used by a household, the different kinds of vessels that a household uses, and treatment of ceramic refuse.

B. Manufacturing Transformations

1. Cultural Context

What was done to the material to make it serviceable? What variations were there in the elaborateness of preparations, the kinds of items made, the by-products? Some societies, for example those of northeast New Guinea (Harding 1967), simply smash nodules, acquired in trade, to obtain usable flakes. Since obsidian flakes are so sharp, they are immediately usable as cutting implements. Is there evidence of such simplicity as well as the evidence of complexity provided by the blades? And what of flakes and blades shaped to make them into desired artifacts?

2. Archeological Context

a. Remains of cores

While remains of blade cores would obviously provide important information, none are in the collections at hand. However, information about them is provided by their products, since a blade detached from a core carries away part of the core's platform and part of its fluted face.

What, if any, treatment was given to the core's surface in preparation for the application of force? Considerable variation is possible. A core's surface might be dihedral, facetted, flat flaked (or plain), scratched, ground, have a negative bulb or cortex (Barnes 1947; Bordes 1961; Crabtree 1968). The surface of the remnant of the core platform remaining on the flake or blade, what I refer to as the "cap" (rather than "platform," "platform remnant," or "butt"), is indicative of the core's surface preparation.

After a blade is removed from a core, an overhanging lip is part of the scarring left on the core. This lip is usually removed before more blades are knapped from that part of the core (Bordes 1969). This modification will therefore appear in the dorsal area of blades near the juncture of the cap and dorsal surfaces. I use the term "nape" to refer to this area (although some find it abhorrent to use an anatomical metaphor--see Jelinek <u>et al</u>. 1971). Some have referred to this as the "area of battering" (Sanger, McGhee, Wyatt 1970), but not all of the modifications in this area are the result of battering. Again, there is considerable variation. Is such treatment afforded other flakes? (For a listing of the attribute states considered here, see Tables 4.25g and 4.26c.)

A number of other variables can supply information as to the kind of core or "parent" body from which a blade or flake was derived. Some deal with other characteristics of the dorsal surface of the piece. The pattern of scars and ridges on the dorsal surface is one major example of this. An obvious instance is a "blade," whose dorsal scars and ridges indicate the fluted core from which it was derived. The patterning on the back surface has been used here to define the manufacturing basis of pieces. Another example is based on the angle between the dorsal surface and the cap (the remnant of the core platform). Other characteristics can be informative. The distal end of a flake or blade can provide information about the base of the core, if it does not terminate short of the base by "hinging out." The regularity of a blade core can to some extent be measured by the blade's cross-section and its thickness to width ratio. However, as noted previously, the core undergoes changes during its use (and so do its products); hence, core types cannot be viewed rigidly.

b. Application of force

The application of force can be measured indirectly, in a number of ways. A measure of the distance from the point of applied force to the core edge is provided by the cap thickness. It has been suggested that there is a relationship between this distance, the angle between the striking platform and the adjacent core face, the length of of the flake, the relation of flake width to length, and the method of applying force (e.g. Bordaz 1970: 24-25; Speth 1972).

For blade production, there are several clues as to the method of applying force. Crabtree (1968;463) has suggested that the parallel-sided blades are pressure flaked, as opposed to others which would be produced by indirect percussion, at least when one is working with obsidian. Indeed, different kinds of pressure flaking may be distinguishable by considering the length of obsidian blades, for the chest crutch supplies more force than does an arm device (Crabtree 1968).

Other variation is also interpretable. Cylinder hammer flaking strikes the edge of the core directly and does not produce a full cone of percussion nor produce an isolatable point of impact at the juncture of cap and ventral surface (e.g. Leakey 1954; Newcomer 1971). Secondly, if the cap surface is dihedral, it seems likely that direct percussion contact was made with the ridge, for use of a punch or of a pressure-flaking implement would not find secure seating there. Thirdly, if there are two points of applied force, it is likely that the application of force was transmitted through a large contact surface such as is provided by a hammerstone, rather than the point of a punch. Similar reasoning applies to multiple secondary flakes (see Jelinek <u>et al</u>. 1971), i.e. to two or more flakes produced simultaneously such that inner flakes would have their positive and negative conchoidal surfaces back-to-back with positive and negative bulbs emanating from the same platform.

The characteristics of the positive conchoidal surface are also thought to be indicative of the method of applying force. The bulb is thought to be more prominent ("salient") with hard hammer percussion while less pronounced (or "diffuse") if other methods are used (see Bordaz 1970; Newcomer 1971). This correlation has been challenged however (Speth 1972). Some other possibly related variables include presence of absence of ventral lipping (Newcomer 1971) and characteristics of bulbar scars (Faulkner 1973). Not included in this analysis is a measure of the nature of the conchoidal surface, i.e. how smooth, rippled or undulating the surface is.

c. <u>Difficulties</u>

Some difficulties are noteworthy. One is a reminder that various stages in the trajectory of artifact manufacture may have been carried out elsewhere. For example, if blades were "traded" in, then the reconstructed manner of production would be attributable to other communities. Thus, the spatial locus and the cultural identities of the artisans would have to be determined for each stage in the sequence of manufacturing activities.

A second difficulty deals with manufacturing sequences for which there are no models. A case in point concerns flakes resulting from the smashing of nodules. What characteristics would one look for? The parameters discussed above, such as thickness of cap, prominence of bulb, ridge patterning on the dorsal surface, all of these might very well be irrelevant. It was only while examining specimens that I gained some insight regarding this issue. I came across various manufacturing anomalies. In particular, there were specimens with two positive conchoidal surfaces seemingly produced simultaneously. This would suggest that force was being applied to the core from two different directions at two different places simultaneously. Logically, this situation could occur when a nodule was smashed and uncontrolled forces were ricocheting through the nodule. Thus, I came to associate manufacturing anomalies with nodule smashing. In Chapter 3, I present the characteristics which distinguish many artifacts in these collections from the artifacts produced by any of the usual knapping techniques, as discussed in the literature.

Several problems relate to subsequent modification. In the case of intentional modification, the retouch could remove traces of earlier manufacturing stages. Especially in the case of bifacially worked pieces, the nature of the items from which they were made would not be directly determinable. Some modification could result from use. For example, blades might snap, edges become concave via "use retouch," or points exhibit impact fracture. Finally, some modification could result from accidental natural or cultural modification of refuse, i.e. from depositional factors. "Snapped blades" and "retouch" might be the products of depositional accidents.

d. Rejuvenation

Finally, rejuvenation of items blunted or broken through use can leave their traces. Frison (1963) and Shafer (1970) have discussed several types of rejuvenation flakes. Such rejuvenation would occur on retouched items such as bifacially worked points and unidirectionally trimmed scrapers. The information from such waste flakes can produce useful information. For example, it has been pointed out that implements produced by retouching may be rather rare in parts of Mesoamerica. Kidder (1947: 72) argues that one factor relating to this rarity at Uaxactun was the "fact that obsidian chips and flakes and flake-blades could be put to many uses without reshaping." However, it might be argued that finished artifacts tended to be held onto by their users; thus, rarity of finds might indicate care of items rather than infrequency of occurrence or use (Binford 1973). One test of the alternatives might be the abundance of rejuvenation flakes, for even if few finished artifacts found their way into the midden, the rejuvenation flakes would be an indication of the abundance or use frequency of finished artifacts.

II. The Cultural System

How does the manufacture of lithic artifacts take place? What activities involve the use of lithic artifacts? Indeed, how are activities to be measured?

Activities can be considered as having three components (in addition to the time and space dimensions). One component consists of the material elements which comprise the instruments of labor, i.e. the tools which are used. A second component is concerned with the social relations of the activity, i.e. how people are organized to carry out the activities. The third component consists of the knowledge employed--which leads me to a philosophical digression regarding the causal relation between ideas and behavior. I follow Kuhn's (1970) approach on this--his "exemplars," the shared examples people are trained on so as to learn how to see and do the culturally defined, indicate that consciousness follows and is shaped by experience (this aspect of Kuhn's approach is, of course, a dialectical materialist position--cf. Stalin 1952). Deetz's "mental template" (1967) is idealist in presenting only the later stages of the process, namely that people try to make the same ideal types of things, with varying degrees of success, because they, somehow, share the same ideas of what they are trying to make. Deetz's model, unlike Kuhn's, does not take into account how individuals acquire shared ideas, how consistent the idea is in one person's mind (post-training variation), how much of a match there is between the ideas shared by different people (do they really have the identical mental image in their minds), or how precise or imprecise the discrimination of sameness is.

The final consideration is that activities can be classified as to the input being processed. This results in the traditional tripartite division into economy, sociology, and ideology. Economy would refer to activities that are primarily processing material items, sociology to the processing of people, and ideology to the processing of ideas. While it is clear that material items are processed, the same may not be true of people and ideas. People can be viewed as being processed when they go through rites of passage, other kinds of initiations, training, enculturation, acculturation, etc. Ideas can be viewed as being processed when idea systems (themes or mental modes) are being developed--for example, the development of different geometries based on different axioms, or, the development of different systems of social law using different rights and values and interests to be protected.

Such a tripartite classification should not be viewed as producing a rigid, layer-cake model, with sharply demarcated economic, social and ideological realms. These categories are cross-cut by material, social and ideological dimensions as mentioned above (see Figure 2.1). For example, a hunt involves the processing of materials (animal products). As such it is "economic." However, the hunters are a work unit. Are they kinsmen or non-kin neighbors, are they men only or do women and children help, are they specialists or are they performing roles generally assumed by any member of the society? Also, ideas ranging from "supernatural" to "scientific" would be utilized in the planning, the carrying out, and the post-hunt analysis. Hence, from this perspective, Binford's (1962) division of artifacts into technomic, sociotechnic, and ideotechnic is essentially dealing with the use and/or manufacturing context of artifacts. However, this does not mean that technomic artifacts are without social and ideological dimensions, or that sociotechnic and ideotechnic artifacts are similarly

Figure 2.1. Dimensions of activities vs. Types of activities

dimensions of the activity	activities classified according to major items being processed		
	economy (materials)	sociology (people)	ideology (ideas)
material elements	material elements used in processing other materials	material elements used in processing people	material elements used in processing ideas
social relations	social relations used in processing materials	social relations used in processing people	social relations used in processing ideas
ideas	ideas used in processing mater- ials	ideas used in processing people	ideas used in processing other ideas

restricted. Kessing expresses a similar idea from a somewhat different vantage point (1974; 82-83): "Knowledge and strategy about environments and ways of extracting subsistence from them, about making tools, about forming work groups, are as much a part of the ideational realm . . . as patterns of cosmological belief or religious ritual."

The material traces of past cultural complexity will, obviously, give only slight indication of that past complexity. Slight as they are, the material traces nevertheless provide means for testing alternate hypotheses drawn from the relative completeness of theoretical models:

> Any given theory has innumerable implications and makes innumerable predictions which are unaccessible to available measures at any given time. The testing of the theory can only be done at the available outcroppings, those points where theoretical predictions and available instrumentation meet. Any one such outcropping is equivocal, and all types available should be checked. The more remote or independent such checks, the more confirmatory their agreement. (E.J. Webb et al. 1966: 28)

How can the limited evidence of lithic remains be used to test ideas about past activities?

A. Manufacturing lithic artifacts

1. Cultural context

In dealing with cultural activities in which lithic materials are the objects undergoing processing, one's concern is with the instruments of labor, the social relations of production, and the ideas used in processing lithic materials. What tool kits were used? Were there craft specialists? What knowledge was used? What differences occurred in the production of different kinds of artifacts? How were materials transported from one processing area to the next?

2. Archeological context

Lithic materials can yield information if used in conjunction with experimental and ethnographic/ethnohistorical data. A major consideration is that different products require different technologies.

The instruments of labor would vary considerably for the different kinds of products. The simple smashing of a nodule requires little. However, the production of fine, prismatic obsidian blades suggests a pressure-flaking technique using a pressure-flaker and accessory tools (there are some disagreements between the interpretations of the experimental approach and the ethnohistorical, but much in the way of agreement--see Crabtree 1968; Fletcher 1970; Feldman 1971). The complexity of the instruments of labor range between the extremes represented by those required for smashing nodules, and those required for pressure-flaking blade-cores; there are the tools required for producing simple flakes, retouch, bifacially shaped artifacts, rejuvenation of spent tools, etc. (Crabtree 1967b).

The social relations of production would also vary considerably for different kinds of products. Smashing of nodules can be done by anyone, and ethnographic instances of nodule smashing offer no surprises in this regard (Gould, Koster, and Sontz 1971; Harding 1967). On the other hand, production of fine prismatic obsidian blades suggests craft specialization for several reasons. For one, considerable training and practice is suggested. Indeed, even the hard-hammer direct percussion technique used by modern Turkish flint-knappers requires much training and practice (Bordaz and Bordaz 1974). Secondly, blade production is an efficient technique for mass production, dozens (if not hundreds) of blades being produced from a single core (Sheets and Muto 1972; Kidder, Jennings and Shook 1946, citing Motolinia); hence the production of a surplus is built into the technique. (It would be interesting to study the various Upper Paleolithic cultures from the standpoint of craft specialization--e.g., Bordaz speculates that "some men would have been more dextrous than others and might well have been given the task, whenever possible, of flaking flint nuclei" and that "perhaps the reason why so few hammerstones have been found is because knappers represented a relatively small group and that they would rarely have abandoned serviceable hammerstones" [Bordaz 1970: 56].)

From the ideational standpoint, it would seem that certain principles of knapping would have to have been understood in order to carry out the various steps in the manufacturing procedure. Thus, ideas as to the manner of placement of a pressure applicator on the core in relation to ridges and distance from the edge, core preparation from the establishing of ridges to the trimming of overhang, and the various other procedures, would have to have been understood. However, such knowledge would have been only a small portion of the related ideology; much else is missing. These manufacturing concepts were undoubtedly embedded in an ideological framework expressing the perceptual paradigms of that culture and would be rather different from the various models used by contemporary experimental knappers, who use such concepts as the "Hertzian cone," tensile strength, stress pulse, velocity of wave propagation, and so on, as in Speth 1974. Additionally, there were probably associated concepts pertaining to the formation of social relationships and/or the legitimization of ideational systems.

For example, Kidder, Jennings, and Shook (1946; 135-136) quote Motolinia's account of a ceremonial context in which master craftsmen fast and pray before detaching the blades to be used in cutting tongues open for ceremonial bloodletting, then perfume the detached blades with incense, "and when the sun has completely set, all the priests being together, four of them sing songs of the devil to the knives, beating on their drums . . ."

What of temporal and spatial dimensions? Were there specialized workshops within sites as Spence (1967, 1973) has found at Teotihuacan? Was production of various items seasonal, for example, done only when agricultural activities were not being carried out (as is the case for modern Turkish blade producers)? Previous discussion of the input system indicated that the various stages of manufacture could occur at different loci and that the debitage and variation within an artifact type could be used as indicators of the stages of manufacture present. Additionally, the reduction strategy of lithic manufacturing results in a vast amount of waste. Quantitative estimates, even relative measures of abundance, of lithic debitage at the various sites should be indicative of manufacturing loci, if such were present.

Transportation of items involves two main considerations, which will vary depending on the nature and bulk of the transported items as well as on the terrain and distances to be traversed; namely, what kinds of containers or wrappings were used, and what means of transport. For example, if blades are being transported and are in demand because of the sharpness of their unretouched edges, then their edges would have to be protected by individual wrapping of each blade (the cost of this individualized attention can be offset by the considerably greater trade value of individual blades than of cores--but more on this later). Indeed, Pires-Ferreira (1973: 78) notes: "Certainly this was the case in later periods; NacNeish (personal communication) reports finding obsidian blades wrapped in bark cloth, presumably to prevent breakage during transportation in one Tehuacán cave." If masses of material are to be moved considerable distances, then, in the wheel-less Mesoamerican societies, porter-slave caravans, as ethnohistorically described, would be one means. Thus, again, the quantity and quality of the archeologically recovered lithic materials are important parameters.

B. Activities in which lithic artifacts are used to process other materials

1. Cultural context

Feldman, working with ethnohistoric/linguistic remembrances of Post-classic ideas, indicates that native categories of rocks and minerals were cued by recognition of particular traits and/or uses (Feldman 1973). What kinds of uses were lithic tools/weapons put to? Were they used for cutting, sawing, piercing, gouging, or what? Were they hand-held as they were, held in protective wrappings ("Mexican merchants are reported to have sold obsidian razors with leather handles"--Feldman 1971: 214), or hafted? And the most difficult question: what materials were processed using stone tools? Were stone tools used to shape wood, bone, other stone, vegetal material (in harvest or food preparation); were they used to butcher meat, scarify, or bloodlet; were they symbols or rank or of ritual meaning?

2. Archeological context

The objective of chipping stone is to produce usable artifacts, so one would expect at least some of the morphological characteristics resulting from manufacture to be also related to uses. However, the questions would now be couched in terms of function rather than with manufacturing procedures. If the concerns are with cutting, scraping, piercing, rather than with knapping, what characteristics are relevant?

a. Shape

Two classes of artifact are clearly the result of planning: flakes from prepared cores (here, this for the most part refers to blades) and specimens shaped by retouch (e.g. bifacially retouched projectile points). Hence, their morphology is (within the limits of the knapper's capabilities, the properties of the materials used, and accidental variation) the result of design. The overall shaping is thus significant for use interpretations. For these classes of artifacts, the overall shape should present some limits within which the artifact could have been used, or, worded from the opposite perspective, should rule out those uses an artifact could not have had. A pointed implement could have been used for piercing although it may not have been; but implements without a pointed extremity could scarcely have been used for piercing. Pieces with long, sharp, natural edges, such as blades, may have been used for slicing through relatively soft material, whereas obtuse angle pieces (Crabtree 1973) could scarcely have had the same function.

Many artifacts are selected from amongst an assortment--for example the few flakes selected from the debitage of a smashed nodule as suitable for particular uses. Here, many details of morphology may be irrelevant, since the reason for selection may be a single distinctive feature, such as the presence of a thin, sharp edge, the rest being "noise." Hence overall shape may not be relevant. Using the logic of shape in this situation, one would look for the presence of edges or points that could have been used and attempt to verify that such was the case by looking for evidence of wear or retouch.

Finally, much material is waste--i.e. neither designed nor selected for use. Lack of proposed uses for its shape together with lack of retouch or wear constitute the evidence, though negative evidence leaves considerable room for error, especially since some experimenters have stated that stone tools used properly will not show use retouch (Crabtree 1968; Outwater 1957).

An important issue is thus the characterization of edges. A number of edge attributes may be indicative of use. Edge outline is one. For example, concave edges may have been designed as such ("spokeshaves") or the result of repeated action against an object narrowed than the edge (e.g. the adzes described by Gould, Koster and Sontz 1971) or both. A toothed edge may be indicative of sawing (Semenov 1964: 19). Direction of retouch may supply additional information. Unidirectional (unifacial) retouched edges may be indicative of scraping or similar usages where the implement makes contact mainly on one surface (Semenov's "whittling knives" [1964:19]), whereas bidirectional retouched edges may be indicative of knives, saws (Semenov 1964:19) or other implements making contact on both surfaces with the object being worked. However, since some have referred to bidirectional scrapers (e.g. Frison 1968: 149), directionality of retouch is not the only indicator of use.

Characterization of the kind of retouch present ranges from use-retouch to manufacturing retouch. Small, irregular nicks or scars may be use-retouch, whereas larger, regular scars are probably the result of pre-use manufacturing. On edges having two types of retouch with one cutting into the other, the larger retouch scars are probably the result of manufacture whereas the smaller scars are probably the result of use. Caution should be exercised in distinguishing between edge grinding in manufacture to produce striking platforms (Bordaz 1970; Wilmsen 1968; Sheets 1973) and edge grinding resulting from use (Semenov 1964; Wilmsen 1968). Of course, unused debitage, after having been discarded, may be "retouched" by a number of accidental or natural processes. A number of procedures have been suggested for distinguishing between retouch and non-cultural factors. These include: consideration of the depositional context and the degree of disturbance (Keeley 1974: 327); study of micro-wear; obsidian hydration dating to confirm contemporaneity of the artifact and scars.

It has been argued that the angle of the working edge is indicative of use (Semenov 1964; Wilmsen 1968; Crabtree 1973). This indeed seems plausible, whether for the type of cutting edge that has been shaped by retouch or for the naturally sharp cutting edges of unretouched blades and flakes. However, the measurement of edge angles of either type is not easily accomplished. Part of the problem is in the measuring instrument. Some have simply eye-balled the specimen against a polar coordinate type of graph paper calibrated in degrees (David Thomas commented personally that the repeated measurement of particular angles, as part of his Great Basin studies, indicated that such measurement was replicable ± 10 degrees). Another approach has been to use a template former, a carpenter's tool made up of a series of over a hundred small metal rods which, sliding independently of one another when their ends are pressed against molding or some other irregular shape, replicate the shape against which the template is pressed. Since the diameter of each metal rod is 1 mm, I find it difficult to imagine (and have found it impossible to carry out) precise measurement of sharp angles with the template former as has been claimed (Crosby 1967). I have used a goniometer in these studies. The goniometer, a simple measuring device used by geologists (it consists of a protractor with a pivotable arm attached), while seeming to be a straightforward way of obtaining angle measurements, is unable to overcome another type of problem, namely variability of the angle itself on any given specimen.

Especially when considering a retouched edge, variability of edge angle is a problem, for each retouch scar of the many shaping the edge (as well as the ridges between scars) will have different angle measurements. Also, the surfaces forming the edge angle are not flat, being either concave (if a negative conchoidal surface) or convex (if a positive conchoidal surface)--hence the angle varies as one follows the surfaces away from the edge.

Thus, while I have tried to be consistent in angle measurements, such have much variability built into them, and while more precision is possible than with the old "steep" and "semi-steep" retouch categories, edge angle measurement is not as precise as some of the more recent work would have us believe. However, while recognizing measurement problems, readings were obtained for a number of different types of manufacturing categories, especially blades, since it was hoped that the measurement technique used would be sufficient to disclose variation in the sharpness of edge angle that could be related to usage, e.g., to the type of material against which the edge had been used.

Finally, the length of the edge may be a clue as to use. One can measure the length of edge for unretouched but sharp natural edges as well as the length of the retouched portion of an edge. For example, if a concave edge was indeed a "spokeshave," the length of the edge could be related to the diameter of the shaft being shaped. Or an edge that is thought to have been used as a "saw," i.e. moved in line with the edge, should be longer than an edge which was moved perpendicularly to the edge.

One of the difficulties that arises here is that specimens are often fragments of once larger artifacts. Hence a distinction has to be made between measurements that are of complete edges and those of incomplete working edges.

Measurements such as these suggest a dimension other than "shape," namely "size."

b. Size

The size of the artifact may also be some indication of use. For example, it has been suggested that spear points can be distinguished from arrow points on the basis of weight (Fenenga 1953). Within the same shape category, frequency distributions of sizes may indicate clusters suggestive of functionally discrete types (W. E. Taylor 1962--but see re-evaluation by Wyatt 1970; Read 1974 is another example). Also, small items may have required hafting for leverage or have been part of a composite item involving a series of similar lithic inserts (e.g. Mesolithic microliths, Neolithic flint sickle-blades, or Aztec macana/macuahuitl blades).

c. Relationships of artifact features

It is obvious when dealing with fully-shaped artifacts that the sense of shape involves the relationship of parts--a hafting element may be defined by a "tang" projecting in opposition to the blade (as in "knife blade"--unlike the previous references to special prismatic flakes also called blades) element or by "shoulders" demarcating a transition via constriction from blade to haft element. There are less obvious situations in which relationships of parts is related to use.

Some pieces, presumably hand-held, have a cutting edge opposite an edge which is either naturally dull or which has been dulled by retouch or burin blow so that the user's fingers are safe in pressing against the dulled edge (Bordes 1961; Semenov 1964). The concern here is part of the more general issue as to the nature of opposing edges. That is, other items may have different retouch on opposing edges. There is ethnohistoric evidence of Mesoamerican blades having been mounted in wooden handles (Crabtree 1968: 453), so left and right edges should differ in their attributes. Similarly, the single-edged scrapers of various kinds may have been hafted so that the opposite edge has a different pattern of attributes.

III. Final Cautions

Having given a brief overview of the theoretical models shaping my perceptions and some of the practical problems in operationalizing variables, I am left with only a residue of issues to comment about before moving on to the results obtained.

Webb et al. (1966: 33) refer to the proportion of data that is irrelevant for the research problem as the dross rate, the higher the rate the lower the relevant information: "If one elected to measure attitudes toward Russia by sampling conversations on public transportation, a major share of the experimental effort could be spent in listening to comparisons of hairdressers or discussions of the Yankees' one-time dominance of the American League. For a specific problem, conversation sampling provides low-grade ore." Lithic analysis is also low-grade ore. Much effort may produce very limited results. Speth (1972) has attempted to reduce the effort by demonstrating a predictable relationship between some of the variables so that not all of them need be taken, e.g. that thickness can predict length in hard-hammer-produced flakes. However, while the validity of such relationships is subject to various conditions and uncertainties, some clustering techniques require the use of interdependent variables to demonstrate the legitimacy/interpretability of the factors being generated (Comrey 1973). McGhee, after expending considerable effort in precise measurement of a number of variables in samples of microblades, notes with some sanity-saving humor (1970: 96): "Variation within samples is fairly similar for all attributes relating directly to microblade manufacture (standard deviation generally between 1/3 and 1/5 of the mean), and suggests a low degree of standardization and selective control applied to these attributes. In sum, it seems fair to conclude that the quantitative comparison of Dorset microblade samples on these attributes had yielded roughly as much information as would visual comparison of the samples from a distance of approximately one meter."

I have elected not to use microscope analysis to study wear, but have limited observation of edge wear to those traces seen by the unaided eye (or, at most, aided by a 10X eye-piece). This decision is based on several considerations. First, the dross rate was anticipated to be very high--too high an investment with too little in the way of expected information (indeed, as translator Thompson ponders in his forward to Semenov 1964, how many specimens did Semenov have to study before finding clear traces of wear?). Another factor, magnifying the dross rate, was the training and equipment necessary if I were to achieve the requisite expertise and obtain the high-magnification equipment called for by Keeley (1974). And, also magnifying the dross rate, was the problem of discriminating noise (accidental striations on discarded specimens amidst the garbage) from use wear--unfortunately, there were no finds in activity preserved contexts to yield pieces free of post-use damage.

The focus of this chapter's discussion has been on the specimens themselves. However, much information about both manufacturing and usage could be obtained if contextual information was also used--a manufacturing locus would perhaps have debitage of the steps in the manufacturing process, a burial might have a craft specialist's tool kit, or a ceremonial cache might indicate a belief constellation regarding various artifact types. However, the material here discussed is from vertical shafts through undifferentiated village refuse excavated primarily to ascertain temporal sequences. Some information about the nature of the context can be obtained by considering the proportions and types of ceramic material from the same lots and by considering the nature of the sites themselves. The information derivable from such gross estimation of context, while limited, can be useful in conjunction with the many bits of information available from the artifact analyses. The above disclaimers still leave room for much that is relevant, for, "if the restraints on validity sometimes seem demoralizing, they remain so only as long as one set of data, one type of method, is considered separately. Viewed in consort with other methods, matched against the available outcroppings for theory testing, there can be strength in converging weakness" (Webb et al. 1966: 29).

Chapter 3

EXPECTATIONS

In developing the analytic framework in Chapter 2, questions regarding the functioning of cultures were raised. This was done so as to survey the kinds of answers that might be forthcoming and, hence, to focus on the kinds of archeological data that would enable one to discriminate between theoretically possible alternatives. The interest was in specifying the archeological clues that would enable one to suggest what particular cultural activities were going on at prehistoric sites. Now that the general framework has been established, the task of this chapter is to elaborate the particular theoretical expectations of lithic systems. This is a two-part process. One part is the elaboration of various models of how chipped stone artifacts are made and used. The other part is the specification of the archeological traces to be expected if a particular manufacturing procedure or usage had indeed been an actuality. Thus, this chapter generates an array of clues referable to various manufacturing and use models, i.e., an array of interpretable measurements. This array of measurements is used to produce, in Chapter 4, the descriptive data, i.e. the results of specific ways of "seeing" some 2500 obsidian and 1200 non-obsidian chipped stone specimens from Paul Tolstoy's field projects in the Basin of Mexico. Since interpretation proceeds, in part, on the basis of the dialectic force obtained by pitting theoretical expectations against empirical observation, Chapter 5 will present the inferences that can be made on the basis of such comparison.

I. Input System: Expectations

In general terms, the "input system" refers to the cultural processing of the entire range of raw materials ingested and the transformations that result in these materials being either assimilated into the structure of the culture or used up. However, since this definition, even limited to lithic raw materials, is rather too global, I have divided the "selection and procurement" aspect of the input system into various alternative ways of acquiring stone raw material and I have divided the "manufacturing transformations" aspect into several subsystems which produce stone artifacts and whose definition is based upon the lithic end-product. The acquisition alternatives are: (1) quarrying; (2) collection. The manufacturing subsystems, which will be discussed in turn, are: (1) blade-core subsystem; (2) nodule-smashing subsystem; (3) shaping subsystem; and a catchall (4) for ambiguous items which have not been placed in a particular manufacturing sequence.

A. Selection and Procurement: Expectations

An extremely important matter of interest is the location of the geologic sources of lithic raw materials, especially vis-a-vis obsidian. It has even been argued that the location of some major sites has been, in part at least, chosen because of proximity to such sources. Usually, in Mesoamerica, the discussion centers on obsidian. But William Coe (1965) has argued that Tikal's location was in part related to use of local chert.

Two matters related to location of sources require consideration, namely the accessibility of the material and whether or not natural processes moved the material from the provenience of geologic formation. Geologic processes affect the character and location of rock not only during formation but subsequently as well. While rock may be massed in large, solid veins, flows, etc., when initially formed, subsequent natural events can break up the original formation in situ and even carry and further break up the material either on land (e.g. erosional events resulting in boulders being rolled down hill-slopes) or in water (e.g. long distance movement of cobbles by the action of rivers).

1. Quarrying: expectations

If material is being obtained from veins, flows, etc. then: (1) material would be quarried, accessory technology being necessary to break free suitable pieces; (2) relatively few pieces would have cortex on them since most material is gotten from within the mass; (3) trace analysis of chemical constituents would indicate the actual location of acquisition. The second point needs qualification. It may be that material formed as nodules (see Crabtree 1967a, re: nodular "flint" and beds of "chert") was broken up in situ (e.g. by earthquakes) but that quarrying was still necessary to get to the material. In which case, there could be a considerable number of resulting flakes with cortex on them, since the naturally broken mass may have acquired a cortex on its outer surface. The "Otumba" quarries (the main source used by Teotihuacan, located in the Teotihuacan Valley--also known as T.A.-79 and Barranca de los Estates) may be an instance of such a situation.

Spence and Parsons (1972: 20) note that obsidian there was apparently mined from "the loose conglomerate matrix" in which the obsidian nodules were loosely embedded. However, they also argue (ibid: 5) that abandoned pits in Hidalgo were probably filled with loose debris when a new neighboring mine was opened; hence it may be that the unconsolidated matrix was merely the refuse of refilled quarry pits. They do note the existence of "veins" of the reddish obsidian at T.A.-79.

2. Collection: expectations

If natural processes produced nodules which could be simply collected, then: (1) no special ancillary quarrying technology would be necessary; (2) many flakes would have cortex on them (the smaller the nodule the proportionally greater the number of cortex flakes--cf. DeBoer 1976: 55); (3) trace analysis would indicate only approximately the location of acquisition. In dealing with Mesoamerica, one can presume that erosional processes on land have resulted in movement over relatively small distances (glacial action has not been a major force). For example, Spence and Parsons (1972: 17) refer to workshop site 15 in Hidalgo in which "chunks of obsidian eroded down from the higher land to the north to pepper the soil here, providing raw material." River action, however, may have moved rock considerably. Spence has thought that considerable quantities of obsidian from T.A-79 were carried down by the Rio San Juan and deposited in a bend of the river in the Teotihuacan city itself. Millon (1973:52) notes that most of early Teotihuacan's obsidian probably "would have come from the deposits of 'gray' obsidian in the eastern part of the Valley of Teotihuacan, or just beyond it to the east, or from water-borne nodules in the eastern drainage of the valley." Also, Spence and Parsons (1972:13) refer to the source of raw material for workshop sites 2 and 4 in Hidalgo: "obsidian chunks of varying size are embedded in tepetate in a stream bed running along the west base of the hill, and also seem to be eroding out onto the site surface from a subsoil stratum."

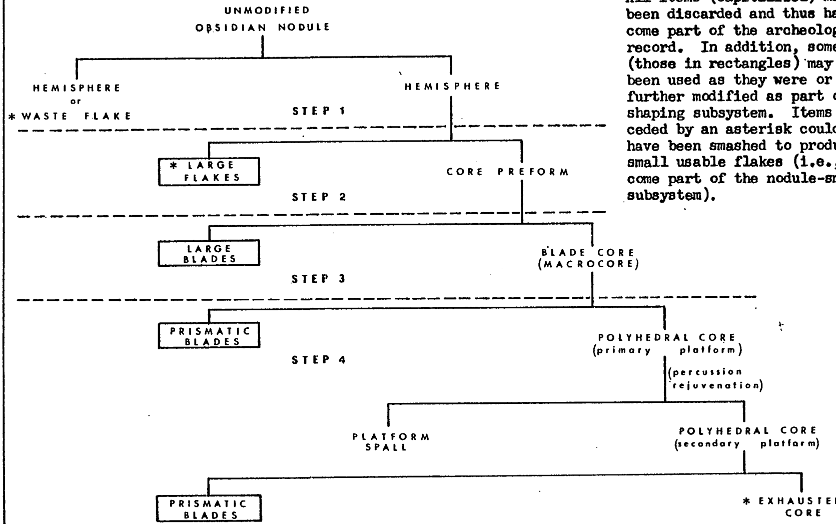
B. Manufacturing Transformations: Expectations

Once acquired, the lithic raw material would be changed into culturally usable forms.

1. Blade-core subsystem: expectations

Sheets (1972, 1974, 1975) has presented a model for Meoamerican blade manufacture which accords well with earlier presentations (e.g. Barnes 1947, Crabtree 1968, Bordes 1969, Bordes and Crabtree 1969) and will be used here with two modifications (see Fig. 3.1). The first modification is related to Sheets' (1972: 19) suggestions that "the great majority of Mesoamerican chipped stone tools, at least those made from obsidian, may have been derived from various points" along the "series of procedures and the resultant products of Mesoamerican core and blade technology." I maintain that core and blade technology, while a very important route to producing obsidian artifacts, was not the major route in the Preclassic, and I will be discussing this point further, especially in dealing with the nodule-smashing subsystem.

Figure 3.1. Sheets' Model for the Blade-Core Reduction Strategy (based on Sheets 1975: 375, but with modifications).



All items (capitalized) may have been discarded and thus have become part of the archeological record. In addition, some items (those in rectangles) may have been used as they were or been further modified as part of the shaping subsystem. Items preceded by an asterisk could also have been smashed to produce small usable flakes (i.e., become part of the nodule-smashing subsystem).

The second modification is to limit the blade-core subsystem to that part of the trajectory of material processing that ends with prismatic blades. The sequence of steps up to that point can stand alone since all these steps involve shaping and use of the core so as to produce blades and since prismatic blades could have been and were used without further modification. Thus, in contrast to Sheets, I do not include any subsequent retouching of blades as part of the blade-core technology. I think it useful to consider any additional retouching (shaping) as part of a separate subsystem since treating retouch procedures as a separate process invites common treatment of all types of flakes that have been shaped into similar artifact forms.

The first steps in the blade-core technology are designed to preform the core. The major preforming tasks are: (1) to produce a platform for application of force so as to remove blades; (2) to establish ridges on the core to guide the detachment of blades; (3) to refine the core for pressure production of fine prismatic blades by both regularizing the facetting and reducing the size of the core. There are various ways of carrying out these tasks and the first two tasks can be done in reverse order. Sheets' model for blade production, based on a sample of debitage from a workshop in a single Highland Mayan site, Bustamante, seems to represent the major core reduction strategy (and related variants) in Mesoamerica. I will present it step by step, trying to indicate the kinds of durable debitage that would result (see Fig. 3.1).

<u>Step 1. Producing a platform</u>

This step may not actually be the first in the stone processing trajectory--an earlier subsystem relating to quarrying may have been required to produce the nodules. Whether it results from quarrying or from natural geologic processes, the nodule is then modified so as to create a platform for the application of force. One alternative is to split the nodule in half, both halves having virtually flat platforms and either or both could be worked further into blade cores. Hence the debitage from this approach would consist of split nodules that had not been worked further.

A second alternative, according to Sheets, would be to detach a large flake, using the natural ridging of the nodule to guide the fracture and a natural "platform" on which to apply force. The debitage from this might be: nodules with large shallow negative conchoidal surfaces (the prospective blade-producing platforms); large, relatively flat flakes, perhaps with cortex-surfaced platforms and dorsal surfaces. One suspects that splitting occurred in river-rolled cobbles, since these would be relatively smooth, providing neither natural ridging nor platform. On the other hand, quarried material or angular naturally-occurring nodules ("boulders"), not smoothed by river-rolling, might be prepared using the second approach.

Such large debitage items would be more likely to be found in areas where the raw material is relatively abundant or accessible since it is under those circumstances that such items would be left as garbage. In a resource deficient zone, large items would have been too valuable to leave as refuse, for even if the people in the community did nothing further with these large items themselves, they would have traded them to people having even less access to the desired material (see Harding 1967).

Crabtree (1968: 460-461), based on his experimental work, has suggested an approach which would be an extension of the second alternative discussed above. After detaching the first large flake, a second thick flake is detached immediately behind the first--this second large flake will become a core. Its platform is created by removing the top of it in the form of a "large burin spall." However, this third approach does not produce the typical Mesoamerican core since

> the core will assume the shape of a half-cylinder; when it is exhausted, it will not be polyhedral. The unworked portion, or back, of this core will retain the character of the original surface, and only the worked portion will show the longitudinal scars left by the removal of blades.

There is evidence for the use of large decortication flakes or "naturally tabular pieces of obsidian" as cores. Crabtree notes, in interpreting specimens in the Museo de Antropologia Nacional in Mexico City, evidence of

> blades removed from just one side of an irregular piece, or pebble, of obsidian. Evidently the worker had found a piece of stone with natural ridges and had simply removed blades from one side of the stone. . . . It is not uncommon to find exhausted cores that still retain the original surface cortex on the base and on one or more sides, indicating that blades were removed from one or more faces of the preformed core but not around the entire perimeter. . . (ibid: 455)

From a comparative standpoint, these two reduction strategies are variants of Kobayashi's (1970) "System B" sequence of steps in blade production (based on the archeology of the Japanese archipelago), in which the first step is to produce a platform. In his "System A," on the other hand, the first step is to bifacially shape the nodule, and it is only after that has been done that a platform is produced. In the

Japanese archipelago, this production sequence was used to produce micro-blades only (width of these being about 5 mm). Crabtree (1968) indicates that he has produced similar cores for blade production experimentally, but that he found it easier to produce a striking platform first and then work the core bifacially (to establish two ridges) than it was to first work the nodule bifacially and then produce the striking platform. Bifacially worked cores of either kind seem to have been rather minor reduction strategies in Mesoamerica.

Step 2. Establishing the fluted, polyhedral core

Large flakes are then detached so as to produce the ridged core suitable for blade production. If these have cortex on them (i.e. if they were "decortication" flakes), it would be an indication that weathered cobbles were used rather than quarried material. Sheets (1972: 20) apparently found that unquarried material was used at the Bustamante site since he refers to large flakes being removed from the "raw obsidian boulder" and that "smoother cortex" surfaces present no knapping problems, unlike the "very porous, rough kinds of cortex."

Crabtree (1968: 460-62) discusses several experimental core types that are categorized according to the number of ridges the core is started with. This would appear to affect the relative number of large flakes expected from the initial trimming. As discussed by Crabtree, there could be a very small number of such large flakes per core: for his "core with one ridge" there could be as few as two large flakes per core. However, since the "abandoned and exhausted cores of Mexico indicate that the rectangular type of core was by far the most common," Crabtree and Sheets seem to be talking about the same type of core preparation, and that would result in relatively more large flakes per core--while that number has not been specified, it would appear to be at least 6 per core.

In addition, Crabtree, Bordes and others have indicated that if the ridges formed by the intersection of the facets left by removing the large flakes are irregular, they must be straightened. Or it might be that the natural surface of an unmodified nodule presents an irregular ridge which could be used if straightened. This straightening canbe done by working the irregular ridge bifacially. The flakes that result from ridge straightening tend also to be relatively large (see Bordes and Crabtree 1969:fig. 3, in replicating "Upper Paleolithic" blade-core reduction strategies). Some small flakes may result if further straightening of the ridge is carried out "by striking off the crests between the lateral flake scars" (ibid: 4, again referring to Upper Paleolithic technologies). These small flakes would have longitudinal ridging on them and have blade-like dorsal facets (<u>ibid</u>: 15, fig. 2). The first flake removed along the straightened ridge (and thereby removing the ridge), will have a facetted dorsal surface with scars emanating from the dorsal ridge--such a ridged flake is referred to as a "crested flake" or "lame à crête." Several subsequent flakes will have some dorsal scarring indicative of the lateral flaking done to straighten the ridge on the core.

The significance, from the standpoint of the archeologist trying to reconstruct this step from the archeological remains, is that the debitage expected here would include; large flakes (with or without cortex); large polyhedral cores that were not worked further; perhaps some small flakes with ridging on them; and perhaps some crested flakes or their variants. It is the combination of them that is important. Finding large flakes by themselves would not be conclusive evidence of this step, for large flakes might be produced in a number of ways, obviously, and need not indicate blade-core technology at all. But finding few or no large flakes at a site in which prismatic blades are found raises the suspicion that blades or the already prepared polyhedral cores were traded in.

The same approach has been used by Rovner in discussing obsidian debitage from Mayapan, a Postclassic site of the Maya lowlands. He points out (1974:20):

> The secondary nature of the Mayapan workshop is evidenced by the total lack of expected debitage produced during the early stages of core production. . . . No unworked or partially worked obsidian nodules were present. Cortex flakes and large percussion flakes indicative of early stages of core production are also absent.

Step 3. Producing large, irregular blades

After having ground off the "overhang left above the negative bulbs of percussion" left on the core, large, irregular blades are removed. These can be used as "blanks" for the manufacture of other classes of chipped stone tools." But, more importantly, they change the core into the fluted form suitable for producing prismatic blades (Sheets 1972: 19, 21).

Debitage from this step would include: unretouched large blades; cores ranging from the large polyhedral cores to the smaller more nearly fluted cores. In addition, tools that were made by retouching large blades might be indicators of this step, but since they were the end-products of another series of operations, such tools would be somewhat removed from the manufacturing step under consideration.

Step 4. Producing prismatic blades

Once the core has the suitable ridge regularity and size, it can be used for prismatic blade production. As blades are detached from the core, the core becomes smaller and smaller. Hence, blades become smaller and smaller as the core is worked. At Bustamante, Sheets (1972: 22) found:

> There is an almost unbroken continuum of sizes and shapes from the most massive large blade to the smallest prismatic blade. Within the category of prismatic blades, the size gradient is from a width of 2.6 cm., and a maximum thickness of 0.4 cm. down to a width of 0.8 cm. and a thickness of 0.15 cm.

Therefore, variation in blade size may be an indication of local manufacture. This can be stated more strongly from an opposite perspective. If there is little variation in blade size, it is likely that the community was trading in blades having fairly well-defined size constraints.

Another indication of local blade manufacture would be traces of platform rejuvenation. At times, during the life-time of a core, it becomes necessary to create a new platform. This is done by flaking off the old platform. A fairly large core tablet is thus obtained. The new platform may require some trimming in order to make it "flatter and more nearly perpendicular to the core axis" (Sheets 1972: 24). Such core tablets and core spalls would have blade-core facets rimming or partially rimming their dorsal surfaces since they are removing part of the core's fluting as well as the platform.

Rovner uses the absence of initial core-shaping debitage and the "relative abundance" of core rejuvenation debitage to argue that "fully pre-formed [prismatic blade] cores, ready for blade production, were imported and blades were produced [locally] . . ." Indeed, Rovner goes so far as to suggest that the "presence of 'exhausted' cores does not necessarily constitute evidence for local blade production, particularly if other diagnostic debitage is absent" since "cores may have been sought-after tools [obtuse angle planes, for one--cf. Crabtree 1973], and, as such, regular items of trade in their own right" (1974: 20, 26).

It is unlikely that other types of core rejuvenation would serve to identify the manufacturing locus. While errors in blade production do occur which would need correction, the corrections would differ little from true blades. For example, at Bustamante, a frequent reason for core abandonment was an error which resulted in blades detaching partway down the face of the core in a hinge-out; "A full 68% of the cores recovered had hinge fractures." However, Guy Muto and Payson Sheets, in experimenting with techniques for correcting such errors, found that "the most successful technique involved the removal of blades on either side of the hinged mass, carrying some of the hinge with each blade" (Sheets 1972: 23). Hence, these corrections would look little different from true blades and could be used or traded interchangeably with them. Another technique discussed by Bordes and Crabtree, used on cores with two opposing platforms, would result in debitage that simply looked like a broken blade since it would be a "blade that terminated at the . . . hinge fracture" (1969: 7). A third method, discussed by Rovner (1974: 26) similarly produces pieces very similar to true blades since the hinge fractures are removed "by pecking and grinding in order to smooth the hinge(s) out and permit continued detachment of blades behind the error." Thus such "blades" would not necessarily indicate local manufacturing.

2. Nodule-smashing subsystem: expectations

> There appears to have been no regular blade industry (i.e., flaking from prepared blocks or pressure flaking) associated with the use of obsidian [among the peoples of the Vitiaz Strait region of northeastern New Guinea]. Small blades were obtained by simply smashing a large block with a stone, while in time blades were broken into smaller fragments to obtain newly sharp edges. Judging from the numerous fragments around village sites--mostly micro-blades and waste chips--straight-edged blades and scraper and burin-like forms could be produced by this relatively crude knapping technique. (Harding 1967: 42)

> If the cherty material occurs as nodules on the surface of the ground, the [Western desert] Aborigine [of Australia] generally takes a small boulder and uses it to smash a few nodules. He selects the flakes he wants from the resulting pile of chippings and debris. Working in this way, a man can leave behind as many as 200 waste flakes for each flake he actually chooses. (Gould, Koster and Sontz 1971: 160-161)

There is no need for an elaborate model of nodule-smashing. However, there is need for ways of identifying the debitage of nodule-smashing since the many pieces produced simultaneously are not the flakes of the classic models of "flint-knapping" but can easily be mistaken for them. Some of them, perhaps most of them, might indeed be indistinguishable from ordinary flakes. But some have characteristics which indicate their origin in smashing. The key to identifying such pieces is the simultaneity of their production for such simultaneity means that different forces are travelling through the nodule in different directions and thereby leaving anomalous traces on the pieces which are thus produced.

The only discussions in the literature I am aware of dealing with the characteristics of flakes that depart from the classic models are the brief article by Jelinek, Bradley and Huckell (1971) on "secondary multiple flakes," and the brief comments by Bordes (1961) concerning the "pseudo-burin de Siret" (which I refer to as a "split-flake"). The secondary multiple flakes are not the result of smashing, but comparable ones can be produced by smashing since they result from the use of a hammerstone with a rather large contact area and which therefore could knock off two flakes at a time. Since so little has appeared in print and since so much of the Mesoamerican debitage appears to have been produced by smashing, I find it necessary to discuss the various types of such anomalous debitage, i.e. in which each piece was one of at least 2 flakes detached simultaneously.

Anomalous Group 1: Multiple and Split Flakes.

Items in this group may or may not have been produced by smashing. They might simply be the results of crude craft capabilities and/or crude roughing-out steps in stone chipping. "Multiple flakes" form one behind the other--a simultaneous "exfoliation"; "split flakes" form when a flake splits down the middle as it is being detached from a parent body of some kind.

The following "descriptive types" are used simply to help indicate how to "see," i.e. identify, multiple and split flakes. Any additional significance they may have has not been determined.

Symmetric multiple flaking.

The article by Jelinek, Bradley and Huckell mentioned above deals with what I would call "symmetric" secondary flakes, that is, the negative scar left by the primary multiple flake is centered in the back of the secondary flake (see Fig. 3.2--based on Fig. 1 in Jelinek, Bradley and Huckell 1971: 199). In this situation the primary flake would be indistinguishable from any flake with a longitudinal dorsal ridge (the only flake characteristic found to be correlated with symmetric multiple flaking experimentally was "the presence of a ridge of some sort," ibid: 200).

Asymmetric Multiple Flaking.

I noticed flakes in the assemblages that had a "positive surface" that was actually a composite of 2 positive surfaces. Their ripples had a common area of origin but they were in different "planes" (i.e., parts of different Hertzian cones) and were separated by a clear-cut ridge discontinuity (see Fig. 3.3). I interpreted such flakes to be primary asymmetric multiple flakes. Figure 3.4 indicates this asymmetric pattern schematically.

Subsequently, I saw such oblique multiple flaking on film. In "The Early Americans" (Shell Film Library n.d.) there is a sequence of Bruce Bradley knapping a fluted point. One of the initial direct percussion blows in removing cortex from the still undefined nodule resulted in several large oblique multiple flakes. While no close-ups of such crude work were shown, I suspect the flakes would have had the characteristics indicated above.

Split Flaking

Another type of unusual fracture I noticed in the assemblages

Figure 3.2. Symmetric Multiple Flaking.

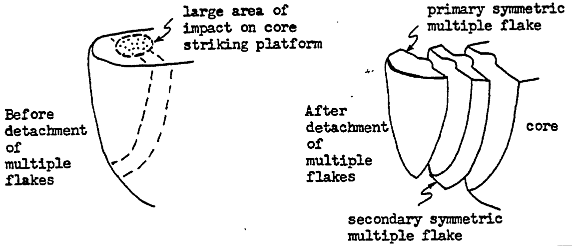


Figure 3.3. Primary Asymmetric Multiple Flake (P50#2 from Tlapacoya, actual size).

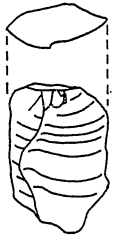


Figure 3.4. Asymmetric Multiple Flaking

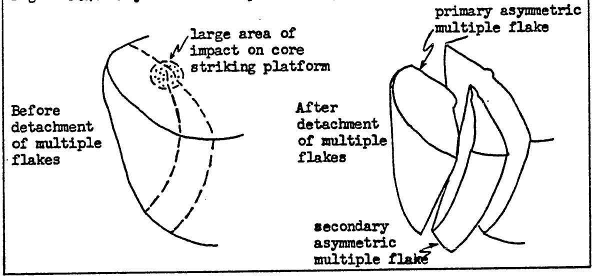


Figure 3.5. Split Flaking.

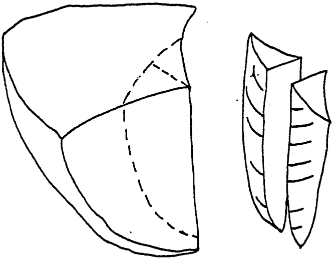


Figure 3.6. Oblique Split Flaking.

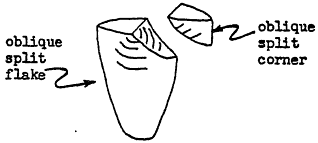


Figure 3.7. Multiple-split Flake (from lot Q105, El Terremote, actual size).

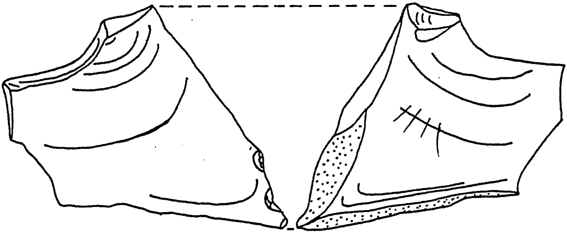


Figure 3.8. Double Positive Surface (the two specimens are shown actual size).

Figure 3.9. Flake Terminated by Positive Surface Emerging from Bulbar Scar (artifact shown actual size).

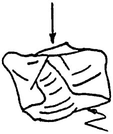


Figure 3.10. Flake with Cap Parallel to Ventral Surface (artifact shown actual size).

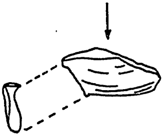


Figure 3.11. Normal Departures from Positive Surface Convexity.

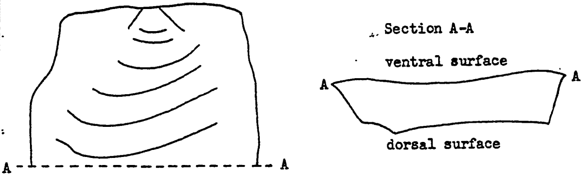


Figure 3.12. Anomalous Positive Surface (A72#8 from Loma de Atoto, actual size).

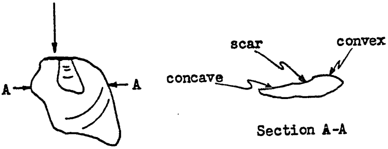


Figure 3.13. Cone Discontinuity (A51#20 from Loma de Atoto, actual size).

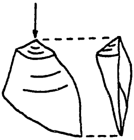


Figure 3.14. Two Opposing Positive Surfaces from Same Cap: Same Termination (S31#47 from Altica, actual size).

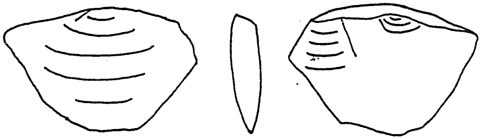


Figure 3.15. Two Opposing Positive Surfaces from Same Cap: Incomplete Match-up (Q7#8 from El Terremote, actual size).

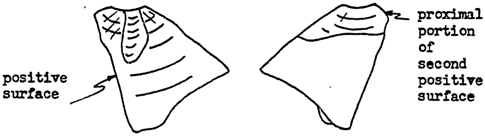


Figure 3.16. Two Adjacent Positive Surfaces (A59#1 from Loma de Atoto, actual size).

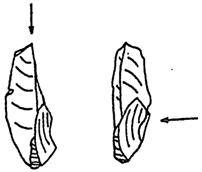
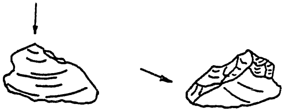


Figure 3.17. Positive Dorsal Facet (Z1019#6 from Coapexco, actual size).



I interpreted as having resulted when flakes split down the middle during knapping. The two identifying characteristics I used were: (1) the ripples on the positive surface of the flake were quarter-circle arcs (instead of the usual half-circle arcs) with a lateral edge "cutting" the ripples; (2) the lateral surface which cut the ripples was approximately perpendicular to the positive surface and was virtually flat (flat surfaces tend to be produced when a piece of stone is knapped in half, apparently because the masses of the resultant pieces are the same--see comments on "percussion shearing" or "quartering" of nodules by Sheets 1972 and Leakey 1954, respectively). Presumably two split flakes would be produced by such flaking (see Fig. 3.5).

In re-reading Bordes (1961: 32), I realized that he had already discussed the same idea when interpreting the "burins" described by Siret as mere flint-knapping accidents:

> Il convient d' exécuter une fois pour toutes le burin dit "de Siret" . . . qui n'est qu'un accident de taille. Il arrive parfois que, lors du détachment d'un éclat, deux plans d'éclatement perpendiculaires se produisent, le second séparant l'éclat en deux parties plus ou moins égales . . . Dans ce pseudo-burin, le "burin" est formé par la rencontre du talon et de la cassure perpendiculaire au plan d'éclatement normal. Il est évident, d'aprés les fissures même de Siret . . . que ses exemplaires les plus typiques ne sont que le résultat d'un tel processus. Ou bien alors . . . il s'agit d'une fracture volontaire, mais non d'un vrai burin.

His diagram (1961: 19, Figure 4, No. 2) is virtually the same as the one shown here as Figure 3.4

Oblique Split Flaking

Less well-defined are flakes which have "corners" missing (or which are the missing corners themselves; see Fig. 3.6). The fracture surface left by the missing corner may look like an ordinary hinge fracture--hence one cannot definitively state in this situation that this oblique splitting occurred during flake production (as opposed to merely being subsequent breakage). However, it seems peculiar that the break should cut through the point of applied force.

In some instances, the missing-corner scar may look like a burin scar, with ripples emanating from either the ventral-cap edge or the dorsal-cap edge. The latter form seems to occur on pieces which are also multiple flakes.

Multiple-split Flaking.

Specimens which have characteristics both of multiple and split flaking are even more likely to have resulted from smashing, since at least three pieces of debitage are produced simultaneously. There are a number of different combinations of multiple-split flaking. One example would be of a specimen which has characteristics indicative of oblique split flaking as well as of symmetric secondary multiple flaking (see Fig. 3.7). Sometimes the scar left by the missing corner is a hinge fracture so, even though the scar intersects the point of applied force, there is the possibility that the corner was snapped off after the flake was removed--in which case it would simply be a symmetric secondary multiple flake.

Anomalous Group 2: Smash Flaking

While multiple and/or split flaking characteristics may be evidence of smashing, the following can most plausibly be explained as having resulted from smashing. Again, the "types" are aides to seeing and may have little, if any, other interpretive value.

Pieces with anomalous positive surfaces

A number of different kinds of characteristics may be used to identify flakes which are the result of nodule-smashing. Some pieces have positive conchoidal surfaces which violate the classic knapping model.

In the classic model, a positive conchoidal surface, which occurs only on a flake, is convex or bulging, i.e., part of the outside surface of a Hertzian cone. The "bulge" or convexity occurs transversely, along tangents to the ripples [longitudinal sections of flakes may show outlines which range from convex (as typified by the short flakes spalled off in producing step retouch) to concave (as typified by prismatic blades)]. There should be a single such surface--no discontinuities (ridging) in it--except for bulbar scars, boundaries between double bulbs (see below), striations, and any subsequent retouch scars. There should be a single set of concentric ripple arcs emanating from a single point of applied force--except for some occurrences of double bulbs, i.e. two adjacent bulbs apparently produced when a large area of contact between hammer and core platform is translated into two neighboring "points" of applied force.

One anomaly indicative of smashing is evidenced by finding two patterns of concentric ripple-circles (rather than one) on the same positive surface, each pattern emanating from a different platform. Figure 3.8 shows 2 patterns which intersect at right angles; Figure 3.9 shows two patterns, with one positive surface emerging from a "bulbar scar" of the other.

Another kind of anomalous surface is evidenced by "impossible" curvature at the bulbar end of the flake, i.e., instead of the normal bulging bulbar contour, there is an extreme bend placing the platform virtually parallel to the ventral surface of the flake (Fig. 3.10). Applying force to produce such a flake would be like shooting around a corner.

Some positive surfaces are not fully positive; that is, rather than being convex along tangents to the ripple-arcs over the entire surface, there are places in which the surface is actually concave. The theoretical expectation is that the flake would have a bulging positive surface whereas the scar left in the "parent body" (core) would have the negative conchoidal surface. This is apparently related to the relative masses of core and flake (or spall). There are normal departures from this complementary opposition. Sometimes, on large flakes with pronounced dorsal ridging, the positive surface may actually be somewhat concave in particular areas because of the relative thickening where the ridges are (cf. Fig. 3.11). Also edge distortions, comparable to the "lipping" that is sometimes found at the ventral-cap edge of flakes, may involve departures from convexity. However, some specimens have departures from convexity which cannot be rationalized by the classic models. In such situations, the interpretation is of nodule-smashing--that during smashing, as the smashings were separating from one another, one part of a piece could have a larger mass than the piece it was detaching from, whereas another part of it could have a smaller mass than the piece it was detaching from--since it was acting in part like a core and in part like a flake, the "positive" surface would be in part positive and in part negative (see Fig. 3.11).

Some specimens exhibit a bulbar area that is discontinuous with the remainder of the positive surface, suggesting that the specimen was produced during the shattering of a Hertzian cone (Fig. 3.12).

Multiple Positive Surfaces

It is possible, using the classic knapping mode, to produce flakes with two or more positive surfaces. First, a large, thick flake would be detached from some parent body. Then the large flake would be used as a core from which smaller flakes would be detached. Part of the positive surface of the larger flake could be detached and show up as a second positive surface on the smaller flake produced, i.e., in addition to the positive surface in the usual ventral location. The location of this second positive surface depends upon the orientation of the larger flake when it served as core. For example, if the positive surface of the larger flake was used as a striking platform, then the smaller flake detached would have two positive surfaces, part of the larger flake's positive surface becoming the cap (butt, platform) of the smaller one.

However, there are many examples of specimens which either are unlikely or impossible using the classic knapping model. One set of unlikely types has two positive surfaces emanating from the same point of applied force. In this regard, they are similar to primary asymmetric multiple flakes--indeed some such "primary multiple flakes" may indeed be smash flakes. However, in the situations being considered here, the relative positions of these two positive surfaces are not explainable as inner and outer shells of concentric Hertzian cones. In extreme, the two positive surfaces are back to back--same point of applied force, same curvature, same termination (see Fig. 3,14). Some specimens show only the proximal portion of the opposed positive surfaces (see Fig. 3.15). Some specimens have their positive surfaces at right angles (Fig. 3.16).

One set of impossible types is distinguished by having a part of a second positive surface whose curvature indicates that it was from a smaller positive surface than its own ventral surface. In some instances, the cap has a positive surface so curved that it could not have been from a larger flake used as a core. In some instances, the dorsal surfaces are multi-facetted, but there is a part of positive surface amidst all the facets that are scares of previous flake removals--the curvature of the positive facet indicating a small complete size (Fig. 3.17).

There are other types of such pieces with two or more positive surfaces, but I think these examples are sufficient in indicating the kind of relationships to look for.

Multiple Positive and Negative Surfaces

Some pieces have a number of conchoidal surfaces (three or more), both positive and negative, emanating from the same point of applied force--indeed some specimens have such multiple radiations from two opposite points of applied force. Again, this would seem to be indicative of nodule-smashing, a number of flakes flying off simultaneously. The above enumeration is not exhaustive, but it does identify many of the smash flakes recognized in these collections.

3. Shaping subsystem: expectations

Retouching of blades, smash flakes, etc., may be carried out in order to turn the specimens into various well-defined shapes. The two different steps in the "life-cycle" of a specimen to be considered here are: (1) tool shaping, i.e., the production of the "shaped tool"; (2) sharpening (rejuvenation) of dulled tools.

Shaping

Relatively few specimens exhibit retouch. Some have edge retouch only, meaning that very small flakes (chips) were removed from edges (either unidirectionally or bidirectionally)--indeed some retouch may have been the result of use rather than pre-use manufacture. The debitage from such retouching would be too small to recover even using a 1/4" mesh screen to sieve excavated soil. The archeological finds in this case would be the retouched specimens themselves.

However, if pieces are facially (unifacially or bifacially) retouched, meaning that a fairly large part of a surface is shaped by flaking, then the removed retouch flakes would be large enough to be recovered by screening--in which case, the archeological finds could be: (1) the facially retouched artifacts; (2) the trimming debitage. Indeed, if facially retouched tools and/or weapons were being made locally, one would expect to find some of the trimming flakes. These small trimming flakes would be of different types, depending upon the kind of retouch. For example, they would be lamellar if the retouched tools exhibited "ribbon-flaking," whereas they would be short, broad flakes terminating in a hinge-out if the retouched pieces exhibited "step-flaking."

Sharpening.

Tools that have been dulled may be rejuvenated by flaking off the dulled edge. Frison (1968) and Shafer (1970) discuss several different types of rejuvenation (sharpening) flakes, all of which are archeologically recoverable.

Longitudinal removal of the dulled working edge (Shafer's Method A) via a burin-like blow delivered to one end of the edge produces a long, narrow rejuvenation flake, with a single dorsal ridge, the flake being relatively thick, the ridge dull (i.e. exhibiting heavy use retouch). Some longitudinal split flakes that happen to have use retouch on their dorsal ridges, may be mistaken for such rejuvenation flakes. The rippling and flatness of surfaces have to be checked to avoid such interpretive errors.

Transverse removal of a unidirectionally retouched edge, using the unretouched surface as platform (as in Frison's 2nd, 4th, and 5th categories, Shafer's Method B), results in flakes whose cap-dorsal edges exhibit heavy use retouch, the retouch extending onto the dorsal surface (it is sometimes difficult to ascertain whether the "use retouch" is really retouch or merely the scars produced by removal of "overhang" on a core edge prior to the removal of the flake). Transverse removal of a unidirectionally retouched edge, using the retouched surface as platform (as in Frison's 3rd category, Shafer's Method C), results in flakes whose cap-dorsal edges exhibit heavy use retouch, the retouch extending onto the cap.

Other variables may indicate the type of tool that was being rejuvenated. For example, the curvature of the flake, the angle of the cap-dorsal juncture, the curvature of the cap, the outline of the retouched edge, and the size of the flake may be used to suggest whether or not it was plano-convex tool, whether it was an end-scraper or a side-scraper, and the steepness of the working edge of the tool.

Bidirectionally retouched edges, the more completely shaped bifacially worked pieces, and the less shaped pieces with edge-on retouch may also be rejuvenated by the above techniques. Frison's 1st category (which he bases on Bordes' "flakes of bifacial retouch") is an example using the transverse approach. Such flakes would be bowed, following the lenticular cross-section of the bifacially worked tool, and would have a rather acute angle between the cap and dorsal surface, this angle being the edge of the bifacial tool undergoing rejuvenation. These would be similar to pre-use manufacturing flakes removed during the thinning and shaping of a biface--indeed there might be difficulty distinguishing heavy use retouch from edge grinding carried out to produce a platform (Nancy 1971, Sheets 1973). However, whether they were "shaping" or "sharpening" flakes, they would be part of the shaping subsystem.

4. Ambiguous Items

There are a number of pieces for which I have no clear-cut interpretation, that is, their interpretation is highly ambiguous. For example, flakes exhibiting ridging can be part of different subsystems. Since dorsal ridges seem to be important in determining the morphology of flakes--flakes with ridging may be produced during ridge-straightening of cores, shaping of bifacially shaped specimens, in the roughing out that sometimes results in multiple flaking, or in nodule smashing. Associations with other debitage, i.e. clustering of artifact types, may be used to give more weight to some alternatives than to others. Some of the more frequent "types" without specific subsystemic referent are indicated below.

Trimming Flakes

Flakes with ridging and/or with a mosaic of facets (scars) on their dorsal surface may indicate the trimming (shaping) of something--whether a core, the roughing out of facially worked implement, or finer shaping of a facially worked implement. Sometimes the patterning of facets on a specimen is so regular as to suggest the last alternative, but most often no finer discrimination has been possible on morphological grounds alone.

Ridged Flakes

Flakes with blade-like proportions and outline may not exhibit the blade's dorsal morphology, namely, one or more facets may not be the scars left by blades detached from the same platform as was the very flake being examined. Laughlin and Aigner (1966) distinguish several different types of ridged flakes. Some types are referable to particular manufacturing subsystems. One type is the previously mentioned crested flake (lame à crête) produced when a ridge is being created during the initial shaping of a blade-core. Another type results from removing (rejuvenating) a blade-core's platform edge: one facet has part of the shallow negative surface that was the core's platform; the other "facet" (actually a number of facets) has the upper portion of the fluted surface of the core's face. A third interpretable type is a "blade" that was taken off a core that had had a hinge error corrected (see discussion above of prismatic blade production).

However, some ridged flakes may be indirect indications of blade-making knowledge. Laughlin and Aigner (1966: 44) suggest, for the Aleutian technology they are considering, that the production of ridged flakes indicates that knappers were "taking advantage of a ridge wherever it was present" in order to produce blade-like flakes. If such is the case, such ridged flake debitage in association with fine prismatic blades may indicate that locals were manufacturing the blades, since they were using blade-making knowledge to produce similar types of flakes.

Small fragments

There are also specimens that are such small fragments of the original item that they are uninterpretable. Among the most defined of these are fragments of what seems to have been shaped artifacts--e.g., a nicely retouched working edge may have "hinged off" some whole artifact. But even if one could be assured that such was the case, it still would not be clear if these fragments resulted from a crude type of rejuvenation, accidental breakage during usage, or post-depositional, natural breakage.

II. Cultural System: Expectations

The means by which chipped stone was processed and the uses to which chipped stone was put are much more difficult to define from the attributes of the chipped stone debitage itself than are the manufacturing transformations. The basic reason for this is that the lithic specimens are merely parts of the once on-going activities. One can see the effects of manufacturing processes on the specimens and infer what produced them. Or one can infer the intended use (piercing, cutting, scraping) of an object from its shape, wear, etc. But most of the information regarding the on-going activities--the types of artifacts the chipped stone implements themselves were helping to manufacture, the social relations of production, scheduling, etc.--would not be derivable from the attributes themselves. One would need the materials with which the chipped stone specimens had been in articulation, i.e. other forms of evidence should be used--as Taylor elaborated in discussing his "conjunctive approach" (1948). However, let us see what inferences are possible based upon the lithic specimens themselves, limited in scope as such inferences may be.

A. Means by which chipped stone is processed; expectations

The steps in the processing of materials have been discussed from the standpoint of the modifications that are wrought on the raw material. One can also look at the processing steps from the standpoint of the processing structures which do the work. I will reconsider each processing step from this latter perspective, using the dimensions discussed earlier: the ancillary material/energy; personnel; and ideology.

1. Selection and procurement; expectations

Since none of the sites under investigation is a quarry site no unmodified quarried material is present. Hence, no information about the accessory material/energy or social relations of production can be derived by describing the lithic material at the sites. However, some limited information about ideology is available--namely, that some persons, somewhere along the transmission route, had to have known the locations of the raw materials. The attributes of the lithic specimens which enable one to determine geologic source location are thus involved. A first level of analytic discrimination would be to identify the various kinds of stone used. Thus, while not pinpointing the particular geologic source, one could distinguish between the obsidians, the cherts, the basalts, and so on. This may not be as easy as it might appear, for the same geologic source may produce a rather heterogeneous array of materials. For example, material from the same source, the Flint Ridge Quarry in Ohio, includes chalcedony, jasper, chert, and agate (Holmes 1919: 176, quoting from Fowke's 1902 Archaeological History of Ohio: 619-621):

> The flint varies greatly at different portions of the deposit. For some distance from the margin on every side it is whitish or grayish in color, cellular or porous in structure from the weathering out of small fossils, and makes an excellent buhr-stone, for which purposes it was formerly in much demand. Within this border it is more compact, freer from impurities, and possesses all the colors and shades ever seen in such stone. Much of it is a typical chalcedony, blue or grayish-blue and translucent. Large beds exist of banded or ribbon jasper, with alternating stripes of light and dark gray. In places there is a glassy variety ranging from almost perfect transparency to complete opacity, except in very thin flakes, included carbonaceous matter producing every gradation from a slight cloudiness to jet black. Much of this can not be distinguished from moss agate. In the central part of the ridge the chalcedony was weathered into various tints of blue, red, brown, yellow, and white; occasional pieces of green and purple are found.

A second level would be to use visual characteristics to distinguish subtypes within each stone category. This is obviously fraught with dangers, as the above Fowke quote indicates. Are "subtypes" of the same rock type merely indicative of the heterogeneity of a single source of that material, or are they indicators of different sources of that material? For example, it is clear to researchers in Mesoamerica that most of the visual characteristics that distinguish one obsidian specimen from another do not serve to distinguish one source from another (e.g. Jack and Heizer 1968). However, some characteristics are useful. One approach that has been suggested is to use the manufacturing peculiarities of the material from a given source. This approach is the result of the experience of experimenters who maintain that the materials from different geologic sources have clearly recognizable differences in manufacturing capabilities (Crabtree 1967: 9a):

> . . . when Dr. Francois Bordes and the writer were doing some experimental work . . ., materials for our project were from . . . seven widely separated sources. After a week of working, the materials were almost entirely utilized and the resulting array of flakes commingled in one big heap. Yet, if any single flake had been given us . . . we could identify the origin without error. . . . after the toolmaker has worked with a given material he will be able to identify its peculiar properties.

Another approach is to examine specimens from known sources or chemically isolatable groupings in order to see if some color characteristics are indeed site specific. Jack and Heizer re-examined specimens after trace analysis had indicated which obsidian artifacts were "mutually distinct volcanic glasses," i.e. after trace analysis had established five chemically defined groups. They found "consistent, although usually subtle, visual characteristics of each of these five chemical groups" (Jack and Heizer 1968; 81) that seem to set apart each of the geologic sources as defined by trace analysis. A third level has just been alluded to. Namely, the use of trace analysis to "fingerprint" sources. In Chapter 2, I discussed some of the problems with this approach (between laboratory measurement inconsistencies). Nonetheless, trace analysis offers the surest way of identifying the geologic sources.

Even armed with such information, the archaeologist would still require other kinds of evidence to determine which persons (role/status defined) knew the location of these sources and how to acquire the raw materials from them.

2. Manufacturing transformations: expectations

Some information about the processing apparatus is implicit, if not obvious, in my earlier elaboration of the transformation of raw materials into cultural ingredients. Indeed, in Chapter 2, I commented that people making blades from prepared cores must have known certain of the knapping principles, even though such minimal, essential (core) principles almost certainly would not have been surrounded by our "scientific" verbiage.

Rather than repeat the obvious, I will here just add some points not contained in the earlier discussion.

a. Blade-core processing apparatus

Two considerations will be investigated here; one relating to the application of force and the other to the removal of "overhang" on the core edge.

Manner in which force is applied.

Experimental and ethnohistoric investigations indicate that the fine, obsidian prismatic blades were produced by pressure-flaking using a "chest-crutch." The major indicator of pressure-flaking appears to be the straightness and parallelness of the sides and dorsal ridges (arrises) of the blades, while the use of the chest-crutch, involving the application of greater force than the shoulder crutch, is indicated by greater length and relative narrowness. Conversely, blades with irregular edges and arrises were probably produced by indirect percussion (e.g. Bordes and Crabtree 1969; Crabtree 1968; Fletcher 1970; Feldman 1971; Sheets 1972).

An idea of the tool kits used is provided by Crabtree (1967b). For pressure production of blades, he used a composite tool as chest crutch--it had a T-shaped wooden shaft with a tip of antler to transmit the pressure applied by leaning the chest against the top of the "T." The manner in which the core was held is in some dispute. Two different methods may have been involved. One holding device that has been suggested is a clamp. Crabtree uses this approach and there is some ethnohistoric supporting evidence. As to its construction, he comments (Crabtree 1967b: 64):

> Since holding devices were, no doubt, made of wood and lashings, no records remain except the information given by the early writers, Catlin, Sellers and Torquemada. There are many designs for clamps, vises and securing mediums and they are limited only by the individual's ingenuity. . . .

A second approach, also supported by some ethnohistoric accounts, does not involve a clamp, but rather involves holding the core directly between the feet. It has been suggested that the core may have been slightly wedged into the ground (Barnes 1947: 103), but this may not be in accord with blade making possibilities since the core face from which the blades are being detached must be unobstructed--otherwise the blades would snap (hinge-out) as they were detaching from the core. Both the clamp-held and feet-held approaches may have been used.

Indirect percussion could involve the same kind of chest crutch but used as a punch, if it has "a projection on the distal end" which could receive the blow. Others kinds of composite punches could have been used or, indeed, simple punches consisting of a single sharpened shaft. The most likely material for the tip of a composite punch or the punch of the simple variety would have been deer antler. Although it is not the most suitable, it would have been the best available material within Mesoamerica. The percussor might be "a rod, billet, club of wood, or hafted stone hammer" (Crabtree 1967b: 64). The earlier steps in the blade-core reduction strategy were all, apparently, carried out using direct percussion, which would have involved different kinds of hammers.

I have already suggested (Chapter 2: 32) that obsidian blade production, using a chest crutch, would have been a specialized activity --because of the skill required, the number of blades produceable from a single core, etc. But does such blade production indicate full-time specialization, mass production, a market economy, and other such attributes of civilization? There is no simple yes-no answer, for different levels of production can produce blades. The levels of production will vary, however, with the economic importance of obsidian blades in the societies under consideration. If obsidian blades are a small part of the debitage, it suggests that they were relatively unimportant. Sheets (1974: 53-54, 286-287) indicates the changing proportion of blades to total chipped stone debitage at Chalchuapa: Early and the earlier part of the Middle Preclassic generally had under 10%; the latter part of the Middle Preclassic generally between 10% and 20%; the end of the Middle Preclassic and the Late Preclassic generally between 30% and 40%; and Classic and Postclassic generally 40% to 50% (with one set of Postclassic lots at 70%). There appears to be a "jump" during the Middle Preclassic: under 20% before the middle of the Middle Preclassic and over 30% after. The cultural systems of the earlier time period would appear to have had either less use for obsidian blades and/or less of a capability for producing them than those of the later period. While blade production may involve craft specialization, such specialization may have been significantly different in earlier times than later. For example, blade production in the earlier time period may have been a part-time specialization of some communities, the communities being poorly integrated into a regional division of labor, the specialist communities generating only a small surplus for trading purposes. On the other hand, blade production in the later period may have involved full-time specialists, working in a number of centers, mass producing blades as part of a well-integrated exchange network the specialists generating a large surplus of blades for market purposes.

Preparation of core edge

Edges of cores may be modified preparatory to blade removal. If done, the trimming apparently serves to remove the "overhang" ("lipping") above the negative bulbs of the facets (scar surfaces) left by the removal of previous blades. Such core edge preparation will show up on the cap-dorsal edges and napes of the blades themselves.

Sheets found temporally distinctive trends in edge preparation techniques in the highlands of El Salvador. During the Early Preclassic he found edge preparation to have been more carefully executed than in later times. It involved the removal "of many tiny long flakes terminating in feather edges" which he interprets as having been "achieved by pressure, perhaps with an antler or hardwood tool" (1972: 27). During the latter part of the Middle Preclassic, the "overhang was likely [being] removed by scraping or rubbing with a hammerstone--at least this is the only method [he has found] which duplicates" the finds (ibid: 19; see also Sheets 1974: 49). Finally, prismatic blades with no overhang removal "are relatively common" in the Classic and Postclassic at Chalchuapa (Sheets 1974: 51; see also Sheets 1972: 27).

Since blades can be produced without preparing the core edge, edge preparation does not appear to be a necessary step in the blade-core reduction strategy. While the technological function of overhang removal is not clear, some correlational information is suggestive. Namely, there is some correlation between core edge treatment, the preparation of the platform surface, and the size of the cap: first, the platforms of the cores with carefully treated edges are plain, fairly flat conchoidal surfaces that have not been modified and blades from such cores have very small cap surface areas; second, the platforms of cores with more crudely treated edges are usually scratched (striated); finally, the platforms of cores with no core edge treatment tend to be more elaborately prepared, "involving extensive striating or grinding of the entire surface" (Sheets 1972: 27) and blades from such cores tend to have relatively large cap surface areas. Two hypotheses, both of which are generated by these apparent correlations, suggest that blade-making efficiency may have been the selective factor.

The first hypothesis focuses on the amount of force necessary to remove a blade. The suggestion is that removal of overhang is used to strengthen the platform when it is necessary to apply a relatively large force to detach a blade. The relative amount of force needed to detach a blade would be indicated by the treatment of the platform surface itself--an unmodified platform would require the most force since the platform's "surface tension [had] not been reduced by abrasion" (Sheets 1972: 23; also see Speth 1972: 38). Removal of overhang would strengthen the platform by removing the weaker, more crushable extension. Restated, the hypothesis is that the greater the force required to detach a blade (the more unmodified the platform surface), the less crushable the core edge must be made (the more the weak overhang has to have been trimmed back). When no overhang is removed, the crutch tip would, presumably, be placed directly above the blade-to-be-detached--not above the overhang. Hence, the larger size of the cap surface in this situation would simply be an epiphenomenon of the failure to trim back the core edge. Conversely, for blades with smaller caps, the shorter distance to the point of applied force from the modified core edge would be the result of moving the edge closer to the point of applied force by removing the overhang. If the above model is correct, then the new information available to later blade makers was that abrading the surface of the platform meant that it was not necessary to trim the core edge. Sheets has suggested that later blade makers were considerably more efficient workers since they did not have to stop repeatedly in order to trim the core edge.

An alternative hypothesis, although consonant with the efficiency conclusion, focuses on the placement of the crutch tip as the crucial factor. Given a context in which blade makers were not mass producing blades, and hence not developing their expertise, the blade makers might not have had sufficient expertise to place the crutch tip at the proper point unless the core edge was trimmed back to reveal the proper position directly above the blade-to-be-detached. Once large numbers of blades were being produced, the blade makers could have acquired the requisite expertise (practice) to place the crutch tip properly, making allowance for the weak platform edge without having to remove the overhang. They might have proceeded to scoriate the platform surface, in this context, to prevent crutch tip slippage (see Barnes 1947: 101; Crabtree 1968: 457; Sheets 1972: 23) and/or to make it easier to detach blades by weakening the surface tension of the platform, both purposes being related to expediting a mass production technology.

While it is presently impossible to choose between these alternative hypotheses (indeed, these do not exhaust the possibilities--it may be forever impossible to establish past motivations and conceptualizations), both suggest a common result. Namely, both suggest increasing efficiency on the part of the blade makers. There may have been some kind of "quantum" step in degree of specialization and in degree of mass production between the Early Preclassic and the Classic. Sheets (1974: 15, 286) has found at Chalchuapa that the "earliest unequivocal occurrence" of blade lacking overhang removal is during the Late Preclassic. It will be interesting to see if the core-edge data from the Basin of Mexico fits the above generalizations and if other lines of evidence support this admittedly weak line of evidence. Another line of evidence already discussed, based on the finds at Chalchuapa, does tend to support this one--namely that the proportion of blades relative to total chipped stone debitage increases as blade production appears to be becoming more efficient.

b. Other processing apparatuses

In addition to the blade-core manufacturing subsystem, I have also referred to the nodule smashing and the shaping subsystems (the miscellaneous ambiguous specimens, clearly, are not referrable to a particular subsystem).

Nodule-smashing is rather simple. It requires no special ancillary materials--perhaps a hammer-stone and a hard, anvil-stone support. The personnel would not be specialists, since it is an inefficient way of producing usable results and since anyone is capable of smashing nodules. Finally, the knowledge involved is minimal. The area in which more informed technological knowledge would be involved, would be in the selection of flakes suitable for particular purposes, since the choices would be based on culturally defined discriminations. However, unless the smash-flakes had been clearly shaped by retouching, it would be difficult to ascertain which pieces were selected as opposed to those not selected, since post-depositional noise could be easily mistaken for traces of wear.

A shaping subsystem can be fairly complex. Pieces might be selected for shaping from either the blade-core subsystem, the nodule-smashing subsystem, or from some, as yet, undefined subsystem. The shaping itself might be carried out by direct percussion or pressure using a hand-held applicator. Shaping can be done by non-specialists, although, even in hunting and gathering cultures, a person who is very capable might be sought out to make fine artifacts for others. Finally, the forms being made indicate something about the definition of cultural objects.

B. Using chipped artifacts in processing other cultural elements: expectations

Again, since much of this was discussed in Chapter 2 (pages 36 to 42), I will just add some points not contained in the earlier discussion.

While one may be able to use shape, size, and relationships of artifact features to make inferences as to the direction of motion, the hardness of the material against which the chipped stone artifact was used, the manner in which the artifact was held, etc., it would be impossible without contextual evidence to ascertain the types of activities in which the chipped stone artifacts were used. Two overlapping approaches that draw on the data of the archeological record can be focused on the chipped stone assemblage: "archeological analogy"; some form of cluster analysis.

1. Archaeological analogy

In determining the activities indicated by debitage when the context is poorly known, one can use the contextual evidence provided by other sites. Just as cross-dating enables one to date finds at one site by matching artifacts with those at another site that had been dated by other means, one can use "archeological analogy" to interpret finds that do not have much contextual information by comparing such debitage with the debitage at sites of the same tradition, or, better still, of the same phase, that do have a considerable amount of contextual evidence. How can one tell from a blade itself whether it was used to process matter/energy as part of economic activities (e.g., in food preparation), to process people as part of sociological activities (e.g. as an offering in a burial rite of passage), or to process ideas as part of ideological activities (e.g. to carry out the ritual purification symbolized by bloodletting)? One can use the characteristics of artifacts that have been found to be distinctive at sites of the same tradition that have contextual evidence of burials, house floors, workshops, temple precincts, middens, etc. One can also use clusters of artifact types (more on clusters below) that have been found distinctive, if indeed any such clusterings have been found. The basic idea is to tie the fragmentary information of one site into the more complete information of other sites.

"Archeological analogy" can suffer from the same types of errors as are found in the more usual "ethnographic analogy" (see Binford 1967). To reduce error, one can try to make the match as complete as possible. Staying with data of the same tradition of course helps in controlling the comparison. However, additional testing is necessary. A minimum test would be to match two characteristics (variables), if possible, in a kind of "hypothesis-testing" procedure, the test being a correlation of the two variables. If possible, one could improve the "test" by using more characteristics, the greater the number of correspondences, the more complete the match-up of the patterning.

The procedure is not so straightforward as the discussion thus far might suggest. Whenever using the data of other researchers, one is faced with a number of problems. First, there is the problem of interpreting the classificatory units (artifact types, for example, or social units for that matter--see Narroll and CA Commentators 1964, "On Ethnic Unit Classification") that were used and of ascertaining their comparability to the units that one is using. This has been a problem in anthropology generally, not merely in archeology. Compare Lévi-Strauss' lament (1962: 346, originally 1953):

> Surprisingly enough, it is at the very moment when anthropology finds itself closer than ever to the long-awaited goal of becoming a true science that the ground seems to fail where it was expected to be firmest: the facts themselves are lacking, either not numerous enough or not collected under conditions insuring their comparability.

Second, is the problem of finding, amidst all the information that was recorded/published, data that are relevant for one's research problems. As Flannery notes regarding Formative Mesoamerica (1976: 8):

> . . . in many cases, we could not test our procedures adequately because the primary data on Formative Mesoamerica were so incomplete. Often, the substantive data were either not collected or at least published in ways that allowed us to analyze them as we wanted to.

Anthropology in general has been beset by this problem too. Again, a Lévi-Strauss comment (1962: 337):

> The case of the Pueblo area is especially striking, since for probably no other area in the world is there available such an amount of data and of such controversial quality. It is almost with despair that one comes to realize that the voluminous material accumulated by Voth, Fewkes, Dorsey, Parsons, and, to some extent, Stevenson is practically unworkable, since these authors have been feverishly piling up information without any clear idea of what it meant and, above all, of the hypotheses which it should have helped to check. The situation changed with Lowie's and Kroeber's entering the field, but the lack of statistical data on marriage choices and types of intermarriage, which could have been gathered for more than fifty years, will probably be impossible to overcome.

Finally, there is the problem of working with seeming inconsistencies and/or ambiguities in the published materials. Another illustration from Flannery (1976: 14-15):

> . . . turn to Pages 614 and 615 [of the site report he was discussing] if you want to discover an amazing fact, known only to a handful of archeologists. [The principal investigator] analyzed his pottery in great detail, by arbitrary level, using it as the basis for a highly detailed chronology. . . . None of this seems particularly remarkable until you [compare the ceramic phases with the architectural features]. . . . Thus, the reader is presented with something truly remarkable: a wattle-and-daub house that lasted through three periods, and whose postmolds were 300 years older than its roof.

All these problems arise in doing "archival" research (see the discussion in Webb et al. 1966).

Let us see if expectations can be generated for the collections under consideration by drawing upon the data of some previous work in Mesoamerica, attempting, at the same time, to deal with the aforementioned problems.

a. House Floors

Two Oaxacan sites, San José Mogote and Tierras Largas, are rare in providing information about Formative Mesoamerican house floors (Flannery 1976; Pires-Ferreira 1973; Winter and Pires-Ferreira 1976).

The published data provide a limited amount of information regarding the obsidian. Three characteristics (variables) presented may be relevant: (1) breakage information (whether blades are whole or fragmentary; (2) the "types" of artifacts--blades, flakes, cores, etc.; (3) the geological source identification (based on trace analysis).

The published data regarding fourteen houses at San José Mogote is a mixed blessing--while yielding some relevant information, it provides much irrelevant data and major problems of comparability. It seems, first of all, based on my reading of the material, that the obsidian artifacts were separated into two groupings before analysis: a sample of 44 specimens which was subjected to neutron activation analysis; and the rest of the obsidian, some 328 specimens, which were not subjected to neutron activation analysis but which were described more carefully. While Pires-Ferreira (1973) does not state that this is the case, there are two indications that such pre-analysis partitioning was done. First, discrepancies appear between the counts of her Table 15 (page 89, "Results of Neutron Activation Analysis of Obsidian from Early Formative San José House Floors at San José Mogote") and the counts of her Table 16 (pages 91-95, "San José Mogote Areas A and C Obsidian Statistics"): House C1 had 3 non-blades subjected to trace analysis (Table 15) whereas it is listed as having only 1 non-blade item (Table 16); House C2 had four non-blades subjected to trace analysis whereas it is listed as having only one non-blade; House C4 had 4 non-blades subjected to trace analysis but it had only 1 non-blade; House 5 had 1 flake-core subjected to trace analysis but it had no flake-cores; House 6 had 1 flake subjected to trace analysis but had no flakes listed in Table 16; House 10 had 2 blades subjected to trace analysis but had only 1 listed in the "statistics." Secondly, the two tables have two different sets of terms to "type" specimens; Table 15 uses blade, flake, flake-core, chunk, debitage; Table 16 uses blade, blade fragment, blade core, flakes (of various shapes, whole and fragmentary), flake core, chunk, core preparaton piece, nodules (of various kinds). Hence, I conclude that the two tables represent analysis of two mutually exclusive subgroups of the San José Mogote collection. To determine overall counts, I will combine the data of the two tables. There is, in addition, a problem of comparability between the two tables: her Table 15 does not distinguish fragments from whole blades; also, her Table 15 categorizes items that are not blades, flakes, or chunks as either "flake core" or "debitage," whereas her Table 16 categorizes them as "core preparation pieces," "split nodule cores," "nodule fragment cores," or "cores on flakes."

A second problem is that of knowing what the categories refer to so as to be able to compare the San José Mogote data with my own. I assume that "blade" refers to fine prismatic blades, although that may not be so. More significantly, I have been distinguishing "trimming" flakes from "smashings" of various types, whereas Pires-Ferreira makes no such distinction. So it is impossible to determine if there had been a nodule-smsahing subsystem at San José Mogote. Pires-Ferreira does indicate many different types of flakes on the basis of their shapes (expanding, contracting, rectangular, oval, etc.) but such, by themselves, have no manufacturing implications. Additionally, Pires-Ferreira distinguished "used" from "not used" specimens, but does not indicate the basis for making such a distinction.

After all this, what information can be gleaned from the published reports? First, for the bulk of the San José Mogote data, blades are indicated as whole or fragmentary. There is only 1 whole blade (House 10 of Area C) as compared with 85 blade fragments. This contrasts with some of the burial information from elsewhere in Mesoamerica (see below) where blades are usually whole. It would have been helpful to have had information on the portion of the blade present. I suspect that the portion of the blade in use in houses would have been the middle (medial) portion, since the medial portion of a fine prismatic blade would be the most regular portion, the bulbar and distal ends having less straight edges, more longitudinal curvature (more bowed), and greater variation in thickness. I therefore would expect proximal and distal fragments to show up in garbage "dumps" and/or workshop areas. Of course, such expectation must be tempered by the realization that post-depositional factors could accidentally produce various "snapped" portions of blades.

Secondly, the types of artifacts in the houses are limited, apparently, to blades, flakes, and chunky, nodular fragments of various types--a rather simple array. There is no mention of points, bifacially shaped pieces, or other shaped pieces. Indeed, one gets the impression that there is little retouching whatsoever, specimens being categorized only as "used" or "not used."

It is hard to tell how much manufacturing debris is present. One apparent blade core fragment is listed for House C1 ("1 core, bullet or blade with cortex, fragment" [ibid: 91]). It is possible that a number of the items listed as flakes, flake cores, chunks, core preparation pieces, nodule fragment cores, etc., are actually referable to a nodule-smashing subsystem.

There is considerable variation between houses in the relative proportion of blades to non-blades. In the four houses of Area A, which "are architecturally the most elaborate so far excavated at San José Mogote" (ibid: 88), blade fragments are 42/66 or 64% of the obsidian. House C1 of Area A, the house with the highest proportion of blades (18/22 = 82%), is the one with the blade core fragment, but it has no other indication of blade-core manufacturing. However, it is possible that blade cores were acquired by members of House C1 who then produced blades from them. In the nine houses of Area C, blade fragments are 70/306 or 23% of the obsidian. However, there is considerable variation between these houses; House 9 has the lowest proportion of blades--none of its 57 obsidian specimens is a blade; Houses 4 and 10 have the highest proportion of blades (considering only houses with an obsidian sample size of 10 or greater)--both have 30%, 36/120 and 3/10 respectively. A suspicion is that wealthier families acquire obsidian blades, whereas poorer families supplement their blade intake with the "cheaper" nodules that can be smashed to produce usable flakes (cheaper because their value does not include the labor of the blade-makers nor the additional care needed in blade transport).

As far as contrasting houses with other activity areas, it would appear that specialized tasks are not represented, so that most, if not all houses are not involved in specialized obsidian manufacturing activities. The absence of obsidian points suggests that either weaponry was not present, that other materials were used for points (see below) or that obsidian points were so valuable that points would not end up as house floor debris. If weaponry was indeed scarce, it would imply that hunting and/or militaristic-"police" activities were performed by a specialized part of the population. Burials would tend to have blades and/or shaped artifacts. It would not be possible, however, to discriminate houses from between-house debris or from garbage dumps using types of obsidian artifacts as the measure; of course, it might be possible to use other artifacts (e.g. ceramics) as measures.

The "source" information may be the variable, of those considered here, least capable of distinguishing between types of activity. Source information by itself would not seem to be relevant, unless the various sources were culturally distinguished. For example, the green "Pachuca" obsidian was apparently of high quality, technologically speaking, being used to produce high quality fine prismatic blades--it also seems to have been used relatively more in some contexts than was fine obsidian blades made of other obsidians. Thus, when "traded" into the Mayan area, it often shows up in burials and ritual caches. However, in the Basin of Mexico, close to the Pachuca source, the same kinds of bottle-glass green obsidian blades are ubiquitous. It appears that the prestige value of such items shifts from a relatively low value within the supply zone to relatively high value in distant areas where it is an "exotic" item.

A further complication is that the prestige value of objects is only in part activity-related. Prestige items cross-cut several different types of activities--those activities having high prestige forms, such as high prestige households and high prestige burials, They would not cross-cut other types of activities--those having only low prestige forms, such as agricultural activities and the manufacturing of utilitarian objects. However, even in the various contexts in which they did appear as symbols of rank, prestige items would be differentially treated--it is not very likely that high value objects would end up as debris on the floors of high status households or in high status middens.

One such effort to measure "prestige" using differences in relative amounts of the various obsidians did not work, but it does serve to illustrate a workable methodology. The idea tried was the construction of a measure of prestige based on the type of obsidian found to correlate with some other prestige indicator--in this case, the type of obsidian correlating with high status houses that would be the "high status obsidian." Thus, at San José Mogote, if Area A houses are indeed of higher prestige than those of Area C, and if different types of obsidian have different prestige value (a very big "if"), then one can "calibrate" the relative prestige of the types of obsidian. Figure 3.18 below shows the relative amounts of each type of obsidian in the trace analysis sample for Areas A and C. The only type of obsidian showing appreciable difference between Areas A and C is the Z (Zinapécuaro) obsidian. The Z obsidian tends to be limited to the higher prestige area where it tends to be as frequent as the B (Barranca de los Estetes) obsidian. So far so good--there is a type of obsidian that correlates with high prestige houses. But does

Figure 3.18. Relative Amounts of Obsidian by Area Within San José Mogote (see text for source names).

		Obsidian Sources								
		Z	B	GV	A	UO	C	OG	Z + B	Other
Area A (N=25)	#	10	10	3	1		1		20	5
	%	40%	40%	12%	4%		4%		80%	20%
Area C (N=19)	#	4	9	2	1	1		2	13	6
	%	21%	47%	11%	5%	5%		11%	68%	32%
Totals (N=44)	#	14	19	5	2	1	1	2	33	11
	%	32%	43%	11%	5%	2%	2%	5%	75%	25%

Figure 3.19. Relative Amounts of Obsidian by House Cluster Within Tierras Largas (from Pires-Ferreira 1973: 87, Table 14)

San José Phase at Tierras Largas			Obsidian Sources						
			Z	B	GV	A	UO	Z + B	Other
Late	Cluster 1 (N=19)	#	12	4	2	1		16	3
		%	63%	21%	11%	5%		84%	16%
	Cluster 2 (N=11)	#	2	5	4			7	4
		%	18%	45%	36%			64%	36%
	Totals (N=30)	#	14	9	6	1		23	7
		%	47%	30%	20%	3%		77%	23%
Early	Cluster 1 (N=9)	#	1	3	3	1	1	4	5
		%	11%	33%	33%	11%	11%	44%	56%
Total		#	15	12	9	2	1	27	12
		%	38%	31%	23%	5%	3%	69%	31%

Figure 3.20. Kinds of Obsidian Identified Among Blade and Non-Blade Specimens at San José Mogote (data from Table 15 in Pires-Ferreira 1973: 89).

	Blades			Non-Blades		
	Z	B	Other	Z	B	Other
Area A	$\frac{6}{9}$=.67	$\frac{3}{9}$=.33	$\frac{0}{9}$=.00	$\frac{4}{16}$=.25	$\frac{7}{16}$=.44	$\frac{5}{16}$=.31
Area C	$\frac{2}{6}$=.33	$\frac{4}{6}$=.67	$\frac{0}{6}$=.00	$\frac{2}{13}$=.15	$\frac{5}{13}$=.38	$\frac{6}{13}$=.46
Total	$\frac{8}{15}$=.53	$\frac{7}{15}$=.47	$\frac{0}{15}$=.00	$\frac{6}{29}$=.21	$\frac{12}{29}$=.41	$\frac{11}{29}$=.38

Figure 3.21. Accessibility of Complex Assimilation Obsidians vs. Obsidian-measured Prestige of Areas/House Clusters.

Obsidian-measured Prestige	Percentage of Z + B Obsidians		
	San José Phase, San José Mogote	Late San José, Tierras Largas	Early San José, Tierras Largas
High	80% (Area A)	84% (Cluster 1)	
Low	68% (Area C)	64% (Cluster 2)	44% (Cluster 1)

this provide a valid measure of prestige or is this a spurious relationship? One test of validity is to apply the measure to another village. Tierras Largas provides us with such an opportunity.

Tierras Largas can be matched with San José Mogote in a number of important respects, thus helping to eliminate the effects of some possibly extraneous variables. Both sites were occupied during San José Phase (1150-850 B.C.), both are in the northwestern (Etla) region of the Valley of Oaxaca and thus of comparable geographic distance from obsidian sources, both had a comparable subsistence base, including comparable reliance upon deer (Flannery and Winter in Flannery 1976: 37), and both have "evidence of shell working in almost every house" excavated, which seems to mark them both as specialist communities within the region (ibid: 39). Although they are of about the same size at the beginning of this time period, they do not remain so. San José Mogote grows quickly during this period, whereas Tierras Largas remains relatively the same. The community of San José Mogote is becoming socially differentiated, whereas Tierras Largas apparently remains socially undifferentiated until the Middle Preclassic. Hence, the house-associated obsidians of Tierras Largas should rate low on the "obsidian prestige" measure. However, Figure 3.19 shows otherwise. Cluster 1 of Late San José Phase is indicated as having high prestige--the obsidian prestige measure does not appear to be validated. Perhaps rejection of the obsidian prestige measure is premature; (1) since the San José Phase is a long period, it may be too large a unit to be able to discriminate cultural changes that would change the indicators of prestige; (2) the sample size was too small to provide a reliable measure of prestige; (3) the "house cluster" unit used at Tierras Largas (which consists of the house and its adjacent courtyard and associated extra-mural features) may not be comparable to the house unit used at San José Mogote; and (4) House Cluster 1 is that of a higher status household, but that the higher status is not reflected in architectural elaborateness (it may be reflected in its being surfaced with a "white, limey clay" [Winter in Flannery 1976: 31] and such surfacing may distinguish "between higher- or lower-status families" [Flannery 1976: 19]). However, another measure of variability within the obsidian debitage also refutes the "obsidian prestige" measure operationalized above. Namely, when source data is used in conjunction with data as to the types of items made from the various source material, we measure little difference between houses. Consider the following.

Examination of the San José Mogote trace analysis sample, although small, suggests that material from Z (Zinapécuaro, Michoacán) and B (Barranca de los Estetes, Basin of Mexico) was used in blade production whereas material from GV (Guadalupe Victoria, Puebla), A (Altotonga, Veracruz), UO (Unknown Oaxaca Source, thought to be near Tlaxiaco), C (El Chayal, Guatemala), and OG (Other Guatemalan source) was not used in blade production (see Fig. 3.20). Blades are about half of Z and half of B obsidian, whereas none of the specimens traced to other sources were blades. While there is some difference between the proportion of obsidian blades to total obsidian of Z and B types, the Z and B material appears to follow a relatively similar "ingestion and assimilation" pattern--this material often ends up as blades--as compared to the other types of obsidian (although we, at this point, are examining the end products of ingestion and assimilation routes and not the cultural mechanisms which carry them out). Thus, there may be an "ingestion and assimilation pattern" defined by Z and B obsidians, in contrast to the "ingestion and assimilation" pattern defined by all other kinds of obsidian. Since the Z and B pattern seems to include blade production but the other does not, I will label Z and B obsidians as "complex assimilation" pattern obsidian and the other obsidians as "simple assimilation" obsidians. The proportion of complex assimilation obsidians to total obsidians may then serve as a measure of the accessibility of complex assimilation obsidian. For San José Mogote, if the trace analysis sample is representative of the site, this proportion is 33/44 or 75% (see Fig. 3.18). While no data as to the types of artifacts is indicated for Tierras Largas in the published materials I have had access to, we can try this same proportion measure for the Tierras Largas obsidian trace analysis sample simply using the source types of obsidian--for San José Phase at Tierras Largas it is 27/39 or 69% (see Figure 3.19). Given the size of the sample (while the Tierras Largas sample was a random sample, it is not clear if the San José Mogote sample was--in which case we have no probability measure of its representativeness), the vagaries of refuse disposition and post-depositional disturbance, and the lack of finer chronological control, there is virtually no difference between "higher status" and "lower status" areas/house clusters at San José Mogote or Late San José Phase at Tierras Largas (see Fig. 3.21) using the "accessibility" measure. Indeed, since the "obsidian prestige" and "accessibility" measures are both based upon Z obsidian, they are not independent variables--the inclusion of the B obsidian counts in the "accessibility" measure has the effect of off-setting the differences due to Z obsidian counts. As to the time factor, note that the lowest accessibility score (44%) is provided by House Cluster 1 of Early San José Phase at Tierras Largas. If representative, this low score may be the result of a shift in procurement patterns taking place between the earlier Tierras Largas Phase and San José Phase (the sample of Tierras Largas Phase House Clusters at Tierras Largas has no Z obsidian at all and the B obsidian is 10/36 or 28% of the obsidian--see Pires-Ferreira 1973: 87, Table 14).

Thus far, I have focused on the obsidian debitage. However, the non-obsidian chipped stone debitage can offer important information, both on the level of artifact analysis and on the level of cluster analysis. In discussing the Oaxaca material, for example, it should be noted that there is a vast difference between Oaxaca and the Basin of Mexico in the relative proportions of obsidian and non-obsidian in the assemblages. For the Basin of Mexico collections, obsidian constitutes some 80% of the chipped stone, while in Formative Oaxacan sites it is on the order of 20%.

One issue, in delineating intra-site variability and identifying activity areas, is whether or not variation in the relative proportion of obsidian is interpretable. Winter and Pires-Ferreira (in Flannery 1976: 307) note a slightly higher percentage of obsidian in House 1 and House 2 (or House Clusters 1 and 2 respectively) of Late San José Phase, Tierras Largas (18.9% and 18.61% respectively) than the average for all Late San José Phase deposits combined (16.05%).

They suggest that this

> may indicate that obsidian was used more frequently in houses than elsewhere in the occupation area. A sample of house floors excavated at San José Mogote also yielded relatively higher frequencies of obsidian in comparison to non-house-floor deposits (unpublished data).

Another issue, raised earlier, is the possibility that types of obsidian artifacts (e.g. projectile points) lacking on house floors were absent because these types of artifacts were usually made out of other materials (e.g. non-obsidian chipped stone). Some relevant data are presented in Flannery (1976) incidental to the discussion of other empirical and theoretical issues. For example, were projectile points, made out of non-obsidian chipped stone, found on house floors? Winter (in Flannery 1976: 27) indicates that House 2 of Late San Jose Phase at Tierras Largas had "a single stone projectile point"; Flannery and Winter (in Flannery 1976: 41, 44) present the plans of House 2 (the preserved east half) in Area C at San José Mogote and of House 1 of Late San José Phase at Tierras Largas--no projectile points are indicated, although plotted _in situ_ are chert core fragments, nodule fragments, debitage, drills, burins, retouch flakes, a biface, obsidian blades, and various hammers and burnishing pebbles. Stone projectile points of any kind appear to be exceedingly rare on Early Formative house floors in Oaxaca.

Further, how does the obsidian debitage compare with the non-obsidian debitage? Were similar manufacturing activities going on? Were artifacts of different materials being put to similar types of usages? Several articles in _The Early Mesoamerican Village_ (Flannery 1976) refer to chipped stone manufacturing and/or utilization activity loci/activity sets associated with Formative Oaxacan house floors: (1) areas that have been interpreted as chipped stone artifact manufacturing loci; (2) areas that have been interpreted as shell-artifact loci; (3) "cutting and scraping tasks, represented by utilized chert and obsidian flakes" (Winter in Flannery 1976: 27).

Regarding chipped stone manufacture, Flannery and Winter (in Flannery 1976: 37) infer that "chipped-stone tools and waste debris, including cores and core fragments of locally available chert or quartz" are rather ubiquitous on Formative Oaxacan house floors, suggesting that at least some chipped stone manufacture was among the "universal household activities." They comment:

> Most of the tools are small utilized flakes and flake fragments, though large (approximately 5 cm long) flakes with secondary retouch are sometimes found. Most, if not all, households seem to have access to local stone, and each household may have produced its own cutting and scraping tools. Antler tines (also present in some household clusters) were evidently used for pressure flaking.

While asserting, in the above comment, that most tools found on house floors are "small utilized flakes and flake fragments," apparently contradictory comments appear elsewhere. For one, there is Flannery's comment (Flannery 1976: 18) that Formative Oaxacan house floors frequently have "countless tiny resharpening or retouch flakes from flint tools made or repaired in the house," which would imply the frequent shaping of stone tools rather than the mere utilization of flakes. For another, there is the suggestion (Flannery and Winter in Flannery 1976: 38) that the manufacture of well-defined chert artifacts, which would result in the "countless" retouching and/or rejuvenation flakes and perhaps be associated with antler tine pressure flakers, was not carried out in every household but was, instead, indicative of household specialization within villages. They use, as example of such household specialization within villages, the contents of a bell-shaped pit at Tierras Largas which included:

> an unusually high number of small chert flakes and flake fragments, undoubtedly the waste debris from stone tool manufacture. Over 300 pieces were recovered, along with a bifacial tool that was probably broken during manufacture.

They then speculate:

> Perhaps each small village had one or two persons sufficiently skilled at pressure flaking to provide the rest of the village with certain tools. Our evidence from other pits and houses would suggest that the average villager rarely did more than pick up a conveniently sharp flake and use it without deliberate retouch.

There are, thus, some unresolved issues: (a) Were the chert and/or quartz "cores and core fragments" really the classically conceived cores or are we dealing with nodule smashing? The flakes and flake fragments are apparently so ill-defined as to allow for little summarizing description. This suggests a rather crude craft capability. (b) Are the antler tines evidence of pressure flaking? Considering what may be a rather limited distribution of bifacial tool manufacture and the more ubiquitous occurrence of antler tines, the interpretation of antler tines as pressure flakers is rather suspect.

If it were to turn out that nodule-smashing was a typical manufacturing technique among the local villagers, it would support the notion that obsidian was worked similarly. That is, since there is little evidence for obsidian (a non-local stone) blade manufacture, save for the one core fragment referred to earlier, and since other obsidian debitage is rather crude, one might infer that obsidian blades and nodules were being imported, the blades being used directly and the nodules being smashed to provide usable flakes.

More descriptive information about the stone tools is provided in the discussion of shell-artifact manufacture. Flannery and Winter (ibid: 39) have identified chert knives, burins and drills in association with shell working:

> A "typical" shell-working activity area at San José Mogote would be an area of 1-2 sq m . . . Such areas were usually in the corner of a house, and they were littered with small flint chips and fragments of cut and discarded shell. They would usually include 1 or more chert knives or burins (for cutting shell) and from 1 to 10 small chert drills or perforators (for drilling shell) . . .

Assuming that these are indeed shell working loci (a number of questions might be raised, e.g. might not flint chips and discarded shell end up in the corner of a house as the result of sweeping?), several particularly relevant issues can be raised. How are the "burins," "drills," etc. manufactured? What characteristics of use do they show? How stable is the tool-kit, i.e. how cohesive is the clustering of tool types?

In interpreting the characteristics of the various tool types, I am limited to the published data, which consist of 6 items illustrated in the article. Assuming that the illustrated specimens are at least representative of such specimens (if not among the better ones), I suspect that at least some of their drills are simply flakes or flake fragments that were selected for their shape (i.e., at least the specimens illustrated do not appear to have been shaped according to design). The 3 drills illustrated (ibid: 39, Figure 2.14 c,d,e) appear to be broken fragments of thin flakes, the intersection of two adjacent hinge fractures producing the "drill tip." Indeed, I cannot suppress the thought that these broken fragments might be "smash flakes." It is with the "smash-flake" issue in mind that I would also like to examine their "burins" (ibid: 39, Fig. 2.14 a,b) since some smash flakes have surfaces which might appear to have been produced by burin blows. The sixth item illustrated, a "utilized chert flake" (ibid: 39. Fig. 2.14 f) is blade-like in outline, but it has a crushed cap and, in cross-section, it is rather thin proximally—perhaps too thin to have been produced by the classic knapping method. Again, I am left to wonder about the production technique.

The evidence of "utilization" is apparently that thin items with pointed outline were found in association with worked shell. There seems to be, in the illustrations, little evidence of use retouch (save for the utilized chert flake).

With regard to "cutting and scraping" tasks, the third activity set being considered here, no further information is provided other than that there are "utilized" chert and obsidian flakes. The flakes probably exhibit edge nicking. Since flakes can appear "utilized" both as a result of manufacturing processes (especially if smash-flaking is involved, since this would result in a fair amount of edge shatter) and of post-depositional processes, such characterization is problematic.

b. Burials

Comparative data on burials within the Mesoamerican tradition shows considerable variation. Any aspect of culture would be expected to manifest inter-cultural differences (the temporal variation of sequent phases of the same regional tradition and/or the spatial variation of regional cultures) and intra-cultural variation (due to differences of economic specialization, kinship group, sex, age, class, status group, etc.). However, more variation seems to occur in burial practices than in household activities. This may be so because burials embody sociological-ideological activities, essentially, and are highly symbolic, whereas household activities are expressions of essentially economic-sociological events and are highly practical (see Binford 1965, regarding his "adaptive area" concept). In addition, since burials are single events, participants in the event must be highly selective in their cultural choices--what they do is a small and perhaps very unrepresentative sample of the cultural repertoire. On the other hand, since household debris is the residue--perhaps inconsequential and of little symbolic selection value to the participants--of a repetitive, daily stream of events, there may be less variation between house floors than between burials.

Since burial practices seem to have been rather varied, I will here present only a few cases from the rather extensive literature on Mesoamerican burials in order to illustrate this variability. I will proceed in reverse chronological order, discussing in turn burial data of the Classic period (Kaminaljuyu), the Late Preclassic (Ticoman), the Middle Preclassic (El Arbolillo and Zacatenco), and the Early Preclassic (Tlatilco).

Kidder, Jennings and Shook (1946) describe in detail some dozen tomb burials of Classic Period (Esperanza Phase) Kaminaljuyu, a highland

Mayan site near an extensive obsidian source. The only chipped stone artifacts found, in what are apparently burials of elite personages and their retainers, are made of obsidian (not considered here are such non-chipped stone artifacts as polished jade items and manos and metates) and are either in the form of prismatic blades or of bifacially worked points/knives, each usually found in distinct groups of 3 to 9 items. Every tomb burial has at least one set of obsidian blades, but only half the burials have bifacially worked artifacts. Many of the blades are whole--depending on how one interprets the burial diagrams and artifact lists, either 60/101 (59%) or 52/101 (51%) are whole. While the type of obsidian is not specified for most specimens, some of the obsidian is color characterized: 25 specimens are said to be green (8 blades and 7 points)--thus at least 15/101 (15%) is of green obsidian. Such green obsidian is probably from the Pachuca sources in Hidalgo, North of the Basin of Mexico, some 700 miles away. In contrast to the tomb burials, there are a half dozen "minor" burials in the same small excavated area of the site. Except for one having several blade fragments, the non-tomb burials have no grave goods.

Ticoman is a small, Late Preclassic site on a "steep and rocky peninsula projecting into the lake" system of the Basin of Mexico (Vaillant 1931: 220). It lies at the tip of the Guadalupe range in the western part of the Basin. Excavations carried out by Vaillant uncovered 56 burials (Vaillant's reference to 61 burials is somewhat misleading—his data indicate that 61 individuals were interred, but in 56 graves--some interments were multiple). Their grave goods are different from either the tomb or the non-tomb burials of Kaminaljuyu discussed above. 23/56 (41%) of the burials have no grave goods, 23/56 (41%) have grave goods but no chipped stone, and only 10/56 (18%) have chipped stone—virtually all of which is obsidian (1 quartz artifact is found together with 13 obsidian artifacts in Burial #34). Post-interment processes have produced some distortion--e.g., the number of burials with no grave goods is doubtlessly inflated, since 25 of the 56 burials (45%) are referred to as "disturbed" or subjected to "erosion," and these account for 16 of the 23 burials (70%) with no grave goods. Nonetheless, it is clear that burial practices varied considerably. Of the 10 burials with obsidian, 8 (80%) had blades (2 of these had points/knives also), 3 (30%) had points or knives (2 of these, just mentioned, had blades also, while the third had a set of 5 points), and only 1 burial with obsidian (10%) had neither blades nor points.

As far as I can determine from the plates, a large proportion of the 12 fine obsidian blades in burials are whole or almost whole; 4/12 (33%) are whole, 4/12 (33%) are almost whole (distal segment missing), 2/12 (17%) are large medial sections; while only 2/12 (17%) are small segments (one proximal and one medial, they may even be part of the same blade--they're both from the same burial and appear to have similar widths and banding patterns).

Vaillant suggests that the burials with obsidian implements may represent leather-working and/or tailoring tool kits, primarily because of the association of obsidian and bone tools in Burials #11, 17, 33, 34, 39, 48. Vaillant's hypothesis about the association of obsidian blades and bone awls/needles as indicative of leather-working and/or tailoring is insightful, although marred by some minor inconsistencies. For example, he states (1931: 300) that the "most probable purpose [of obsidian blades] was the working of leather, for in several graves (Nos. 11, 17, 33, 34, 39, 47, 48, 51, 55, 58) we found blades, either alone, or associated with bone needles and bodkins . . ." This would suggest that 10 burials had blades. As indicated above, I counted only 8. In examining the descriptions of the 10 burials he lists (Vaillant 1931: 416-425), one finds that 2 of them do not have blades (#17 and #51--indeed #51 has no obsidian at all).

Another two sites on the Guadalupe range that were excavated by Vaillant, El Arbolillo and Zacatenco, are, for the most part, assignable to the Middle Preclassic. Zacatenco, like Ticoman to the northwest of it, is on a "rocky peninsula" which had jutted into the lake present at the time (Vaillant 1930: 19). Thirteen of the nineteen burials excavated at Zacatenco were assigned to the Middle Preclassic; one, which had no burial goods, was assigned to the Late Preclassic; and five very disturbed burials were not assigned to any period. The thirteen Middle Preclassic burials had no burial materials (excluding fibers/textiles) except for one young female (Skeleton #17) who may have been buried with an obsidian blade (almost whole--distal element missing) on her lap--"an association which may have been accidental" (Vaillant 1930; 188). Skeleton 17 itself is in an unusual position, with arms and legs splayed out, legs higher than the torso--its position suggests disturbance, which, if true, would support Vaillant's doubts about the association with the blade.

El Arbolillo is also "on the eastern shore of a former arm of

Lake Texcoco, which the Cerros de Guadalupe divide from the main body of water" (Vaillant 1935: 147). It is located on a slope within a "half-circle of foothills" that had probably been "covered with timber" (ibid: 147). Forty-five of the 49 burials (which contain 62 individuals) are assigned to Middle Preclassic times (2 burials are unassigned and 2 are cross-dated to Teotihuacan times). Fifteen (15/45 = 33%) had no grave goods, 24 (24/45 = 53%) had grave goods that did not include any chipped stone items, and only 6 (6/45 = 13%) had grave goods that did include chipped stone items. Most of the small number of chipped stone items in these burials are obsidian (8/11 = 73%). The obsidian items were well defined by prehistoric technology: 5 (5/8 = 63%) blades; 2 (2/8 = 25%) bifacially shaped points; and a single scraper (1/8 = 13%). Of the 6 graves with chipped stone, 5 have blades and 2 have points (1 grave has both blades and points).

Comparing El Arbolillo with the contemporaneous neighbor settlement at Zacatenco, one notes an obvious difference: there are no grave goods in the burials excavated at Zacatenco. There appears to be a difference in the construction of the burial chamber itself--at El Arbolillo, many of the burials are covered and/or lined with stone slabs (15/45 = 33%) or with other inorganic materials (4/45 = 9%; one rock-lined, one clay-lined, and 2 clay-filled graves in sand), while at Zacatenco, according to the original site report, "there was no formal preparation of the graves, like lining it with stones" (Vaillant 1930: 188). One possible explanation for the differences between the two sites is that non-cultural factors are involved. El Arbolillo is "mounded up away from the slopes of the bordering hills" and seems to have had "a gently rolling subsoil, in contrast to the craggy contours [and rockier content] of the original terrain at Zacatenco and Ticoman" (Vaillant 1935: 148; also compare Vaillant 1930: 188). Hence it is possible that: (1) differences in the nature of the subsoil being dug into affected burial construction--looser soil resulted in lining and/or slab covering, while harder, rockier soil did not require such definition; (2) differences in the erosional histories of the sites mean that the burial data of the two sites are not directly comparable but require some preliminary reconstruction--for example, if erosion on the slopes of Zacatenco had seriously disturbed most if not all burials there, then a preliminary step would be to try to reconstruct burial construction from scattered evidence. There is some support for this. Vaillant comments I1935: 185):

> During the excavations at Zacatenco several slab structures were uncovered, but at the time we did not know what they were. That they could be tombs never dawned on us, for finely laminated mud deposits seemed to indicate that they never had been occupied. Yet such an identification would seem probable after our discovery of such structures containing burials at El Arbolillo.

However, such does not appear to account for all differences--there are parts of Zacatenco that have relatively soft subsoil ("where the ground was soft and relatively free from stones, the extended position was found," Vaillant 1930: 188) and two burials there have evidence of organic materials lining the graves (skeleton No. 3--"whitish fiber lines grave," skeleton No. 14--"fibrous lining to grave," ibid: 188). The suspicion is that intra-cultural differences between the two sites are partly responsible for differences in burial construction and grave goods.

Comparing Middle Preclassic El Arbolillo with Late Preclassic

Ticoman, a more definitive cultural contrast than the one just discussed can be distinguished. In particular, obsidian blades in burials of the two time periods appear to have rather different sociological interpretations. At Ticoman, obsidian blades in burials were suggestive of leather-working/tailoring carried out by adult males. However, at El Arbolillo, obsidian blades in burials are not suggestive of any such craft specialization—they are associated with non-adults (the 5 blades occur one each in 5 different burials, three of children between 1 and 2 years of age, one of an adolescent, and one of a young adult), they are not associated with bone awls or needles nor do they tend to be found with other chipped stone materials.

Tlatilco is also on the west rim of the Basin at a confluence of several small waterways on a plain near the former lake system southwest of the sites of the Guadalupe Hills. Paul Tolstoy has been amassing the information on a large number of burials from the several investigators who have actually done the excavating. While the data may be uneven, one gets the impression of considerable variability within this set of burials. (Most of them have not been dated, but those that have date to the latter half of the Early Preclassic.)

Most burials at Tlatilco have no chipped stone at all (288 of 375 burials or 77%). Those with chipped stone (87/375 or 23%) are rather varied. Most (56/87 or 64%) of those with chipped stone have neither points nor blades, only various flakes, fragments, and/or "knives" (23/56 or 41% of these burials have obsidian items only, 24/56 or 43% non-obsidian only, and 9/56 or 16% both obsidian and non-obsidian). About a third (28/87 or 32%) do have projectile points (only 11 of these have other chipped stone as well and only one included blades). As for the projectile points in these burials, 22/28 or 79% of the burials have points of obsidian only, 5/28 or 18% have points of non-obsidian only, and only one (1/28 or 4%) has both obsidian and non-obsidian points. Only 4 of the 87 burials with chipped stone, that is, a mere 3%, have obsidian blades (or, if one considers all 375 burials, slightly more than 1% have obsidian blades).

There is some evidence for craft specialization during the Early Preclassic, at least at such large sites as Tlatilco. Namely, in a very small number of burials (four) at Tlatilco, concentrations of lithic materials (and bone artifacts--reminiscent of the leather-maker's tool kit) are found. One burial (Temporada II, #43) includes, in addition to ceramic items, 3 obsidian points, 6 "pieces" of obsidian, 5 bone "punches," 3 bone needles, and 1 bone awl. Another burial (Temporada IV, #62) has no ceramic items, but does include: 3 obsidian points, 9 obsidian flakes, 4 flint flakes, 3 flint artifacts, and several bone "punches." A third burial (Temporada IV, #74) includes "2 areas of obsidian flakes," 2 perforated hematite mirror fragments, and various bone artifacts. Finally, a fourth burial (Temporada IV, #113) includes 1 obsidian "core," 3 obsidian projectile points, 3 obsidian blades, an obsidian flake, and an obsidian "knife."

c. Specialized Workshops

Spence (1967) has provided a preliminary discussion of a number of locations within the city of Teotihuacan (some of which were in use in the Late Preclassic, some during the Classic period) that have unusually heavy obsidian concentrations. He suggests that at least some of these well-defined loci--beginning with the Late Preclassic--constitute evidence of an obsidian specialization. Indeed, some loci, because of the limited range of obsidian artifact classes found in them, constitute evidence for specialization within the obsidian "industry" itself. That is, in contrast to the loci with a full range of items (blades, scrapers, points, knives, etc.) some loci had a high proportion of--or were almost entirely constituted of--blades. Furthermore, there is also evidence of different ingestion and assimilation patterns. Namely, the debitage of some workshops indicate that different types of obsidian were used for different purposes. For example, in Area No. 3, non-blades were mostly of gray obsidian whereas blades were mostly of green obsidian. In Classic times, green obsidian is increasingly used, the vast majority of blades being green, but also an increasing though still minor proportion of knives, points, and scrapers are being made of green obsidian. These contrasts suggest a temporal trend from Preclassic through Classic Teotihuacan: (1) blades occur in increasingly larger proportions of the debitage; (2) there is an increasing proportion of green to grey obsidian, green first appearing as finished blades but then also appearing as finished shaped artifacts (such as points and knives).

It is not clear if such specialized loci occurred during earlier times. The contents of a small proportion of feature pits at villages sites in Early Preclassic Oaxaca (discussed previously) may indicate craft specialization. However, pits probably cannot be interpreted in the same fashion as work areas (see below).

d. Miscellaneous

Other defined features are found in the Early and Middle Preclassic. However, these either are not directly relevant for lithic studies or involve an even greater number of problems than do house floors, burials, or workshops. Ovens, for example, are not repositories of lithic debitage. Some types of features have exceedingly varied sets of artifacts in association. Thus no clear-cut interpretation of context is possible. For example, Oaxacan feature pits may have remains of plant materials that were stored in them, caches of objects or, when used as garbage dumps, mixtures of accumulated refuse.

e. Summary

Archaeological analogy with regard to activity areas involving Preclassic lithic materials is fraught with problems. Many activities have not been clearly defined because broad area excavation has not been carried out to any great extent. Also many types of lithic remains appear to occur in a number of different contexts, so that identification of an activity from artifact types is uncertain. One should perhaps not expect a one-to-one correlation between artifacts and activities, but rather that specific artifacts may indicate a more or less delimited range of possible alternative interpretations. It seems logical that whole blades would be indicative of some early stages of a blade's "life-cycle." They might not be abundant at blade-producing workshops since one would tend to find the debitage of blade manufacturing rather than the blades themselves. They might be expected to show up in primary distribution centers where they may have been stored prior to re-distribution (see Spence 1967). They also might be expected to show up in burials, since the blades would not undergo further modification prior to interment (see above examples). Points appear to be unusual in houses, but may be more likely to occur in burials. In addition, they may occur outside the village altogether in kill and/or butchering sites--that is, in contexts in which they were used at the end of their "life-cycles."

2. Cluster Analysis

Another approach to usage interpretation is based upon the co-occurrence of tool types. That is, the basic idea of the various statistical approaches to cluster analysis is to partition assemblages into types of artifacts that co-occur under the assumption that types of artifacts that had been used together in an activity would tend to be found together. Thus the particular types present in an assemblage can be important in defining tool kits. That is, by ascertaining which tool types tend to co-oocur in lots, one can define "tool-kits" (Binford and Binford 1966). One might be able to infer the type of activity on the basis of the lithic "tool-kits" themselves, the other associated artifacts (types of ceramics, shell artifacts, bone artifacts), and ecofactual data (associated flora and fauna). However, the tentativeness and uncertainty of tool kit definition even when the activity context is defined raises some doubts about cluster analysis--namely, how can one hope to define tool kits without knowing the activity context when it is so problematic even with knowing the spatially defined activity areas? The major advantage of the cluster approach is sheer numbers. Often one does not know the context--structural features are not present, for example, or one might be dealing with mere refuse accumulations (see Schiffer 1972). Yet even under such circumstances, it is likely that items used together will end up together--even in garbage. By using the "lot" (the excavated material within a level of a square or other such excavation unit) as a small slice of the past (its smallness being some control for temporal and/or activity mixture), one can deal with a much larger sample of co-occurring materials than if one were limited to materials from clearly defined contexts. The larger number of such units should enable one to discriminate patterning--unless the "noise" from mixture is overwhelming. While the material in the collections under investigation were collected mainly for chronological rather than contextual purposes, it will be interesting to see what activity information can be gleaned from them.

Chapter 4

THE DATA

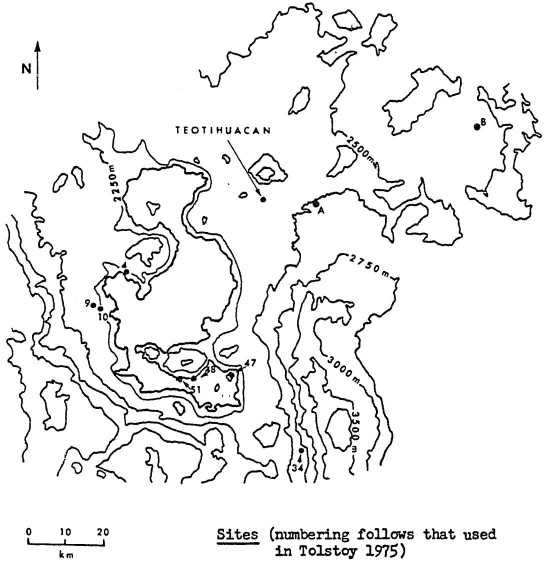
I. Sites and Phases

As noted at the beginning of Chapter 2, I am using variation within assemblages and contrasts between sequent assemblages of the same tradition as a means of interpreting the chipped stone materials. Hence, it is appropriate at this point that the various assemblages be defined. The collections under consideration resulted from excavations carried out at the sites of Loma de Atoto (1965), El Arbolillo (1965), and Tlapacoya-Ayotla (1967). The Principal Investigator was Paul Tolstoy (Tolstoy and Paradis 1970; Tolstoy 1971, 1973, 1975; Tolstoy, Smith, Fish, Boksenbaum, and Vaughn 1977). I will be using Tolstoy's chronological framework (Tolstoy 1978) in the following discussion (see Fig. 4.1 for location of sites, Fig. 4.2 for chronological chart).

Loma de Atoto

Loma de Atoto is a hill-top site overlooking the well-known site of Tlatilco in the western part of the Basin of Mexico, in what is now the western outskirts of Mexico City. The excavations at Loma de Atoto went to a depth of approximately 2 meters, using 10 cm. arbitrary levels in conjunction with subunits based on soil distinctiveness, in four 1-1/2 meter squares.

Figure 4.1. Map of the Basin of Mexico.



Sites (numbering follows that used in Tolstoy 1975)

4 El Arbolillo (East and West)
9 Tlatilco
10 Loma de Atoto
34 Coapexco
47 Tlapacoya
48 Santa Catarina
51 El Terremote

Sources

A TA-79 (Otumba)
B Paredón

Figure 4.2. Chronology in the Basin of Mexico, Based on Tolstoy and Paradis 1970; Tolstoy 1978.

ST[a] (RT[b])	Master Sequence[c]	Old Terminology
630 (510)		
	FI-4[d]	Middle Preclassic (Zacatenco Phase in the Basin of Mexico)
750 (425)		
	FI-3	
890 (700)		
	FI-2	
1000 (840)		
	FI-1	
1150 (950)		
	EH-4[e]	Early Preclassic (Ixtapaluca Phase in the Basin of Mexico)
1290 (980)		
	EH-3	
1400 (1100)		

a. ST: years B.C., bristle-cone pine calibrated C14 years (sidereal time).

b. RT: uncorrected C14 years B.C. (radiocarbon time)

c. Master sequence in the Basin of Mexico as discussed by Tolstoy 1978.

d. FI: First Intermediate

e. EH: Early Horizon

The ceramic materials obtained from the excavations have been used to define two First Intermediate subphases at the site: first, the Totolica Subphase, occurring during FI-3 (the Totolica Subphase was originally defined at Tlatilco); second, the Atoto Subphase, occurring during FI-4 (the Atoto Subphase is defined on the basis of the ceramic materials at Loma de Atoto).

El Arbolillo

El Arbolillo is also located in the western part of the Basin of Mexico. It is in the Guadalupe Hills, in what is now the northern outskirts of Mexico City. Excavations were carried out in two parts of the site.

One part (El Arbolillo West) is on a relatively flat area west of the Ticoman-Cuautepec road which now passes through the site. Excavations here reached sterile sand at approximately 2 meters, the culture-bearing layers being dug in arbitrary 20 cm. levels in eighteen 1-1/2 meter squares covering most of a 9 by 6 meter rectangular area.

The ceramic materials from this part of the site have been the basis for defining one First Intermediate subphase, the Cuautepec Subphase, occurring during FI-4.

The other area excavated by Tolstoy (El Arbolillo East) is on a hill slope east of the Ticoman-Cuautepec road. The excavations here went to a depth of somewhat more than 5 meters, dug by arbitrary 20 cm. levels in three 1-1/2 meter squares and an entrance trench through the hill-slope.

The ceramic materials from this part of the site have been the basis for defining two First Intermediate subphases, the El Arbolillo subphase (FI-2) and the La Pastora subphase (FI-3).

Tlapacoya-Ayotla

Tlapacoya-Ayotla is at the base of a steep volcanic cone, which apparently was then an island off the northeast shore of the former Lake Chalco, part of the Ixtapalapa region in the Basin of Mexico. Excavations here went to a depth of almost 2-1/2 meters in three 1-1/2 meter squares dug by 20 cm. arbitrary levels.

The ceramic materials have been the basis for defining two Early Horizon and one First Intermediate Subphases: Early Ayotla (EH-3), Late Ayotla (EH-4), and Bomba (FI-1). (On the basis of subsequent work at the site by Christine Niederberger, Tolstoy is now equating Late Ayotla with Niederberger's Manantial designation.)

The Assemblages

Two of the above eight subphases are further subdivided so as to take into account post-depositional factors which have mixed later materials in with them, evidence of the later, intrusive materials consisting of Classic and/or Post-Classic sherds. Thus Cuautepec Subphase at El Arbolillo West and La Pastora at El Arbolillo East have been divided into Mixed and Unmixed versions. In addition, a number of lots at Loma de Atoto had insufficient ceramic material to assign them to either Atoto or Totolica. There is thus another ceramically defined unit which consists of Atoto and/or Totolica materials.

Defining "chipped stone assemblages" as consisting of the chipped stone in association with each of the ceramically defined units, I therefore will be dealing with 11 "chipped stone assemblages": 2 in FI-4--Cuautepec (unmixed) and Atoto; 2 in FI-3--La Pastora (unmixed) and Totolica; 1 in FI-2--El Arbolillo; 1 in FI-1--Bomba; 1 in EH-4--Late Ayotla; 1 in EH-3--Early Ayotla; 1 in either or both of FI-4 and FI-3--the unassigned Loma de Atoto materials; 1 partly in FI-4 but mixed with Classic/Post-Classic materials--Cuautepec (mixed); 1 partly in FI-3 but mixed with Classic and/or Post-Classic materials--La Pastora (mixed). For convenience in computer processing of data, I use the following labels for each of these "assemblages":

E47MCUAU	Cuautepec (mixed)
E47UCUAU	Cuautepec (unmixed)
A27ATOTO	Atoto
A30UNKNO	Atoto/Totolica
A36TOTOL	Totolica
L56MPAST	La Pastora (mixed)
L56UPAST	La Pastora (unmixed)
L55ARBOL	El Arbolillo
P14BOMBA	Bomba
P13LAYOT	Late Ayotla (now being referred to as Manantial)
P12EAYOT	Early Ayotla

II. The chipped stone material

It is impossible to separate "data" from "interpretation," since, as indicated in the previous chapters, the observations themselves are interpretations. However, it is possible, as mentioned earlier, to distinguish two levels of interpretation: the analytic level, in which the subject under study is broken down, figuratively speaking, into its component parts, in accord with the defined units of measure; and the synthetic level, in which the results of analysis are integrated to provide a coherent, over-all model of the original subject of study. This section presents the results of analysis, i.e. the data. The next chapter will present the synthetic models which account for ("explain") the data.

The actual analytic procedure I went through involved several quasi-inductive steps, feedback from observation being used to correct the measurement models of the preceding steps (Clarke 1968). Correct match-ups of individual specimens or their attributes with categories defined before observation began was only possible where the previous work of others had defined (via experimentation, variability, comparison) relevant units of analysis. Thus, the pre-observation definition of interpretable units of observation was possible for blades, ridged flakes, core fragments, shaped pieces.

For the bulk of the material, the initial categories were little more than descriptive conveniences. My original intention was to convert such categories having no apparent interpretability, into interpretable categories by using various correlational approaches to discover patterns. Following through on this, I coded many characteristics for all specimens and key-punched this data for computer handling. While going through this lengthy coding process, I realized that I was getting insights on how to interpret the specimens, but that such interpretations were based on characteristics that had not been included in the code. Indeed, it was precisely the anomalies, the unusual positive surfaces, the multiple positive surfaces, the splitting, etc., which I had not been looking for initially--indeed which I had been trying to ignore so as to facilitate the pigeon-holing--which appeared to be of interpretive value. Since most of these newly perceived characteristics were not related to characteristics that had been coded, this new information would not have been retrievable from the original set of data no matter what kind of correlational analysis would have been carried out on it. One achievement resulted from the initial lengthy coding procedure: my ability to define interpretable variation had improved considerably. However, changing the measurement criteria, sometimes consciously, sometimes unconsciously, as I was learning what was significant, was introducing a source of error: "change in the research instrument" (Webb et al, 1966: 22). More importantly, I was introducing corrected units of measure. For not only was it impossible during such inductive exploration to maintain constancy of measurement criteria, it was important that I did modify the measures so as to produce usable results. I therefore had to redo the description of the collection, now that I had clarified what to look for. The whole procedure takes considerable time, the exploration of assemblage variability requiring a number of passes through the material (indeed, being time-limited, I did not re-classify the mixed assemblages). For the nine assemblages that were re-coded, several variables were coded in both "before" (or "trial") and "after" operationalized versions, i.e., the initial "convenient" and the subsequent "interpretable" versions. In the following presentation, the "before" versions will be discussed only insofar as such discussion can indicate what to ignore in future analyses, while the "data" will be based on the "after" versions.

A. Raw Material

Tables 4.1-4-2 present data concerning the raw material used in the chipped stone industries. Two major theoretical variables were considered: one (labeled "MATSRCE") refers to the composition of the material and, ultimately, its geologic source; the second (labeled "MATQUAL") refers to the quality (textural and structural) of the stone vis-a-vis its fracturing characteristics and the sharpness of its freshly-fractured edges.

MATSRCE was operationalized in several hierarchically ordered versions. The most general level was to distinguish obsidian from non-obsidian. This provides a measure of the relative importance of obsidian in each subphase. Other operational levels were subdivisions of these two categories.

Within the category "obsidian," I distinguished many visually distinctive variants, in the hope that some of these could be used to indicate distinct geologic sources. The underlying approach was a macroscopic visual one, but significant information was provided by trace analysis of 54 specimens.

While most visual characteristics do not indicate the different geologic sources from which obsidian is obtained, some do. Jack and Heizer (1968: 81) found that they could use trace-analysis defined groups to isolate those particular visual characteristics that discriminated between source groups:"Examination of the samples in hand specimens has revealed consistent, although usually subtle, visual characteristics of each of these five chemical groups, confirming that they are mutually distinct volcanic glasses. I carried out the visual examination and coding prior to the trace analysis, but expected to be able to correlate at least some of the visual characteristics with subsequent trace analysis."

The initial coding allowed me to provide a wide assortment of specimens for trace analysis. Fifty-four specimens were "sourced" by Robert Cobean at Yale University's facilities. I used the results of that analysis to weed out those visual characteristics which appeared to be irrelevant for sourcing and to focus on those characteristics which appeared to be relevant. The consequence of this was the lumping of some of the initial variants and the establishment of new variants. Because I was establishing some new variants, I had to re-code the assemblages for these new variants. These hypothesized source categories are now being tested at Brookhaven National Laboratory on a project of which I am a Faculty Associate (NSF grant BNS76-80055, Early Exchange Networks in the Basin of Mexico, Paul Tolstoy, principal investigator).

The non-obsidian was further identified by Curt Gorman, then an advanced undergraduate geology major, in consultation with the faculty of the geology department at Queens College, using a standard descriptive framework (Hurlbut 1971; Williams et al. 1954). Since the specimens were not subjected to thin section analysis, the identifications (e.g. basalt, chert) were based on macroscopic characteristics (texture, density, opacity, color, etc.). While no work that I am aware of has been done to "source" non-obsidians in the Basin of Mexico, the working assumption has been that these are "local" materials.

The second theoretical variable, MATQUAL, was operationalized so as to take into account the type of rock, its homogeneity, and its inclusions, as these reflect on the smoothness and regularity of its conchoidal fracture and the sharpness of its edges.

Further, Tables 4.5-4.7 were established to consider the possibility of correlations between the raw material and the manufacturing class of the artifact (see below for elaboration of the measurements that indicate the manufacturing class).

B. Manufacturing Class

The theoretical variable "manufacturing class" refers to the manufacturing procedure which produced the artifact. Tables 4.3-4.4 present data based on various operationalizations of this variable.

An initial version of this variable, labeled BASIS1, did have some interpretable values (blades, ridged flakes, core fragments) as well as some arbitrary values (thin flakes, thick flakes, amorphous pieces, etc.).

In an attempt to gain some understanding of the pieces only arbitrarily categorized, I further described them using the outline of their positive surfaces (this additional variable being labeled BASIS2) as Wilmsen (1967) had done in his analysis of Paleo-Indian lithic assemblages. Wilmsen had, in fact, defined "thirteen formal tool categories" (ibid: 111) based on the shape characteristics of "tools," i.e. "flakes which [had] been modified by retouch on one or more edges" (ibid: 34-35). Each category was "defined by a set of attribute values which co-occur[red] on a large number of specimens" (ibid: 111). Figuring prominently in the correlation procedure he used were the "proximal, left lateral, distal and right lateral edge contours," these constituting four of the eleven variables he considered for sorting purposes (ibid: 118). However, while he was interested in using "regularity in artifact variation" to arrive at "inferences concerning the sociocultural processes" involved (ibid: 111), he did not interpret his categories (ibid: 117-118).

> It must be stressed, however, that these categories are not meant to represent artifact types; they are merely descriptive devices which should be useful in comparing the formal tool configurations found in a number of sites. Moreover, as more work of a formal nature is carried out on stone assemblages . . . the descriptive categories presented here will be modified or replaced by more useful formulations.

In the course of coding positive surface outlines, I noticed that some pieces had two or more clearly defined positive surfaces. While at first tending to ignore these anomalies, I came eventually to examine more carefully all surfaces. To my surprise, a good many of the "facets" which I had passed over as simply being scars of previous flake removals turned out, on closer inspection, to be positive or anomalous in some other way. This ultimately led me to a new operationalization of manufacturing class (labeled BASIS5) which I used for recoding most of the assemblages.

BASIS5 has been operationalized in an hierarchical fashion. On the lowest level, there are many particular characterizations, each of which is an attempt to identify the characteristics of interpretable value. This resulted in some 700 or so categories, a rather unwieldy number. On a more general level, these were lumped to produce a scale of a dozen values, from crudest to most technically proficient: (1) smash flakes; (2) possible smash flakes; (3) split and/or multiple flakes; (4) possible split and/or multiple flakes; (5) dregs--fragments, chunks, etc.; (6) crude flakes; (7) ridged flakes; (8) possible rejuvenation flakes; (9) rejuvenation flakes; (10) fine flakes; (11) blades; (12) blade cores.

In retrospect, it appears that the outline of a flake has little of interpretive value. Only with those manufacturing procedures which can control the outline of the flake (namely blade production) is outline clearly relevant. For non-blade flakes whose production fits the classic knapping model, outline appears to be an epiphenomenon of the dorsal ridge pattern, fracturing tending to follow ridging. Finally, for smashings (the flakes produced by nodule-smashing, two or more flakes detaching simultaneously), the outline appears to be of no interpretive value. Hence, I think it unlikely that Wilmsen could ever generate interpretable "artifact types" based on the correlation of the characteristics with which he had begun his analysis.

C. Use Class

The theoretical variable "use class" is, obviously, concerned with the use to which a specimen is put. I considered retouch characteristics (intentional and/or "use" retouch) of the specimens in producing several operationalized versions of the variable--Tables 4.8-

4.13 present the data.

It should be borne in mind that the use measures employed here are untested, for there are a number of factors which suggest the need for testing. One factor affecting validity is the difficulty in distinguishing the cultural modification one is interested in from "noise." That is, it is necessary to distinguish retouch from the chipping that can result from a number of other causes: the fracturing and edge preparation of the manufacturing process that produced the pre-modified item; the mis-use and/or non-use handling of tools by the user culture (e.g. sticking a pointed implement into the ground, thereby abrading the point, merely to store it in between actual usages); the treatment garbage was subjected to by the user culture; post-depositional modification due to "natural" causes; and accidental archeological modification (resulting from excavation procedures and/or subsequent handling, e.g. "bag retouch"). Secondly, interpreting the intentional modification that prepared items for use requires one to be able to discriminate between alternative interpretations: which edges were shaped as working edges and which for other purposes (hafting, backing, etc.); which characteristics are utilitarian and which have non-utilitarian functions (social, aesthetic, ideological); which variability is due to differences in the skill of the retoucher, the material being worked, the knapping process itself (including the correction of "accidents"). While I attempted to consider these various sources of variability in establishing the use measures I employed here, the validity of use measures derived solely from the attributes of the specimens themselves is not subjectable to testing.

Virtually all specimens were coded on the basis of two early operationalizations of "use class." One, labeled MOD, is an ordinal scale variable. It has 10 values which were used to indicate the highest degree of modification a specimen exhibited (following Bordes' 1961 notion of "dominance"), ranging from no modification to completely (bifacially) retouched. The second, labeled RET, indicates the number and/or location of retouched edges. Both those early versions suffer from my tendency, at that time, to reserve judgment, in the name of "objectivity," and treat all edge scars as possible retouch. First, since at that time I had not been considering smashing and multiple flaking as ways of producing flakes, I had not paid sufficient attention to the possibility that "retouch" could actually be the result of crude manufacturing processes and not retouch at all. Secondly, I did not attempt to discriminate between cultural and non-cultural modification.

Recoding the specimens after changing my orientation on these matters, I used a new operational variable, labeled BASIS4. On the most detailed level, several hundred categories were distinguished. On a more general level, I lumped these into fewer than 10 categories, establishing ordinal scales with values from "unmodified" to "completely shaped."

Two classes of artifacts were coded in greater detail: (1) blades (and ridged flakes); (2) "points." Since blades (and ridged flakes), have such long sharp edges to start with, since blades or portions of blades can be used in various composite implements, since they are so clearly defined by the manufacturing process, and since they were such an important part (i.e., constituted such a large proportion) of subsequent Mesoamerican lithic assemblages, the modification of blades was given special attention. Here I coded for the outline of edges, the direction of retouch, the number of retouched segments on each edge, the kind of retouch in each direction for each edge, the angle of each retouched edge, and the length of the retouched sections.

"Points" were also given special treatment since their shapes are defined by retouch. A considerable number of variables were used to describe points. Such variables as haft outline, blade length, and type of retouch were considered. However, since the number of points is so small, it is not possible to establish point types on the basis of this collection. Hence, I also coded the points using the Texas point typology (Suhm and Jelks 1962) and employed by Tolstoy (1971) for Basin of Mexico materials. Whether these were actually projectile points or other pointed implements (knives, scrapers, etc.) remains problematic. Ahler's work (1970), in which he examined wear patterns on so-called points, suggests that many morphological "projectile points" are not wear-pattern points.

D. Breakage Class

Information about the fragmentary or whole condition of specimens was also considered. Several concerns are served by this variable.

Since "snapped" blades were used in composite implements, it is of interest to consider which portions of blades are found. To this end, I coded the breakage class of blades, with values for whole specimens and for various fragments: proximal, proximo-medial, medial, medio-distal, distal. Some authors have assumed that blade fragments result from intentional breakage and are not the accidental result of post-use breakage. For examine, in analyzing Tehuacán Valley material, MacNeish et al. (1967: 8) comment: "[We] discovered that tips of blades occurred throughout our sequence in no regular manner, but that broken blades with both tips and striking platforms snapped off appeared in significantly large proportions in the upper levels." And in the Pacific Northwest, Browman and Munsell (1969: 258), after stating that "experiments performed by Munsell . . . and Sanger . . . have shown that both intentional and accidental snapping off of either end of a microblade tends to produce a new end, square in outline." nevertheless go on to describe the microblades as being complete, distally square, proximally square, or distally-proximally square, as if these were cultural characteristics. While this may have been the case, it was not demonstrated by these researchers, and since one can imagine long, thin blades being easily snapped during post-use events, one should perhaps at least keep in mind the alternative hypothesis of accidental breakage. I have attempted to use additional sources of information to consider the intentional vs. accidental alternatives in analyzing these collections.

First (Table 4.15), if breakage is due to post-use processes, one would expect non-blades to exhibit some breakage as well. Therefore, a comparison of blades and non-blades was carried out. Secondly (Table 4.16), if accidental breakage was occurring due to post-depositional processes and if the geologic context was not being greatly disturbed, the matching fragments should be found nearby, either in the same or adjacent lots. Consequently, an attempt was made to find matching pieces (two or more pieces that fit in this fashion were treated as a single case, the variable labeled NFRAG indicating the number of fragments that comprise the case). Thirdly, (Table 4.17), if blades were being intentionally snapped, one might expect the fragments to be of a relatively standardized size. Hence, the lengths of the fragments were considered. Additional lines of investigation did not yield much data. For example, if blades were intentionally snapped, subsequent retouch on the hinge fractures would attest to the pre-use snapping. While few specimens in these collections had such retouch, one has to keep in mind that such end retouch would be unlikely if it was the lateral edges of snapped blades that were the working and/or haft-inserted edges.

A second concern is the activity represented by the debitage. If the debitage was essentially refuse (the activity being garbage disposal), then one would expect to find unwanted material in abundance. Unwanted material would include parts of blades having little utility (proximal and distal fragments, any very small fragments), small fragments of points, chunks, splinters, rejuvenation flakes, heavily used items. If the manufacture of particular chipped stone items were going on, then one would expect to find the debitage associated with such manufacturing procedures (for example, the debitage indicating blade making has already been discussed, and nodule-smashing would be indicated by a preponderance of smashings). If some particular use activity were represented, then particular whole, usable items (the "tool kit") should be in greater evidence than in either the manufacturing or garbage lots.

A third concern is to indicate the completeness of the evidence one is using. In making general statements about flakes, one should be aware of how much is based on "reconstructions." For example, in considering the manufacturing class (BASIS5) data, one should have such information (even though most very fragmentary, uncertainly classifiable specimens were coded as "dregs") in order to evaluate any general statements about the various manufacturing class values.

A final concern served by "breakage class" is as control for size measurements. In coding for length and weight, in particular, it is important to consider whether one has the measures or whole or fragmentary specimens. If one is to consider inter-village bulk transport of items, one should have as reliable a way as possible of estimating the size and weight of the items that may have been carried.

E. Size data

Several variables are size variables (Tables 4.22-4.24). All specimens in unmixed assemblages were weighed. The length, width and thickness of blades and ridged flakes, the maximum dimension and the thickness of non-blades, and many linear dimensions of points were measured.

These measurements can be used in addressing various issues, some of which have been discussed earlier. For one, the uniformity of blade size, as indicated by width in particular, could be used to infer import of desired blades, rather than local manufacture.

Were points made from blades? Since points may be completely retouched, a point's surfaces would not indicate the specimen's manufacturing class. However, its dimensions, thickness and width in particular, could be used as negative evidence. That is, if the dimensions of points exceed those of blades, then no reduction strategy could produce points from blades, at least from the blades found in these assemblages.

How do obsidians and non-obsidians compare? The relative sizes of items within an assemblage could reflect differences in the procurement systems. Namely, one would expect items (within the same manufacturing class) that were being imported to be relatively smaller than local materials in the assemblage.

How do obsidians in the different assemblages compare? If there is an hierarchical distribution pattern, one could use size differentials to map the distribution pattern, larger fragments occurring in assemblages higher in the hierarchy, again controlling for manufacturing class (this could be done only with assemblages that were contemporaneous).

F. Proximal element data

Data regarding the application of force in knapping necessarily focuses attention on the proximal element (Tables 4.25-4.26). Several operational variables were used.

One set of variables supplies information about the cap itself (that is, the top surface of the flake, which has that part of the target carried away when the flake was detached [Boksenbaum 1977]):

the nature of the surface, its outline, its length and width. Another set of variables supplies information about the ventral surface and its relation to the cap: the prominence of the bulb, the angle between the cap and the ventral surface, and the presence of bulbar scars. A third set of variables supplies information about the dorsal surface and its relation to the cap: two variables (three for blades) that describe whatever core edge preparation was carried out prior to the flake's removal; and a variable that is the measure of the angle between the cap and the dorsal surface. One variable indicates the proximal element outline. Finally, one variable indicates the angle between the cap's surface (which is perpendicular to the axis of force) and the longitudinal axis of a linear flake.

Again, several problems are addressed by these variables. Within manufacturing classes, are temporal differences in core preparation discernible? Can one find preparation differences between manufacturing classes? In what ways, if any, are smash flakes anomalous?

G. Other variables

Several additional variables were utilized (Tables 4.27-4.28, 4.18-4.22). One, the number of cortex surfaces, provides information which can be related to the nature of the raw material (cobble or "vein") and to the locale of the initial steps in reduction procedures. Absence of cortex surface is a negative sort of evidence, though, and is not as informative as the presence of cortex surfaces.

The distal termination of flakes was also coded. This is of some utility in comparing the different manufacturing classes, since it relates to the way flakes peeled off cores.

Tables 4.18-4.22 provide general evaluations of the clusters of artifacts found together in excavation units.

III. Tabulations and Discussion of Data

Table 4.1: Types of Raw Material

Table 4.1 presents data regarding the materials used, indicating both frequencies and percentages of occurrences for all 11 assemblages. Two levels of precision are indicated. One consists of only two values: obsidian and non-obsidian. The second consists of 9 obsidian subgroups and 4 non-obsidian subgroups. Percentages are calculated for all categories both within the total assemblage and within the obsidian and non-obsidian subgroups.

Obsidian artifacts are present in greater numbers than is the non-obsidian in all assemblages, except L56UPAST at El Arbolillo East. Earlier work in the Basin of Mexico, especially from Vaillant's excavations, had led to the observation that "obsidian accounts for never less than 80 per cent of all chipped stonework" (Tolstoy 1971: 271). However, the material under consideration here departs considerably from those findings. Indeed, in only one assemblage, P14BOMBA at Tlapacoya, is the obsidian above 80% of the chipped stone.

There does not appear to be any overall time trend in the proportion of obsidian in unmixed assemblages (the series, from early to late, is 66.9%, 72.2%, 82.1%, 55.3%, 44.8%, 74.2%, 68.2%, 54.7%). However, there appears to be a spatial patterning, by site. Tlapacoya's assemblages (the assemblages beginning with "P"), showing a temporal trend of increase from EH-4 through FI-1 (66.9%, 72.2%, 82.1%), and

Table 4.1. Types of Raw Material. Percentages are calculated both within assemblages (%A) and obsidian/non-obsidian subgroups (%S).

	Obsidian										Non-Obsidian					
	ANOM1	GREEN	HALO	FUZZY	CLEAR	ANOM2	MAHOG	GRAY	TAN	Subtotal	CRPTO	BSALT	VOLCO	MISC	Subtotal	TOTAL
E47MCUAU[a] #		69			3	1		110	1	184	67	27	8		102	286
%S		37.5			1.6	0.5		59.8	0.5		65.7	26.5	7.8			
%A		24.1			1.0	0.3		38.5	0.3	64.3	23.4	9.4	2.8		35.7	
E47UCUAU #		14			4	4		59		81	51	3	13		67	148
%S		17.3			4.9	4.9		72.8			76.1	4.5	19.4			
%A		9.5			2.7	2.7		39.9		54.7	34.5	2.0	8.8		45.3	
A37ATOTO #		8		2	4	4	1	161		180	62	20		2	84	264
%S		4.4		1.1	2.2	2.2	0.6	89.4			73.8	23.8		2.4		
%A		3.0		0.8	1.5	1.5	0.4	61.0		68.2	23.5	8.6		0.8	31.8	
A30UNKNO #								29		29	6	2			8	37
%S								100.0			75.0	25.0				
%A								78.4		78.4	16.2	5.4			21.6	
A36TOTOL #	1	2		2	4		1	154		164	47	9	1		57	221
%S	0.6	1.2		1.2	2.4		0.6	93.9			82.5	15.8	1.8			
%A	0.5	0.9		0.9	1.8		0.5	69.7		74.2	21.3	4.1	0.5		25.8	
I56MPAST[a] #		160	1		12	1		466		640	276	32	4	8	320	960
%S		25.0	0.2		1.9	0.2		72.8			86.3	10.0	1.3	2.5		
%A		16.7	0.1		1.3	0.1		48.5		66.7	28.8	3.3	0.4	0.8	33.3	
I56UPAST #		6		2	4	8		145		165	159	36	3	5	203	368
%S		3.6		1.2	2.4	4.8		87.9			78.3	17.7	1.5	2.5		
%A		1.6		0.5	1.1	2.2		39.4		44.8	43.2	9.8	0.8	1.4	55.2	
I55ARBOL #		12			3	10		85		110	54	32	3		89	199
%S		10.9			2.7	9.1		77.3			60.7	36.0	3.4			
%A		6.0			1.5	5.0		42.7		55.3	27.2	16.1	1.5		44.7	
P14BOMBA #		8		4	7	12	3	478		512	51	52	9		112	624
%S		1.6		0.8	1.4	2.3	0.6	93.4			45.5	46.4	8.0			
%A		1.3		0.6	1.1	1.9	0.5	76.6		82.1	8.2	8.3	1.4		17.9	
P131AYOT #		10		8	14	25	4	272		333	76	41	11		128	461
%S		3.0		2.4	4.2	7.5	1.2	81.7			59.4	32.0	8.6			
%A		2.2		1.7	3.0	5.4	0.9	59.0		72.2	16.5	8.9	2.4		27.8	
P12EAYOT #		3		1	3	6		72		85	16	24	2		42	127
%S		3.5		1.2	3.5	7.1		84.7			38.1	57.1	4.8			
%A		2.4		0.8	2.4	4.7		56.7		66.9	12.6	18.9	1.6		33.1	

a. Data for obsidian subgroups of mixed assemblages (E47MCUAU, I56MPAST) are not comparable with unmixed assemblages, except for GREEN, MAHOG, TAN.

Loma de Atoto's FI-3 and 4 assemblages (those beginning with "A": 74.2%, 68.2%) have the highest proportions of obsidian. The two El Arbolillo "sites" have the lowest proportions--El Arbolillo East's ("L" assemblages) FI-2 and 3 assemblages having 55.3% and 44.8% respectively and El Arbolillo East's ("E" assemblages) FI-4 assemblage having 54.7% obsidian. Even the mixed assemblages at the El Arbolillo sites have relatively low amounts of obsidian (66.7% in L56MPAST and 64.3% in E47MCUAU).

The 9 obsidian subgroups are possible source groups. GRAY, by far the major visually-distinguished group, refers to obsidians which, while exhibiting considerable variation in visual characteristics (banded and unbanded grays of differing opacity and degree of grayness), are thought to be from the source area in Teotihuacán Valley, TA-79 (referred to also as Otumba, Barranca de los Estetes). This is based on the trace analysis carried out by Cobean at Yale University (see Table 4.7). Even as early as EH-3 , the bulk of the obsidian is GRAY.

It may be that two sources are involved, one a recently identified source, Paredón (on the northeastern edge of the Basin of Mexico) which is difficult to distinguish from the TA-79 source if only a few trace elements are used in the analysis. As David Grove noted in a personal communication to Paul Tolstoy (letter of August 24, 1977): "If you use the elements commonly used by others (Mn, NA, Sr, Zr, Rb), then Charlton's new source looks exactly like the Teo source and you [cannot] differentiate them. You'd never know you had two sources." Early findings from Tolstoy's exchange patterns project indicates that some Paredon material is present.

It still remains to be ascertained if GRAY includes Paredón material. Cobean seems to have distinguished some Paredón specimens but was not able to assign them to any known-to-him source--he assigned four such specimens to the Group A "unknown source" defined on the basis of artifacts from San Lorenzo. These were CLEAR specimens (see below). But it still remains to be confirmed that the Paredon material is the visually distinctive CLEAR category.

ANOM2 is a very tentative category. It is a gray obsidian with fine parallel opaque threads in a rather matte-like transparent gray medium. As such, it is somewhat intermediate between GRAY and FUZZY (see below). If the anomalous visual characteristics do indeed indicate a distinct source, then such a source would be a distant second in popularity (third if there are two sources TA-79 and Paredon, categorized as GRAY). During EH-3 through FI-4, it ranges between about 2% and 9% of the obsidian, the only exception being the A36TOTOL assemblage which has none. There does not seem to be any trend either of increase or decrease. (Data for the mixed assemblages is not comparable, since the material was not recoded for ANOM2.)

GREEN, a generally transparent ("bottle-glass") green obsidian, probably from the Pachuca area in Hidalgo, is third in popularity. During EH-3 through FI-4, it ranges between about 1% and 4% of the obsidian, the two exceptions being the 11% of FI-2 L55ARBOL and the 17% of FI-4 E47UCUAU. By contrast, the mixed assemblages have considerable quantities of it (25% in L56MPAST and 38% in E47MCUAU). Indeed, the high percentage of GREEN in E47UCUAU may be evidence of mixture.

CLEAR is based upon four specimens analyzed by Cobean. It is a transparent obsidian, either colorless or gray, having no streaking in it (two specimens analyzed by Cobean that were transparent obsidians but with traces of subtle streaks were sourced as being from TA-79). The specimens are probably to be placed within Group A, a source group defined on the basis of artifacts at San Lorenzo on the Gulf Coast and which may now be associated with the Paredón obsidian source area. If CLEAR obsidian is indeed a valid source group, it is almost as popular as GREEN during EH-3 through FI-4. It usually falls within 2% and 5% of the obsidian. Initial and incomplete examination of EH-2 and EH-3 assemblages at Coapexco and El Terremote in the Basin of Mexico suggest that CLEAR obsidian was more popular in those assemblages.

FUZZY, an obsidian with heavy black or dark gray fuzzy swathe-like layers in a transparent medium, is possibly from the Zinapécuaro source in Michoacán (and/or the El Ocotito source in Guerrero, since four specimens analyzed by Cobean, but subsequently lost by the Yale facilities, are thought to have had similarities to the FUZZY specimen on the basis of preliminary descriptive notes). It is found as 1 or 2% of the obsidian in all of the assemblages from EH-3 through FI-4 except for E47UCUAU. By contrast, initial and incomplete examination of EH-2 and EH-3 assemblages at Coapexco and El Terremote suggest that FUZZY obsidian was rather popular in those assemblages.

The remaining four obsidian subgroups are present in trace amounts. MAHOG, an opaque reddish-brown obsidian mixed with varying amounts of opaque dark gray or black, is probably a variant of the TA-79 source group, since the two specimens analyzed by Cobean were. Spence and Parsons (1972:20) note:

> Near one cave entrance there is a vein of the distinctive red and black spotted "meca" obsidian. All the rest of the obsidian, both in the caves and on the adjoining hill, is gray-black in color.

Indeed, when I was at the TA-79 source in 1972, Peter Tiscione and I saw one "pocket" of such obsidian amidst all the gray (this pocket was apparently being mined by a present-day artisan, a small cabin at the top of one hill having a pile of such mahogony debitage outside it). However, pockets of reddish-brown obsidian have been found at several different sources.

HALO is an opaque shiny-black obsidian which looks green along its very edges when held up to the light. One such specimen was found by Cobean to possibly be from Penjamo in Guanajuato (however, another HALO specimen from Tlatilco was attributed to a "new unknown source" by Cobean). The specimen is from one of the mixed assemblages. That it may be attributable to a later time period is suggested by a recent comment from Cobean that obsidian with a green halo was turning up at Tula.

TAN, a transparent obsidian with a tan tint, was defined by Jack and Heizer (1968: 92): "Light gray with distinct tan tint, particularly in thicker sections. Dense flecking of fine tan, brown, to black spots. . . ." This "Type B" obsidian is from Altotonga, Veracruz (Hester, Jack, Benfer 1973). The single TAN specimen found (in a mixed assemblage) may or may not conform to Jack and Heizer's definition, although it was the closest I could find.

Finally, one specimen having small fuzzy opaque patches in a transparent gray medium was the basis for the category ANOM1, since it did not fit any of the other visually-defined patterns (although it may be a variant of FUZZY).

Three of the four non-obsidian subgroups are different rock types that are likely to be from different sources. However, each of these subgroups may include several different sources, that is, there is a minimum of three different non-obsidian sources, but there probably are more.

One major non-obsidian, CRPTO, is a cryptocrystalline quartz, which includes materials that can be referred to as chert, chalcedony, jasper, etc. It tends to be the predominant non-obsidian in later times (76% in E47UCUAU, 74% in A27ATOTO, 82% in A36TOTOL, 78% in L56UPAST), but is sometimes overshadowed by BSALT (basalt), the other major non-obsidian, in earlier times (CRPTO constituting only 61% of the non-obsidian in L55ARBOL, 46% in P14BOMBA, 59% in P13LAYOT, 38% in P12EAYOT).

The minor non-obsidian grouping, VOLCO, is comprised of various volcanic rocks other than those previously distinguished. It includes specimens of brown or red rhyolite or tuff as well as fine-grained green specimens. VOLCO tends to be more popular in earlier assemblages, the same assemblages having relatively high amounts of basalt.

Finally, a small number of diverse specimens (14) did not conform to any of the above categories and so were placed in a separate MISC category. All, save one, are found at El Arbolillo East (8 in L56MPAST and 5 in L56UPAST).

Table 4.2: Quality of Raw Material

A rough idea of the quality of the materials used can be derived from Table 4.1 by considering the categories presented there according to their "average" qualities. Namely, we could have a rough 4-value scale: (1) obsidian, (2) cryptocrystalline quartz; (3) basalt, (4) other volcanics and miscellaneous. Or one could simply dichotomize the variable into "high" (obsidian and cryptocrystalline quartz) and "low" quality (all others). In this fashion, looking back at Table 4.1, one would determine that "high" quality chipped stone ranged between 88.7% and 95.5% for all assemblages except L55ARBOL (82.5%) and P12EAYOT (79.5%).

However, if one considers the fracturing quality of the materials used as a separate variable, a somewhat more accurate scale can be provided. Such data is presented in Table 4.2.

Two levels of precision are indicated. One consists of only two values: HIGH and LOW quality. The second level consists of four values, two being subdivisions of HIGH (EXCEL and GOOD) and two being subdivisions of LOW (FAIR and POOR). These scales take into account the fineness of the crystalline structure and the presence and nature of inclusions. (The quality of the obsidian in mixed assemblages was not assessed separately. However, since virtually all of the obsidian in these assemblages is of excellent quality, all obsidian in the mixed assemblages was placed in EXCEL.)

Measured in this way, the picture is rather different. HIGH quality chipped stone between 87% and 88% of the assemblages is found in P13LAYOT, P14BOMBA, A36TOTOL (and A30UNKNO). HIGH quality stone between 81% and 84% is found in A37ATOTO (and the mixed assemblages).

Table 4.2. Quality of Raw Material.

		EXCEL	GOOD	HIGH Subtotal	FAIR	POOR	LOW Subtotal
E47MCUAU	#	184	48	232	44	10	54
	%	64.3	16.8	81.1	15.4	3.5	18.9
E47UCUAU	#	78	32	110	26	12	38
	%	52.7	21.6	74.3	17.6	8.1	25.7
A37ATOTO	#	176	46	222	37	5	42
	%	66.7	17.4	84.1	14.0	1.9	15.9
A30UNKNO	#	28	5	33	2	2	4
	%	75.7	13.5	89.2	5.4	5.4	10.8
A36TOTOL	#	162	34	196	21	4	25
	%	73.3	15.4	88.7	9.5	1.8	11.3
L56MPAST	#	641	154	795	134	31	165
	%	66.7	16.0	82.8	14.0	3.2	17.2
L56UPAST	#	161	76	237	99	32	131
	%	43.8	20.7	64.4	26.9	8.7	35.6
L55ARBOL	#	106	27	133	56	10	66
	%	53.3	13.6	66.8	28.1	5.0	33.2
P14BOMBA	#	504	54	558	61	5	66
	%	80.8	8.7	89.4	9.8	0.8	10.6
P13LAYOT	#	331	74	405	54	2	56
	%	71.8	16.1	87.9	11.7	0.4	12.1
P12EAYOT	#	84	14	98	27	2	29
	%	66.1	11.0	77.2	21.3	1.6	22.8

HIGH quality stone in the 70% to 79% range is found in P12EAYOT and E47UCUAU. Finally, HIGH quality stone in the 60% to 69% range is found in L55ARBOL and L56UPAST.

Table 4.3: The Manufacturing Classes

Table 4.3 presents manufacturing data (variable MFGCLSS), indicating both frequencies and percentages of occurrences within each assemblage. Two levels of precision are indicated. One level consists of four values: CRUDE, UNCERTAIN, GOOD, EXCELLENT. The second level consists of: four subgroups of the CRUDE category, two subgroups of the UNCERTAIN category, six subgroups (with one repeat of an UNCERTAIN subgroup) of the GOOD category, and two subgroups of the EXCELLENT category. Percentages are calculated both within the total assemblage and within the obsidian and non-obsidian subgroups.

The four-values level is operationalized as an indicator of skill in stoneworking. CRUDE refers, obviously, to the least skillful. It includes specimens that are or possibly are smashings, multiple flakes, and/or split flakes. The four subdivisions of the CRUDE category are; SMASH, smash flakes; PSMASH, possible smash flakes; MULT, multiple and/or split flakes; PMULT, possible multiple and/or split flakes. (Since the two mixed assemblages were not recoded after I had developed the "smash flake" concept, their data is not comparable with the other 9 assemblages, except vis-a-vis blades and ridged flakes.)

UNCERTAIN has two subgroups. One, DREGS, includes chunks and flake fragments that, while of ambiguous interpretation, are probably the result of either crude or of simple knapping technique (in Table 4.4, I divide UNCERTAIN proportionately between CRUDE and SIMPLE values). Indeed, a goodly number of these would undoubtedly be what Lavine-Lischka (1976:12) would refer to as "shatter"; that is,

Table 4.3. Manufacturing Class. Percentages are calculated within the obsidian subgroup, the non-obsidian subgroup, and the total assemblage for each manufacturing category.

		CRUDE														
		SMASH			PSMASH			MULT			PMULT			Subtotal		
		OBS[a]	NON[b]	TL[c]	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL
E47MCUAU	#													12	12	24
	%													6.6	11.8	8.4
E47UCUAU	#	23	5	28	8	6	14	3	8	11	3	2	5	37	21	58
	%	28.4	7.5	18.9	9.9	9.0	9.5	3.7	11.9	7.4	3.7	3.0	3.4	45.7	31.3	39.2
A37ATOTO	#	62	12	74	19	10	29	12	10	22	1	5	6	94	37	131
	%	34.4	14.3	28.0	10.6	11.9	11.0	6.7	21.9	8.3	0.6	6.0	2.3	52.5	44.0	49.6
A30UNKNO	#	10	0	10	5	0	5	0	2	2	1	0	1	16	2	18
	%	34.5	0.0	27.0	17.2	0.0	13.5	0.0	25.0	5.4	3.4	0.0	2.7	55.2	25.0	48.6
A36TOTOL	#	56	6	62	20	6	26	11	8	19	3	3	6	90	23	113
	%	34.1	10.5	28.1	12.2	10.5	11.8	6.7	14.0	8.6	1.8	5.3	2.7	54.9	40.4	51.1
L56MPAST	#													34	105	139
	%													5.3	32.8	14.5
L56UPAST	#	69	40	109	19	25	44	11	19	30	0	6	6	99	90	189
	%	41.8	19.7	29.6	11.5	12.3	12.0	6.7	9.4	8.2	0.0	3.0	1.6	60.0	44.3	51.4
L55ARBOL	#	45	14	59	11	3	14	6	9	15	0	3	3	62	29	91
	%	40.9	15.7	29.6	10.0	3.4	7.0	5.5	10.1	7.5	0.0	3.4	1.5	56.4	32.6	45.7
P14BOMBA	#	147	14	161	40	10	50	60	23	83	18	7	25	265	54	319
	%	28.7	12.5	25.8	7.8	8.9	8.0	11.7	20.5	13.3	3.5	6.3	4.0	51.8	48.2	51.1
P13LAYOT	#	96	14	110	22	2	24	24	33	57	13	7	20	155	56	211
	%	28.8	10.9	23.9	6.6	1.6	5.2	7.2	25.8	12.4	3.9	5.5	4.3	46.5	43.8	45.8
P12EAYOT	#	27	4	31	3	4	7	5	9	14	4	2	6	39	19	58
	%	31.8	9.5	24.4	3.5	9.5	5.5	5.9	21.4	11.0	4.7	4.8	4.7	45.9	45.2	45.7

a. OBS: obsidian specimens.

b. NON: non-obsidian specimens.

c. TL: total obsidian and non-obsidian specimens in the category.

Table 4.3 (Cont.)

	UNCERTAIN[d]									CRUDE +			GOOD[d]		
	DREGS			BIFCL[d]			Subtotal			UNCERTAIN[d]			SIMPLE		
	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL
E47MCUAU #							86	90	176	98	102	200			
%							46.4	88.2	61.4	53.3	100.0	69.9			
E47UCUAU #	17	39	56			0	17	39	56	54	60	114	4	7	11
%	21.0	58.2	37.8			0.0	21.0	58.2	37.8	66.7	89.5	77.0	4.9	10.4	7.4
A37ATOTO #	36	32	68	2	1	3	38	33	71	132	70	202	21	14	35
%	20.0	38.1	25.8	1.1	1.2	1.1	21.1	39.3	26.9	73.3	83.3	76.5	11.7	16.7	13.3
A30UNKNO #	9	5	14	1	0	1	10	5	15	26	7	33	1	1	2
%	31.0	62.5	37.8	3.4	0.0	2.7	34.5	62.5	40.5	89.7	87.5	89.2	3.4	12.5	5.4
A36TOTOL #	37	23	60	1	1	2	38	24	62	128	47	175	19	8	27
%	22.6	40.4	27.1	0.6	1.8	0.9	23.2	42.1	28.1	78.1	82.5	79.2	11.6	14.0	12.2
I56MPAST #							405	183	588	439	288	727			
%							63.3	57.2	61.3	68.6	90.0	75.7			
I56UPAST #	34	87	122	4	1	5	38	88	126	137	178	315	8	25	33
%	20.6	42.9	33.2	2.4	0.5	1.4	23.0	43.3	34.2	83.0	87.7	85.6	4.8	12.3	9.0
I55ARBOL #	22	50	72	4	0	4	26	50	76	88	79	167	7	10	17
%	20.0	56.2	36.2	3.6	0.0	2.0	23.6	56.2	38.2	80.0	88.8	83.9	6.4	11.2	8.5
P14BOMBA #	127	51	179	8[e]	1	9	135	52	187	400	106	506	29	6	35
%	24.8	45.5	28.9	1.6	0.9	1.4	26.4	46.4	30.0	78.2	94.6	81.1	5.7	5.4	5.6
P13LAYOT #	111	63	174	5[f]	0	5	116	63	179	271	119	390	20	8	28
%	33.3	49.2	37.7	1.5	0.0	1.1	34.8	49.2	38.8	81.3	93.0	84.6	6.0	6.3	6.1
P12EAYOT #	27	21	48	2	0	2	29	21	50	68	40	108	7	2	9
%	31.8	50.0	37.8	2.4	0.0	1.6	34.1	50.0							

d. BIFCL included in both UNCERTAIN and GOOD.

e. Two of these appear to be simple flakes, one appears to be a smash flake.

f. One of these appears to be a simple flake.

Table 4.3 (Cont.)

	GOOD[d]														
	RIDGED			PREJUV			REJUV			FINE			BIFCL[d]		
	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL
E47MCUAU #															
%															
E47UCUAU #			0	1	0	1	2	0	2			0			0
%			0.0	1.2	0.0	0.7	2.5	0.0	1.4			0.0			0.0
A37ATOTO #	2	0	2			0	3	0	3	3	0	3	2	1	3
%	1.1	0.0	0.8			0.0	1.7	0.0	1.1	1.7	0.0	1.1	1.1	1.2	1.1
A30UNKNO #			0			0			0			0	1	0	1
%			0.0			0.0			0.0			0.0	3.4	0.0	2.7
A36TOTOL #	1	1	2	1	0	1	3	0	3	3	0	3	1	1	2
%	0.6	1.8	0.9	0.6	0.0	0.5	1.8	0.0	1.4	1.8	0.0	1.4	0.6	1.8	0.9
L56MPAST #															
%															
L56UPAST #	2	0	2	1	0	1	1	0	1			0	4	1	5
%	1.2	0.0	0.5	0.6	0.0	0.3	0.6	0.0	0.3			0.0	2.4	0.5	2.4
L55ARBOL #			0			0	1	0	1			0	4	0	4
%			0.0			0.0	0.9	0.0	0.5			0.0	3.6	0.0	2.0
P14BOMBA #	11	0	11	4	0	4			0	2[g]	0	2[g]	8	1	9
%	2.1	0.0	1.8	0.8	0.0	0.6			0.0	0.4	0.0	0.3	1.6	0.9	1.4
P13LAYOT #	4	0	4	1	1	2			0			0	5	0	5
%	1.2	0.0	0.9	0.3	0.8	0.4			0.0			0.0	1.5	0.0	1.1
P12EAYOT #			0			0			0			0	2	0	2
%			0.0			0.0			0.0			0.0	2.4	0.0	1.6

d. BIFCL included in both UNCERTAIN and GOOD.

g. These have expanding rather than parallel sides.

Table 4.3 (Cont.)

		GOOD[d]			EXCLT												TOTAL		
		Subtotal			BLADE			BCORE			Subtotal								
		OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL				OBS	NON	TL
E47MCUAU	#	11	0	11							75	0	75				184	102	286
	%	6.0	0.0	3.9							41.0	0.0	26.3						
E47UCUAU	#	7	7	14	20	0	20			0	20	0	20				81	67	148
	%	8.6	10.4	9.5	24.7	0.0	13.5			0.0	24.7	0.0	13.5						
A37ATOTO	#	31	15	46	18	0	18	1	0	1	19	0	19				180	84	264
	%	17.2	17.9	17.4	10.0	0.0	6.8	0.6	0.0	0.4	10.6	0.0	7.2						
A30UNKNO	#	2	1	3	2	0	2			0	2	0	2				29	8	37
	%	6.9	12.5	8.1	6.9	0.0	5.4			0.0	6.9	0.0	5.4						
A36TOTOL	#	28	10	38	9	0	9	0	1	1	9	1	10				164	57	221
	%	17.1	17.5	17.2	5.5	0.0	4.1	0.0	1.8	0.5	5.5	1.8	4.5						
L56MPAST	#	18	32[e]	50							183	0	183				640	320	960
	%	2.8	10.0	5.2							28.6	0.0	19.1						
L56UPAST	#	16	26	42	14	0	14	2	0	2	16	0	16				165	203	368
	%	9.7	12.8	11.4	8.5	0.0	3.8	1.2	0.0	0.5	9.7	0.0	4.3						
L55ARBOL	#	12	10	22	14	0	14			0	14	0	14				110	89	199
	%	10.9	11.2	11.1	12.7	0.0	7.0			0.0	12.7	0.0	7.0						
P14BOMBA	#	54	7	61	66	0	66			0	66	0	66				512	112	624
	%	10.5	6.3	9.8	12.9	0.0	10.6			0.0	12.9	0.0	10.6						
P13LAYOT	#	30	9	30	37	0	37			0	37	0	37				333	128	461
	%	9.0	7.0	8.5	11.1	0.0	8.0			0.0	11.1	0.0	8.0						
P12EAYOT	#	9	2	11	10	0	10			0	10	0	10				85	42	127
	%	10.6	4.8	8.7	11.8	0.0	7.9			0.0	11.8	0.0	7.9						

d. BIFCL included in both UNCERTAIN and GOOD.

"all the irregular pieces of debris which did not exhibit any flake characteristics." The second subgroup, BIFCL, includes bifacially retouched pieces (points, etc.). Considering BIFCL as an UNCERTAIN subgroup provides one way of dealing with the "blank" from which the bifacially-worked items were made. However, I have also placed BIFCL into the GOOD category to take into account the retouching procedure that shaped the "blank."

GOOD encompasses a broad range of techniques, from simple to fine flaking. Its six subdivisions are: SIMPLE, RIDGED, PREJUV, REJUV, FINE, and BIFCL (discussed above). SIMPLE flakes appear to conform to the classic knapping model of what a flake is; they have various patterns of scars and ridges on their dorsal surfaces, but they lack any special characteristics. RIDGED flakes are special in having blade-like proportions, but their dorsal scar pattern deviates from the blade pattern. PREJUV and REJUV are flakes which have morphological characteristics which appear to indicate that they are or possibly are rejuvenation flakes (see Frison 1968; Shafer 1970), while FINE flakes are small lamellar flakes which appear to be retouch flakes.

Finally, EXCELLENT includes blades and blade cores (or fragments thereof).

In all of the unmixed assemblages, the CRUDE and UNCERTAIN categories (both of which indicate little skill in stoneworking) constitute the major portion of the assemblages. With some exceptions, they constitute about 80% of the obsidian in each assemblage and 90 to 95% of the non-obsidian. The exceptions, which have lower percentages, have either relatively more simple flakes and/or more blades. More of the non-obsidian may be classified as UNCERTAIN simply because of the greater difficulty in interpreting the poorer conchoidal fracture surfaces of non-obsidian. However, it is clear that the major differences between obsidian and non-obsidian are: the presence of blades in the former and their complete absence in the latter; the presence of bifacially-retouched pieces in the former and their almost complete absence in the latter.

As to the relative abundance of GOOD quality knapping, except for the Loma de Atoto ("A") assemblages, GOOD quality work constitutes 9 to 11% of the obsidian of unmixed assemblages. In both Loma de Atoto assemblages, GOOD quality work constitutes almost two times the percentages of the other assemblages, i.e. about 17% (the difference is somewhat diminished by the relatively smaller amount of BIFCL at Loma de Atoto). The difference is due to relative greater occurrence of simple flakes, rejuvenation flakes, and fine retouch flakes. Within the non-obsidian materials, there appears to be a gradual increase in GOOD quality work (between 5 and 7% from EH-3 to FI-1, between 10 and 19% from FI-2 to FI-4). However, Loma de Atoto assemblages are again exceptional in their higher percentages of GOOD quality work, all of it here, though, being due to higher percentages of simple flakes.

The excellent quality work (EXCLT), that of the blade-core reduction strategy, is found only in obsidian working (the morphology of one non-obsidian item suggests that it is possibly a lame à crête but some of its dorsal facets are not perpendicular to the longitudinal ridge). Virtually all of this is in the form of blades (usually fragments).

Blades constitute between 11 and 13% of the obsidian from EH-3 to FI-2 and appear to decrease to between 5 and 9% of the obsidian during FI-3. However, the low percentage of 5.5% for A36TOTOL at Loma at Atoto may be part of a spatially distinctive pattern since it conforms with the low percentages reported (tentative findings) for the nearby site of Tlatilco (in the refuse deposits, not the burials, Tolston 1971: 273). (Also, the variation evidenced may simply be due to sampling error.) During FI-4, blades appear to increase in relative frequency, rising to 10% (still lower than pre-FI-3 times) at Loma de Atoto and jumping to a very high 24.7% at El Arbolillo West.

Findings, with regard to blades, in the Basin of Mexico seem to depart somewhat from the findings in Chalchuapa, El Salvador, which show blades continually on the increase. Sheets (1974; 52-54, 15, 286-287) found, at Chalchuapa, that blades in the Early and the early part of the Middle Preclassic, constituted between 5 and 10% of the chipped stone (almost all of which was obsidian). In the later part of the Middle Preclassic, they constituted between 10 and 20% of the chipped stone. Finally, at Chalchuapa, blades were generally between 20 and 50% of the chipped stone from the end of the Middle Preclassic through the Late Preclassic.

In the Basin of Mexico collections studied there are no blade cores, core tablets or other such core debitage. However, three smash flakes, 1 in A37ATOTO and 2 in L56UPAST, have characteristics which indicate that they probably are from the smashing of blade cores. Such is the limited extent of support for Vaillant's assertion regarding waste flakes at Zacatenco (1930: 37):

> The flakes seem to show that after the core of obsidian was too small to produce blades of requisite length, it was then broken up and the fragments were chipped into arrowheads. . .

Table 4.4: The "Uncertain" Category--An Alternative View

Table 4.4 presents a slight revision of the data of Table 4.3 with regard to the UNCERTAIN category. Since UNCERTAIN reflects either crude or simple flaking, I have, as an estimate of how much is which, divided UNCERTAIN obsidian and non-obsidian of the unmixed assemblages proportionately between the CRUDE and SIMPLE categories. The underlying assumption for this measure is that the same proportion of crude and simple flaking is present among the uncertain specimens as is distinguishable in the assemblage.

The overall picture is generally the same, if more conservatively approached, as is achieved by considering the composite CRUDE + UNCERTAIN category of Table 4.3. However, some differences can be seen. Namely, simple flaking of non-obsidian seems to be: (1) relatively greater than that of obsidian; (2) considerably more frequent from FI-2 to FI-4 (about 26% of the non-obsidian is classified as SIMPLE--26.1% in L55ARBOL, 17.7% in L56UPAST, 25.0% in A36TOTOL, 27.7% in A37ATOTO, 25.3% in E47UCUAU) than from EH-3 to FI-1 (9.5% in P14BOMBA, 12.5% in P13LAYOY, 9.8% in P12EAYOT, that is, about 11% in the Tlapacoya assemblages). Also, by separating SIMPLE from the other GOOD subdivisions and by considering these other GOOD subdivisions (except for BIFCL) as a separate category (SPECIAL), it is clear that there is virtually no special flaking (no ridged flakes, rejuvenation flakes, fine flakes) of non-obsidian.

Table 4.4. Amendation of Manufacturing Class.

	CRUDE+[a]		SIMPLE+[b]		SPECIAL		BIFCL[c]		EXCLT		TOTAL	
	OBS	NON	OBS	NON	OBS	NON	OBS	NON	OBS	NON	OBS	NON
E47UCUAU #	52	50	6	17	3	0	0	0	20	0	81	67
%	64.2	74.6	7.4	25.3	3.7	0.0	0.0	0.0	24.7	0.0		
A37ATOTO #	125	61	28	23	8	0	2	1	19	0	180	84
%	69.4	72.6	15.6	27.3	4.4	0.0	1.1	1.2	10.6	0.0		
A30UNKNO #	25	5	2	3	0	0	1	0	2	0	29	8
%	86.2	62.5	6.9	37.5	0.0	0.0	3.4	0.0	6.9	0.0		
A36TOTOL #	121	41	26	14	8	1	1	1	9	1	164	57
%	73.8	71.9	15.9	24.6	4.9	1.8	0.6	1.8	5.5	1.8		
L56UPAST #	134	159	11	44	4	0	4	1	16	0	165	203
%	81.2	78.3	6.7	21.7	2.4	0.0	2.4	0.5	9.7	0.0		
L55ARBOL #	85	66	10	23	1	0	4	0	14	0	110	89
%	77.3	74.2	9.1	25.8	0.9	0.0	3.6	0.0	12.7	0.0		
P14BOMBA #	387	101	42	11	17	0	8[d]	1	66	0	512	112
%	75.6	90.2	8.2	9.8	3.3	0.0	1.6	0.9	12.9	0.0		
P13LAYOT #	258	111	33	16	5	1	5[e]	0	37	0	333	128
%	77.5	86.7	9.9	12.5	1.5	0.8	1.5	0.0	11.1	0.0		
P12EAYOT #	64	38	11	4	0	0	2	0	10	0	85	42
%	75.3	90.5	12.9	9.5	0.0	0.0	2.4	0.0	11.8	0.0		

a. CRUDE plus a proportional part of UNCERTAIN (see Table 4.3).

b. SIMPLE plus a proportional part of UNCERTAIN.

c. BIFCL also proportionately divided up, as part of UNCERTAIN, between CRUDE+ and SIMPLE+ (the TOTAL takes into account this duplication).

d. Two of these appear to be simple flakes, one appears to be a smash flake.

e. One of these appears to be a simple flake.

Table 4.5a-h: Manufacturing Classes Controlling for the Type of Raw Material

If the various subgroups of raw material distinguished (Table 4.1) do indeed represent different sources, it would be of interest to consider what was done to them. Were there different procurement and manufacturing systems for the different types of material?

Table 4.5a shows the manufacturing class information for GRAY (which is, presumably, source TA-79). Gray specimens, which comprise the bulk of obsidian in unmixed assemblages, run the gamut of manufacturing classes found in these assemblages, although some classes are found only in trace amounts. The largest category is CRUDE+ with 1,111 (76.4%) of the 1455 gray specimens in unmixed assemblages (CRUDE+ includes SMASH, PSMASH, MULT, PMULT and a proportional amount of UNCERTAIN--see Tables 4.3 and 4.4). Next are SIMPLE+ with 153 (10.5%) and BLADES with 151 (10.4%) specimens, then RIDGED flakes with 16 (1.1%), and less than 1% each for PREJUV, REJUV, FINE, BCORE, and BIFCL. (The GRAY specimens of the mixed assemblages are not comparable to those of the unmixed assemblages--they may include some ANOM2 and FUZZY specimens since the mixed assemblages were not recoded to take into account such categories.)

The Early Horizon assemblages appear to have relatively less GRAY than First Intermediate assemblages, although GRAY is over 80% of the obsidian in both. Early Horizon assemblages have about 83% (84.7% in P12EAYOT and 81.7% in P13LAYOT), while First Intermediate assemblages have about 90% (93.4% in P14BOMBA, 87.9% in L56UPAST, 93.9% in A36TOTOL, 89.4% un A37ATOTO) with two exceptions, 77.3% in L55ARBOL and 72.8% in E47UCUAU (both of these have relatively more

Table 4.5a. Manufacturing Class controlling for Gray Obsidian.

	SMASH	FSMASH	MULT	FMULT	UNCERTAIN[a]	SIMPLE	RIDGED	PREJUV	REJUV	FINE	BLADE	BCORE	BIFCL[a]	Total GRAY	S[b]	A[c]
E47MCUAU[e] # %	11 10.0				70 63.6		6 5.4				23 20.9			110	184 59.8	286 38.5
E47UCUAU # %	19 32.2	4 6.8	3 5.1	2 3.4	13 22.0	3 5.1		1 1.7	1 1.7		13 22.0			59	81 72.8	148 39.9
A37ATOTO # %	55 34.2	18 11.2	12 7.5	1 0.6	30 18.6	18 11.2	2 1.2		3 1.9	3 1.9	18 11.2	1 0.6		161	180 89.4	264 61.0
A30UNKNO # %	10 34.5	5 17.2		1 3.5	10 34.5	1 3.5					2 6.9		1 3.5	29	29 100.0	37 78.4
A36TOTOL # %	52 33.8	19 12.3	11 7.1	3 2.0	36 23.4	19 12.3	1 0.7	1 0.7	2 1.3	1 0.7	9 5.8		1 0.7	154	164 93.9	221 69.7
L56MPAST[e] # %	27 5.8				343 73.6		10 2.1				86 18.5			466	640 72.8	960 48.5
L56UPAST # %	63 43.5	16 11.0	10 6.9		29 20.0	8 5.5	2 1.4	1 0.7	1 0.7		13 9.0	2 1.4	1 0.7	145	165 87.9	368 39.4
L55ARBOL # %	37 43.5	9 10.6	5 5.9		19 22.4	4 4.7					11 12.9		1 1.2	85	110 77.3	199 42.7
P14BOMBA # %	135 28.2	38 8.0	57 11.9	18 3.8	128 26.8	27 5.7	10 2.1	4 0.8		2[d] 0.4	59 12.3		4 0.8	478	512 93.4	624 76.6
P13LAYOT # %	86 31.6	19 7.0	20 7.4	12 4.4	95 34.9	19 7.0	1 0.4	1 0.4			19 7.0		4 1.5	272	333 81.7	461 59.0
P12EAYOT # %	20 27.8	2 2.8	4 5.6	4 5.6	28 38.9	7 9.7					7 9.7		1 1.2	72	85 69.9	127 59.4
Mixed Totals[e] # %	38 6.6				412 71.5		16 2.8				109 18.9	1 0.2		576	824 69.9	1246 46.2
Unmixed Totals # %	477 32.8	130 8.9	122 8.4	41 2.8	388 26.7	106 7.3	16 1.1	8 0.5	7 0.5	6 0.4	151 10.4	3 0.2	13 0.9	1455	1659 87.7	2449 59.4

a. BIFCL included within UNCERTAIN as well as considered separately.

b. S is the obsidian subgroup here, the % is of GRAY within S.

c. A is the total assemblage, the % is of GRAY within A.

d. These have expanding rather than parallel sides.

e. The mixed assemblages are not directly comparable to the unmixed ones.

Table 4.5b. Manufacturing Class controlling for ANOM2.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN[a]	SIMPLE	RIDGED	PREJUV	REJUV	FINE	BLADE	BCORE	BIFCL[a]	Total ANOM2	S[b]	A[c]
E47UCUAU	#	2	2												4	81	148
	%	50.0	50.0													4.9	2.7
A37ATOTO	#	2	1			1									4	180	264
	%	50.0	25.0			25.0										2.2	1.5
A30UNKKO	#														0	29	37
	%															0.0	0.0
A36TOTOL	#														0	164	221
	%															0.0	0.0
L56UPAST	#	2	1			5								1	8	165	368
	%	25.0	12.5			62.5								12.5		4.8	2.2
L55ARBCL	#	2	1	1		3	2					1			10	110	199
	%	20.0	10.0	10.0		30.0	20.0					10.0				9.1	5.0
P14BOMBA	#	2		2		6						2		3	12	512	624
	%	16.7		16.7		50.0						16.7		25.0		2.3	1.9
P13LAYCT	#	2		1		8		1				13			25	333	461
	%	8.0		4.0		32.0		4.0				52.0				7.5	5.4
P12EAYOT	#	4		1		1								1	6	85	127
	%	66.7		16.7		16.7								16.7		7.1	4.7
Unmixed Totals	#	16	5	5		24	2	1				16		5	69	1659	2449
	%	23.2	7.2	7.2		34.8	2.9	1.4				23.2		7.2		4.2	2.8

a. BIFCL included within UNCERTAIN as well as considered separately.

b. S is the obsidian subgroup here, the % is of ANOM2 within S.

c. A is the total assemblage, the % is of ANOM2 within A.

Table 4.5c. Manufacturing Class controlling for GREEN obsidian.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN[a]	SIMPLE	RIDGED	PREJUV	REJUV	FINE	BLADE	BCORE	BIFCL[a]	Total GREEN	S[b]	A[c]
E47MCUAU[d]	#	1				13		5				50			69	184	286
	%	1.4				18.8		7.2				72.5				37.5	24.1
E47UCUAU	#	2	1		1	3						7			14	81	148
	%	14.3	7.1		7.1	21.4						50.0				17.3	9.5
A37ATCTO	#	3				3	2							2	8	180	264
	%	37.5				37.5	25.0							25.0		4.4	3.0
A30UNKNO	#														0	29	37
	%															0.0	0.0
A36TCTOL	#	1				1									2	164	221
	%	50.0				50.0										1.2	0.9
L56MPAST[d]	#	2				56		8				94			160	640	960
	%	1.3				35.0		5.0				58.8				25.0	16.7
L56UPAST	#	1		1		3						1		2	6	165	368
	%	16.7		16.7		50.0						16.7		33.3		3.6	1.6
L55ARBOL	#	4				4	1			1		2		3	12	110	199
	%	33.3				33.3	8.3			8.3		16.7		25.0		10.9	6.0
P14BOMBA	#	4		1		1						2		1	8	512	624
	%	50.0		12.5		12.5						25.0		12.5		1.6	1.3
P13LAYOT	#	1	1	1		7								1	10	333	461
	%	10.0	10.0	10.0		70.0								10.0		3.0	2.2
P12EAYOT	#	1	1									1			3	85	127
	%	33.3	33.3									33.3				3.5	2.4
Mixed Totals[d]	#	3				69		13				144			229	824	1246
	%	1.3				30.1		5.7				62.9				27.8	18.4
Unmixed Totals	#	17	3	3	1	22	3	0	0	1	0	13	0	9	63	1659	2449
	%	27.0	4.8	4.8	1.6	34.9	4.8	0.0	0.0	1.6	0.0	20.6	0.0	14.3		3.8	2.6

a. BIFCL included within UNCERTAIN as well as considered separately.

b. S is the obsidian subgroup here, the % is of GREEN within S.

c. A is the total assemblage, the % is of GREEN within A.

d. The mixed assemblages are not directly comparable to the unmixed ones.

Table 4.5d. Manufacturing Class controlling for CLEAR obsidian.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN	SIMPLE	RIDGED	PREJUV	REJUV	FINE	BLADE	BCORE	BIFCL	Total CLEAR	S[a]	A[b]
E47UCUAU	#	1				1	1			1					4	81	148
	%	25.0				25.0	25.0			25.0						4.9	2.7
A37ATOTO	#	1				3									4	180	264
	%	25.0				75.0										2.2	1.5
A30UNKNO	#														0	29	37
	%															0.0	0.0
A36TOTOL	#	1	1			1					1				4	164	221
	%	25.0	25.0			25.0					25.0					2.4	1.8
L56UPAST	#	1	2			1									4	165	368
	%	25.0	50.0			25.0										2.4	1.1
L55ARBOL	#	2	1												3	110	199
	%	66.7	33.3													2.7	1.5
P14BOMBA	#	3	2			2									7	512	624
	%	42.9	28.6			28.6										1.4	1.1
P13LAYOT	#	6	2	2	1	3									14	333	461
	%	42.9	14.3	14.3	7.1	21.4										4.2	3.0
P12EAYOT	#	1										2			3	85	127
	%	33.3										66.7				3.5	2.4
Unmixed Totals	#	16	8	2	1	11	1	0	0	1	1	2	0	0	43	1659	2449
	%	37.2	18.6	4.7	2.3	25.6	2.3	0.0	0.0	2.3	2.3	4.7	0.0	0.0		2.6	1.8

a. S is the obsidian subgroup here, the % is of CLEAR within S.

b. A is the total assemblage, the % is of CLEAR within A.

Table 4.5e. Manufacturing Class controlling for FUZZY obsidian.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN	SIMPLE	RIDGED	PREJUV	REJUV	FINE	BLADE	DCORE	BIFCL	Total FUZZY	S[a]	A[b]
E47UCUAU	f														0	81	148
	%															0.0	0.0
A37ATOTO	f	1					1								2	180	264
	%	50.0					50.0									1.1	0.8
A30UNKNO	f														0	29	37
	%															0.0	0.0
A36TOTOL	f	1								1					2	164	221
	%	50.0								50.0						1.2	0.9
L56UPAST	f	2													2	165	368
	%	100.0														1.2	0.5
L55ARBOL	f														0	110	199
	%															0.0	0.0
P14BOMEA	f							1				3			4	512	624
	%							25.0				75.0				0.8	0.6
P13LAYOT	f					1		2				5			8	333	461
	%					12.5		25.0				62.5				2.4	1.7
P12EAYOT	f	1													1	85	127
	%	100.0														1.2	0.8
Unmixed	f	5				1	1	3		1		8			19	1659	2449
Totals	%	26.3				5.3	5.3	15.8		5.3		42.1				1.1	0.8

a. S is the obsidian subgroup here, the % is of FUZZY within S.

b. A is the total assemblage, the % is of FUZZY within A.

Table 4.5f. Manufacturing Class controlling for Cryptocrystalline Quartz.

		SMASH	PSMASH	MULT	FMULT	UNCERTAIN[a]	SIMPLE	RIDGED	PREJUV	BCORE	BIFCL[a]	Total CRPTO	S[b]	A[c]
E47MCUAU[d]	#	11				56						67	102	286
	%	16.5				83.6							65.7	23.4
E47LCUAU	#	5	6	6	1	27	6					51	67	148
	%	9.8	11.8	11.8	2.0	53.0	11.8						76.1	34.5
A37ATOTO	#	10	8	9	4	21	10					62	84	264
	%	16.1	12.9	14.5	6.5	33.9	16.1						73.8	23.5
A30UNKNO	#			2		3	1					6	8	37
	%			25.0		37.5	12.5						75.0	16.2
A36TOTOL	#	6	5	7	3	17	7	1		1		47	57	221
	%	12.8	10.6	14.9	6.4	36.2	14.9	2.1		2.1			82.5	21.3
L56MPAST[d]	#	43	30	17	6	152[e]	28					276	320	960
	%	15.6	10.9	6.2	2.2	54.7	10.5						78.3	43.2
L56UPAST	#	34	22	15	4	62	22				1	159	203	368
	%	21.4	13.8	9.4	2.5	39.0	13.8				0.6		78.3	43.2
L55ARBOL	#	13	3	6	26	6						54	89	199
	%	24.1	5.6	11.1	48.1	11.1							60.7	27.2
P14BOMBA	#	12	6	12	3	16	2				1	51	112	624
	%	23.5	11.8	23.5	5.9	31.4	3.9				2.0		45.5	8.2
P13LAYOT	#	11	2	25	5	27	5		1			76	128	461
	%	14.5	2.6	32.9	6.6	35.5	6.6		1.3				59.4	16.5
P12EAYOT	#	3	3	2	1	7						16	42	127
	%	18.8	18.8	12.5	6.3	43.8							81.3	27.5
Mixed Totals[d]	#	54	30	17	6	208[e]	28					343	422	1246
	%	15.7	8.7	5.0	1.7	60.6	8.2						81.3	27.5
Unmixed Totals	#	94	55	84	47	186	53	1	1	1	2	522	790	2449
	%	18.0	10.5	16.1	9.0	35.6	10.2	0.2	0.2	0.2	0.4		66.1	21.3

a. BIFCL included within UNCERTAIN as well as considered separately.

b. S is the non-obsidian subgroup here, the % is of CRPTO within S.

c. A is the total assemblage, the % is of CRPTO within A.

d. The mixed assemblages are not directly comparable to the unmixed ones.

e. One of these appears to be a small flake core.

Table 4.5g. Manufacturing Class controlling for Basalt.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN[a]	SIMPLE	RIDGED	PREUUV	ECORE	BIFCL[a]	Total BSALT	S[b]	A[c]
E47MCUAU[a]	#	1				26						27	102	286
	%	3.7				96.3							26.5	9.4
E47UCUAD	#				1	2						3	67	148
	%				33.3	66.7							4.5	2.0
A37ATOTO	#	2	2	2	1	9	4				1	20	84	264
	%	10.0	10.0	10.0	5.0	45.0	20.0				5.0		23.8	8.6
A30UNKNO	#					2						2	8	37
	%					100.0							25.0	5.4
A36TOTOL	#		1	1		6	1				1	9	57	221
	%		11.1	11.1		66.7	11.1				11.1		15.8	4.1
I56MFAST[a]	#	1		5	1	23	2					32	320	960
	%	3.1		15.6	3.1	71.9	6.3						10.0	3.3
I56UFAST	#	4	2	4	2	22	2					36	203	368
	%	11.1	5.6	11.1	5.6	61.1	5.6						36.0	16.1
L55ARBOL	#	1		3	3	21	4					32	89	199
	%	3.1		9.4	9.4	65.6	12.5						36.0	16.1
P14BOMBA	#	2	3	10	4	29	4					52	112	624
	%	3.9	5.8	19.2	7.7	55.8	7.7						46.4	8.3
P13LAYOT	#	2		8	2	26	3					41	128	461
	%	4.9		19.5	4.9	63.4	7.3						32.0	8.9
P12EAYOT	#	1	1	6	1	13	2					24	42	127
	%	4.2	4.2	25.0	4.2	54.2	8.3						57.1	18.9
Mixed Totals[d]	#	2		5	1	49	2					59	422	1246
	%	3.3		8.5	1.7	83.1	3.3						14.0	4.7
Unmixed Totals	#	12	9	34	14	130	20				2	219	790	2449
	%	5.5	4.1	15.5	6.4	59.4	9.1				0.9		27.7	8.9

a. BIFCL included within UNCERTAIN as well as considered separately.

b. S is the non-obsidian subgroup here, the % is of BSALT within S.

c. A is the total assemblage, the % is of BSALT within A.

d. The mixed assemblages are not directly comparable to the unmixed ones.

Table 4.5h. Manufacturing Class controlling for other Volcanic non-obsidian.

		SMASH	PSMASH	MULT	PMULT	UNCERTAIN	SIMPLE	RIDGED	PREJUV	BCORE	BIPCL	Total VOLCO	S[b]	A[c]
E47MCUAU[d]	#					8						8	102	286
	%					100.0							7.8	2.8
E47UCUAU	#			2		10		1				13	67	148
	%			15.4		76.9		7.7					19.4	8.8
A37ATOTO	#											0	84	264
	%												0.0	0.0
A30UNKNO	#											0	8	37
	%												0.0	0.0
A36TOTOL	#					1						1	57	221
	%					100.0							1.8	0.5
L56MPAST[d]	#					4						4	320	960
	%					100.0							1.3	0.4
L56UPAST	#	1				1	1					3	203	368
	%	33.3				33.3	33.3						1.5	0.8
L55ARBOL	#					3						3	89	199
	%					100.0							3.4	1.5
P14BGMEA	#		1	1		7						9	112	624
	%		11.1	11.1		77.8							8.0	1.4
P13LAYOT	#	1				10						11	128	461
	%	9.1				90.9							8.6	2.4
P12EAYOT	#			1		1						2	42	127
	%			50.0		50.0							4.8	1.6
Mixed Totals[d]	#					12						12	442	1246
	%					100.0							5.3	1.7
Unmixed Totals	#	2	1	4		33	1	1				42	790	2449
	%	4.8	2.4	9.5		78.6	2.4	2.4					5.3	1.7

b. S is the non-obsidian subgroup here, the % is of VOLCO within S.

c. A is the total assemblage, the % is of VOLCO within A.

d. The mixed assemblages are not directly comparable to the unmixed ones.

GREEN).

The only materials indicating any blade core working (aside from the blades themselves) are the three GRAY specimens indicated here. These are the three smash flakes with blade core characteristics that were discussed earlier (see Table 4.3).

Considering variation between assemblages, several minor differences do appear. First, while blades generally comprise between 9 and 12% of the gray obsidian in each assemblage, three assemblages are outside of this range. Two are lower: 7.0% in EH-2 P13LAYOT and 5.8% in FI-3 A36TOTOL. The third is considerably higher--22.0% in FI-4 E47UCUAU. Secondly, there may be a decrease in the relative frequency of SIMPLE flaking from Early Horizon (9.7% and 7.0%) to First Intermediate phases (5.7%, 4.7%, 4.5%, and 5.1%) except for the Loma de Atoto assemblages (12.3%, 11.2%). Thirdly, although only appearing in small amounts, rejuvenation (PREJUV, REJUV) and pressure retouch flakes (FINE) occur in greater amounts in the Loma de Atoto assemblages (3.7% in A37ATOTO and 2.6% in A36TOTOL).

Table 4.5b shows the manufacturing class information for ANOM2 obsidian. ANOM2 constitutes only 4.2% (69 specimens) of the obsidian of unmixed assemblages. While it has a similar distribution to that of GRAY, there are some differences (interpretation, however, should be tempered by the small sample sizes). First, blades comprise a relatively large part of this (24.6% as opposed to 10.4% of GRAY). All blades occur in assemblages from EH-4 to FI-2, almost all of them in EH-4 P13LAYOT. Secondly, ANOM2.BIFCL occurs in relatively high proportion (7.2%) compared with that of GRAY (0.9%). The classes present in trace amount in GRAY are not present in ANOM2, this quite possibly being due to the small ANOM2 sample sizes.

Table 4.5c shows the manufacturing class information for GREEN. The 63 green obsidian specimens in unmixed assemblages (again a set of small samples) have a similar distribution to that for ANOM2. As in ANOM2, blades are a relatively large part of the material (20.6%). BIFCL specimens are even more numerous than in ANOM2 (14.3%, double that for ANOM2). Again, except for 1 possible rejuvenation flake, rejuvenation flakes and pressure retouch flakes are absent. So too are ridged flakes.

Three assemblages have no GREEN blades. While this may merely be sampling error, certain patterns are suggestive. First, A36TOTOL, has a low percentage of blades altogether. Secondly, P13LAYOT has a relatively high percentage of ANOM2 and FUZZY blades.

By contrast, in the mixed assemblages, the majority of GREEN specimens occurs as blades (62.9%--also, as noted earlier, GREEN constitutes a large part of these mixed assemblages). An additional 5.7% are ridged flakes.

Table 4.5d shows the manufacturing class information for CLEAR obsidian. There are 43 CLEAR specimens, 2.6% of the obsidian in unmixed assemblages. Their distribution is somewhat different from the preceding obsidian subgroups. There is a relatively low proportion of blades, the only two blades occurring in EH-3 P12EAYOT. Given the low proportion of blades, simple flakes, rejuvenation flakes and retouch flakes, the absence of ridged flakes and bifacially worked items, the profile for CLEAR is heavily weighted in the direction of CRUDE (and CRUDE+) manufacturing. P12EAYOT is exceptional in deviating from this pattern (again, however, the small sample size warrants caution).

Table 4.5e shows the manufacturing class information for FUZZY obsidian. There are only 19 FUZZY specimens, 1.1% of the obsidian in unmixed assemblages. Their distribution is unusual in showing the highest proportion of blades (42.1%). If the blade-like RIDGED flakes (15.8%) are included, then blade-like specimens constitute almost 60% of FUZZY obsidian debitage. This unusual pattern becomes even more pronounced if one considers variation between assemblages. All blades and ridged flakes occur in two sequent phases at Tlapacoya (EH-4 P13LAYOT and FI-1 P14BOMBA). In those two phases, blades and ridged flakes constitute 11 of the 12 FUZZY specimens (91.7%).

Table 4.5f shows the manufacturing class information for crypto-crystalline quartz (various cherts and chalcedonies). There is little in the manufacturing that indicates any specialized skill. The two possible quality work debitage specimens in A36TOTOL (the ridged flake and the crested flake coded as BCORE) become extremely doubtful when one considers that there is no other evidence of non-obsidian blade-working (no other evidence in the other 520 CRPTO specimens in the unmixed assemblages or, for that matter, all 863 other CRPTO specimens). It is likely, therefore, that these two specimens merely have chance morphological similarities to blade-working debitage. There are two bifacially shaped specimens (1 in L56UPAST and 1 in P14BOMBA) and one possible rejuvenation flake (in P13LAYOT). Otherwise debitage is either of CRUDE or SIMPLE type (including one specimen in L56MPAST which appears to be a small flake core).

Table 4.5g, showing the manufacturing class information for basalt, similarly indicates either CRUDE or SIMPLE debitage, except for 2 bifacially shaped items at Loma de Atoto. There is, however, indication that multiple flaking is more prevalent than smash flaking in working basalt. In all the obsidian subgroups, evidence of smash flaking is much more prevalent than multiple flaking, and in CRPTO, the two are found in similar proportions, whereas in BSALT, multiple flaking is almost three times more prevalent. A definite assertion that basalt is worked somewhat differently from the other materials is compromised by the large number of UNCERTAIN non-obsidian items. It remains an interesting and not-to-be-ignored possibility, however.

Finally, Table 4.5h indicates that the bulk of the small number of other volcanics is UNCERTAIN.

Table 4.6a-b: Types of Raw Material used for Blades and Bifacially Worked Artifacts

Information on the types of materials used for blades and bifacially-shaped pieces is provided here. Table 4.6a indicates the materials used for blades and Table 4.6b those used for bifacially-shaped pieces.

Most blades in unmixed assemblages are of GRAY obsidian. Indeed, during FI-3 and 4, Loma de Atoto blades are all of GRAY obsidian, and at the El Arbolillo sites, the only other blade material is GREEN obsidian. On the other hand, from EH-3 to FI-2, blades of other obsidian subgroups are present as well. In EH-3 at Tlapacoya (P12EAYOT), two of the 10 blades are of CLEAR obsidian. In EH-4 at Tlapacoya (P13LAYOT), 13 (35.1%) of the 37 blades are of ANOM2 obsidian and another 5 (13.5%) are of FUZZY obsidian. Such high percentages of FUZZY and ANOM2 obsidian are clearly anomalous given the relatively small number of non-blade artifacts of these materials. Of course, the exceedingly low 51.4% proportion for GRAY obsidian blades is the complementary anomaly. In FI-1 at Tlapacoya (P14BOMBA), 3 (4.5%) of 66 blades are of FUZZY obsidian and 2 (3.0%) of ANOM2 obsidian. Finally, in FI-2 at El Arbolillo East (L55ARBOL), 1 (7.1% of this very small sample) of 14 blades is of ANOM2 obsidian.

In the mixed assemblages, on the contrary, most blades are of GREEN obsidian, with GRAY second. There are also rare occurrences of CLEAR and ANOM2 obsidian blades (but these figures are suspect since the mixed assemblages were not recoded).

Table 4.6b indicates the limited finds of bifacially-shaped (retouched on the "faces," not merely the margins) pieces (including

Table 4.6a. MATSRCE controlling for BLADES.

		GREEN	FUZZY	CLEAR	ANOM2	GRAY	Total BLADE	S[a]	A[b]
E47MCUAU	#	50		1	1	23	75	184	286
	%	66.7		1.3	1.3	30.7		41.0	26.3
E47UCUAU	#	7				13	20	81	148
	%	35.0				65.0		24.7	13.5
A37ATOTO	#					18	18	180	264
	%					100.0		10.0	6.8
A30UNKNO	#					2	2	29	37
	%					100.0		6.9	5.4
A36TOTOL	#					9	9	164	221
	%					100.0		5.5	4.1
L56MPAST	#	94		2		86	182	640	960
	%	51.6		1.1		47.3		28.4	19.0
L56UPAST	#	1				13	14	165	368
	%	7.1				92.9		8.5	3.8
L55ARBOL	#	2			1	11	14	110	199
	%	14.3			7.1	78.6		12.7	7.0
B14BOMBA	#	2	3		2	59	66	512	624
	%	3.0	4.5		3.0	89.4		12.9	10.6
P13LAYOT	#		5		13	19	37	333	461
	%		13.5		35.1	51.4		11.1	8.0
P12EAYOT	#	1		2		7	10	85	127
	%	10.0		20.0		70.0		11.8	7.0
Mixed Totals	#	144		3	1	109	257	824	1246
	%	56.0		1.7	0.4	42.4		31.2	20.6
Unmixed Totals	#	13	8	2	16	151	190	1659	2449
	%	6.8	4.2	1.1	8.4	79.4		11.5	7.8

a. S is the obsidian subgroup here, % is of blades within S.

b. A is the total assemblage, % is of blades within A.

Table 4.6b. MATSRCE controlling for BIFCL (see Table 4.3 for totals and percentages for BIFCL).

	GREEN	ANOM2	GRAY	CRPTO	BSALT	
E47UCUAU #						
A37ATOTO #	2				1	
A30UNKNO #			1			
A36TOTOL #			1		1	
L56UPAST #	2	1	1	1		
L55ARBOL #	3		1			
P14BOMBA #	1	3	4	1		
P13IAYOT #	1		4			
P12EAYOT #		1	1			
Unmixed # Totals %	9 29.0	5 16.1	13 41.9	2 6.5	2 6.5	31

some of the "points") in the unmixed assemblages (compare Table 4.8 on USECLSS for data on edge-shaped items--which includes the rest of the "points" and other edge-retouched pieces). 27 (87.1%) of the 31 items are obsidian and an unexpected 4 (12.9%) are non-obsidian. The major material, in this small sample, is GRAY obsidian, GREEN an unexpectedly high second (9 of 31), followed by ANOM2 (5 of 31), CRPTO (2 of 31) and BSALT (2 of 31).

Table 4.7: Basin of Mexico Artifacts Trace-Analyzed by Robert Cobean at Yale University

Table 4.7 shows the manufacturing class information for the 54 specimens trace analyzed by Robert Cobean using the Yale University facilities. The sample analyzed was not randomly chosen--selection was made so as to get a broad range of obsidian based upon visually observed distinctions.

Of the Early Preclassic materials analyzed, blades are of non-local obsidian (i.e. from outside the Basin of Mexico), whereas flakes are of local obsidian. In fact, the 4 El Ocotito specimens are all blades. These El Ocotito specimens had originally been selected for analysis as rather usual streaked or banded gray obsidian--it is therefore unusual that none of the banded gray obsidian blades turned out to be from TA-79. It is unfortunate that all El Ocotito-assigned specimens were lost at the Yale University facilities and could not be subjected to visual re-examination (or to a second trace analysis at Brookhaven National Laboratory as part of Tolstoy's exchange patterns project). It is still uncertain, therefore, if they might be distinguished on the basis of some thus far ignored visual characteristics.

However, some of the other specimens appear to be visually distinctive. The Zinapécuaro specimen had black cottony swaths in a cloudy gray medium; and the Group A pieces were transparent (compare earlier discussions of FUZZY and CLEAR).

Re: the Middle Preclassic (FI-1 to 4) materials analyzed, blades are made of both local and non-local obsidian--use of local

Table 4.7. Basin of Mexico artifacts analyzed by Robert Cobean at Yale University.

	Blades				Shaped Pieces					Other				Totals
	I	II	III	IV	I	III	V	VI	VIII	I	II	III	VII	
E47MCUAU	1													1
E47UCUAU		1								4	1			6
A37ATOTO	1		1				1			3	2	1		9
A30UNKNO														
A36TOTOL	1					1				3				5
L56MPAST										1				1
L56UPAST	1													1
L55ARBOL		1						1		3				5
P14BOMBA	1			1	1					2				5
P13LAYOT				2						3				5
P12EAYOT		1	1	1						4				7
Mixed Totals	1									1				2
Unmixed Totals	4	3	2	4	1	1	1	1		22	3	1		43
Tlatilco sample									1	7			1	9

I - TA-79	36
II - Pachuca, Hidalgo	6
III - Group A (Paredón?)	4
IV - El Ocotito, Guerrero (?)	4
V - Zinapécuaro, Michoacán	1
VI - Panjamo, Queretaro	1
VII - Group C (?)	1
VIII- New Unknown Source	1

obsidian appearing to be predominant, Loma de Atoto appears to be somewhat unusual in having 3 Group A specimens,

Table 4.8: Use Classes

Table 4.8 provides data on USECLSS, one of the variables devised to measure the evidence of artifact usage which could be detected with the unaided eye (save perhaps for a 10X eye-piece). Two levels of precision are indicated.

The more gross level of precision consists of two values: MODIFIED and UNMODIFIED. Each of the two values was established by lumping somewhat finer values as follows. UNMODIFIED was produced by lumping five values (ordered according to increasing edge modification): NONE: INDET, indeterminate; NIBBLED, edges have very small nicking scars--their interpretation is uncertain, for they might be either accidental/post-depositional edge damage or traces of use; SLIGHT, continuous sections of edge scarring and/or abrasion--interpretively these are probably "use" retouch; NATPT, naturally-pointed flake (the flake was not retouched to form a point) with slight evidence of use. The other gross value, MODIFIED, was produced by lumping three finer values: EDGE, at least one edge has been considerably retouched, but the retouching does not shape the flake to any overall pattern--this is either use and/or design retouch; NONPT, specimen shaped by retouch to overall pattern, but the specimen is not projectile-point-like--this is design retouch perhaps with use modification; POINT, specimen shaped by retouch to projectile-point-like shape. (Again, the mixed assemblages are not exactly comparable to the unmixed assemblages since the mixed ones were not recoded. While the mixed assemblages have more modification than the unmixed assemblages, the data shown here is somewhat inflated because of a change in measuring

Table 4.8. USECLSS, Evidence of Modification From or For Use.

		UNMODIFIED													
		NONE			INDET			NIBBLED			SLIGHT			NATPT	
	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL
E47MCUAU #	25	68	93	2	0	2	37	19	56	58	7	65	1	0	1
%	13.6	66.7	32.5	1.1	0.0	0.7	20.1	18.6	19.6	31.5	6.9	22.7	0.5	0.0	0.3
E47UCUAU #	27	61	88	0	0	0	21	3	24	19	3	22	2	0	2
%	33.3	91.0	59.5	0.0	0.0	0.0	25.9	4.5	16.2	23.5	4.5	14.9	2.5	0.0	1.4
A37ATOTO #	92	68	160	0	0	0	44	13	57	27	2	29	0	0	0
%	51.1	81.0	60.6	0.0	0.0	0.0	24.4	15.5	21.6	15.0	2.4	11.0	0.0	0.0	0.0
A30UNKNO #	15	4	19	0	0	0	7	2	9	6	2	8	0	0	0
%	51.7	50.0	51.4	0.0	0.0	0.0	24.1	25.0	24.3	20.7	25.0	21.6	0.0	0.0	0.0
A36TOTOL #	95	43	138	0	0	0	46	8	54	18	2	20	0	0	0
%	57.9	75.4	62.4	0.0	0.0	0.0	28.0	14.0	24.4	11.0	3.5	9.0	0.0	0.0	0.0
L56MPAST #	155	285	440	3	1	4	154	22	176	192	10	202	0	0	0
%	24.2	89.1	45.8	0.5	0.3	0.4	24.1	6.9	18.3	30.0	3.1	21.0	0.0	0.0	0.0
L56UPAST #	62	174	236	0	0	0	70	19	89	21	8	29	1	0	1
%	37.6	85.7	64.1	0.0	0.0	0.0	42.4	9.3	24.2	13.3	3.9	8.2	0.6	0.0	0.3
L55ARBOL #	51	83	134	3	0	3	28	5	33	15	1	16	0	0	0
%	46.4	93.3	67.3	2.7	0.0	1.5	25.5	5.6	16.6	13.6	1.1	8.0	0.0	0.0	0.0
P14BOMBA #	234	91	325	0	0	0	177	12	189	71	6	77	0	0	0
%	45.7	81.3	52.1	0.0	0.0	0.0	34.6	10.7	30.3	13.9	5.4	12.3	0.0	0.0	0.0
P13LAYOT #	168	108	276	2	0	2	112	13	125	38	6	44	0	0	0
%	50.5	84.4	59.9	0.6	0.0	0.4	33.6	10.2	27.1	11.4	4.7	9.5	0.0	0.0	0.0
P12EAYOT #	35	33	68	2	0	2	30	4	34	11	5	16	0	0	0
%	41.2	78.6	53.5	2.4	0.0	1.6	35.3	9.5	26.8	12.9	11.9	12.6	0.0	0.0	0.0
Mixed #	180	353	533	5	1	6	191	41	232	250	17	267	1	0	1
Totals %	21.8	83.6	42.8	0.6	0.2	0.5	23.2	9.7	18.6	30.3	4.0	21.4	0.1	0.0	0.1
Unmixed #	779	665	1444	7	0	7	535	79	614	226	35	261	3	0	3
Totals %	47.0	84.2	59.0	0.4	0.0	0.3	32.2	10.0	25.1	13.6	4.4	10.7	0.4	0.0	0.1

Table 4.8 (Cont.)

		UNMODIFIED			MODIFIED								
		Subtotal			EDGE			NONPT			POINT		
		OBS	NON	TL	OBS	NON	TL	OBS	NON	TL	OBS	NON	TL
E47MCUAU	#	123	94	217	55	8	63	3	0	3	3	0	3
	%	66.8	92.2	75.9	29.9	7.8	22.0	1.6	0.0	1.0	1.6	0.0	1.0
E47UCUAU	#	69	67	136	8	0	8	2	0	2	2	0	2
	%	85.2	100.0	91.9	9.9	0.0	5.4	2.5	0.0	1.4	2.5	0.0	1.4
A37ATOTO	#	163	83	246	12	0	12	0	0	0	5	1	6
	%	90.6	98.8	93.2	6.7	0.0	4.5	0.0	0.0	0.0	2.8	1.2	2.3
A36TOTOL	#	159	53	212	4	4	8	0	0	0	1	0	1
	%	97.0	93.0	95.9	2.4	7.0	3.6	0.0	0.0	0.0	0.6	0.0	0.5
I56MPAST	#	154	201	355	5	1	6	2	1	3	4	0	4
	%	93.3	99.0	96.5	3.0	0.5	1.6	1.2	0.5	0.8	2.4	0.0	1.1
I55ARBOL	#	97	89	186	9	0	9	1	0	1	3	0	3
	%	88.2	100.0	93.5	8.2	0.0	4.5	0.9	0.0	0.5	2.7	0.0	1.5
P14BOMBA	#	482	109	591	20	0	20	5	1	6	5	2	7
	%	94.1	97.3	94.7	3.9	0.0	3.2	1.0	0.9	1.0	1.0	1.8	1.1
P13LAYOT	#	320	127	447	7	1	8	3	0	3	3	0	3
	%	96.1	99.2	97.0	2.1	0.8	1.7	0.9	0.0	0.7	0.9	0.0	0.7
P12EAYOT	#	78	42	120	5	0	5	0	0	0	2	0	2
	%	91.8	100.0	94.5	5.9	0.0	3.9	0.0	0.0	0.0	2.4	0.0	1.6
Mixed Totals	#	627	411	1038	167	10	177	16	0	16	14	0	14
	%	76.1	97.4	83.3	20.3	2.4	14.2	1.9	0.0	1.3	1.7	0.0	1.1
Unmixed Totals	#	1550	779	2329	70	6	76	14	2	16	25	3	28
	%	93.4	98.6	95.1	4.2	0.8	3.1	0.8	0.3	0.7	1.5	0.4	1.1

Table 4.8 (Cont.)

		MODIFIED Subtotal			TOTALS		
		OBS	NON	TL	OBS	NON	TL
E47MCUAU	#	61	8	69	184	102	286
	%	33.2	7.8	24.1			
E47UCUAU	#	12	0	12	81	67	148
	%	14.8	0.0	8.1			
A37ATOTO	#	17	1	18	180	84	264
	%	9.4	1.2	6.8			
A30UNKNO	#	1	0	1	29	8	37
	%	3.4	0.0	2.7			
A36TOTOL	#	5	4	9	164	57	221
	%	3.0	7.0	4.1			
I56MPAST	#	136	3	139	640	320	960
	%	21.3	0.9	14.5			
I56UPAST	#	11	2	13	165	203	368
	%	6.7	1.0	3.5			
I55ARBOL	#	13	0	13	110	89	199
	%	11.8	0.0	6.5			
P14BOMBA	#	30	3	33	512	112	624
	%	5.9	2.7	5.3			
P13IAYOT	#	13	1	14	333	128	461
	%	3.9	0.8	3.0			
P12EAYOT	#	7	0	7	85	42	127
	%	8.2	0.0	5.5			
Mixed Totals	#	197	11	208	824	422	1246
	%	23.9	2.6	16.7			
Unmixed Totals	#	109	11	120	1659	790	2449
	%	6.6	1.4	4.9			

criteria.)

Generally, all of the unmixed assemblages are comparable in having little evidence of modification of flakes either from or for use. Considering the obsidian first, almost half shows no macroscopic evidence of modification, almost a third is merely nibbled, 14% exhibits slight modification, while only 4% is EDGE modified and less than 2% is shaped to an over-all pattern. Individual assemblages vary only slightly from this overall use profile. The possibly meaningful departures (and they are all slight departures) are: L55ARBOL, which seems to have a relatively higher amount of MODIFIED (both EDGE and POINT pieces); A36TOTOL, which, in contrast with the others, has a relatively small amount of MODIFIED, having no POINTS and a large amount of NONE; A37ATOTO, which has the relatively higher amount of MODIFIED; and E47UCUAU, which shows considerably higher MODIFIED percentages.

When considering the non-obsidian, however, each of the deviations above are offset by complementary deviations from the non-obsidian use profile, as the following indicates. First, the general use profile for non-obsidian shows even less modification of flakes from or for use than does obsidian's: almost 85% shows no macroscopic evidence of modification, an additional 10% is merely nibbled, and 4% exhibits slight modification--thus almost 99% of the non-obsidian is UNMODIFIED. The individual assemblages which depart from this profile tend to do so in a manner opposite of that for the obsidian in the same assemblages: L55ARBOL has a relatively higher amount of NONE with no MODIFIED at all; A36TOTOL has a relatively high proportion of EDGE pieces, A37ATOTO has a single non-obsidian POINT as its sole MODIFIED item; and E47UCUAU has no MODIFIED non-obsidian.

While, in general, obsidian is more modified than non-obsidian, the suggestion of a complementary distribution for the non-obsidian and obsidian deviations from pattern might add some sense of "free variation"--i.e., perhaps the obsidian and non-obsidian could be used somewhat interchangeably for some purposes.

Table 4.9: Uses of the Manufacturing Classes

Table 4.9 presents data resulting from the comparison of manufactuting and use categories (for the obsidian of unmixed assemblages). The question raised, essentially, is: how are the different manufacturing classes used?

For this table, the manufacturing categories were reduced to 8 by lumping the "possible" and more certain variants (e.g. PSMASH lumped with SMASH as P/SMASH) and by including the 3 BCORE items with P/SMASH since they are smash flake remnants of blade cores. Also the use categories were reduced to 4 ranked categories by: lumping NONE, INDET and NIBBLED (U1); lumping SLIGHTLY and NATPT (U2); leaving EDGE unchanged (U3); and lumping NONPT and POINT (U4).

The use information for each of the 8 manufacturing categories (for the obsidian in each of the 9 unmixed assemblages) is indicated. The percentage of each manufacturing category's use subdivisions to the total for each use category is also indicated. In order to interpret these figures, the manufacturing category's subtotal and its percentage within each obsidian assemblage is presented. Using reasoning similar to that employed in χ^2 tests, one can argue that if use is not related to manufacturing category, then the percentage indicated for each of its use subdivisions should be the same as the percentage of the manufacturing category to the total obsidian in the assemblage, and that departures from such expectations might imply that there is a relationship between use and manufacturing categories. For example, P/SMASH from E47UCUAU is 38.3% of the obsidian assemblage. If there is no relationship between use and manufacturing categories then, this

Table 4.9. Uses of the Manufacturing Classes for Obsidian Specimens in Unmixed Assemblages.

		P/SMASH					P/MULT					UNCERTAIN				
		U1	U2	U3	U4	MT[a]	U1	U2	U3	U4	MT	U1	U2	U3	U4	MT
E47UCUAU	#	22	6	1	2		2	4	0	0		11	0	4	2	
	%	45.8	28.6	12.5	50.0	38.3	4.2	19.0	0.0	0.0	7.4	22.9	0.0	50.0	50.0	21.0
A37ATOTO	#	66	11	4	1		11	1	1	0		29	3	4	2	
	%	48.2	40.7	33.3	25.0	45.6	8.0	3.7	8.3	0.0	7.2	21.3	11.1	33.3	40.0	13.9
A30UNKNO	#	11	4		0		1	0		0		7	2		1	
	%	50.0	66.7		0.0	51.7	4.5	0.0		0.0	3.4	31.8	33.3		100.0	34.5
A36TOTOL	#	69	6	1			12	2	0			32	2	3	1	
	%	48.6	33.3	25.0		46.4	8.5	11.1	0.0		8.5	22.7	11.1	75.0	100.0	23.2
I56UPAST	#	77	10	2	1		10	1	0	0		29	4	1	4	
	%	57.5	45.5	40.0	25.0	54.5	7.5	4.5	0.0	0.0	6.7	22.0	18.2	20.0	66.7	23.0
I55ARBOL	#	46	5	5	0		6	0	0	0		18	2	2	4	
	%	56.1	33.3	55.6	0.0	50.9	7.3	0.0	0.0	0.0	5.5	22.0	13.3	22.2	100.0	23.6
P14BOMBA	#	160	23	3	1		71	6	0	1		105	15	10	5	
	%	38.8	32.4	15.0	11.1	36.5	17.2	8.5	0.0	11.1	15.2	25.5	21.1	50.0	50.0	26.4
P13IAYOT	#	104	13	1	0		34	3	0	0		99	9	3	5	
	%	36.7	34.2	14.3	0.0	35.4	12.0	7.9	0.0	0.0	11.1	35.1	23.7	42.9	83.3	34.8
P12EAYOT	#	25	3	2	0		8	1	0	0		22	2	3	2	
	%	36.8	27.2	40.0	0.0	35.3	11.8	9.1	0.0	0.0	10.6	32.8	18.2	60.0	100.0	34.1
Unmixed Totals	#	580	81	19	5		155	18	1	1		352	39	30	26	
	%	43.7	35.4	27.1	15.6	41.3	11.7	7.9	1.4	3.1	10.5	26.6	17.0	42.9	66.7	26.9

a. MT = Manufacturing Class subtotals

Table 4.9 (Cont.)

		SIMPLE					RIDGED					P/REJUV				
		U1	U2	U3	U4	MT	U1	U2	U3	U4	MT	U1	U2	U3	U4	MT
E47UCUAU	#	2	2	0	0							3	0	0	0	
	%	4.2	9.5	0.0	0.0	4.9						6.3	0.0	0.0	0.0	3.7
A37ATOTO	#	17	2	0	2		2	0	0	0		1	1	1	0	
	%	12.4	7.4	0.0	50.0	11.7	1.5	0.0	0.0	0.0	1.1	0.7	3.7	8.3	0.0	1.7
A30UNKNO	#	1	0		0											
	%	4.5	0.0		0.0	3.4										
A36TOTOL	#	16	3	0			1	0	0			3	1	0		
	%	11.3	16.7	0.0		11.6	0.7	0.0	0.0		0.6	2.1	5.6	0.0		2.4
L56UPAST	#	7	1	0	0		1	1	0	0		1	0	1	0	
	%	5.2	4.5	0.0	0.0	4.8	0.7	4.5	0.0	0.0	1.2	0.7	0.0	20.0	0.0	1.2
L55ARBOL	#	7	0	0	0							1	0	0	0	
	%	8.5	0.0	0.0	0.0	6.4						1.2	0.0	0.0	0.0	0.9
P14BOMBA	#	25	2	0	2		7	3	1	0		4	0	0	0	
	%	6.1	2.8	0.0	22.2	4.3	1.7	4.2	5.0	0.0	2.1	1.0	0.0	0.0	0.0	0.8
P13LAYOT	#	16	2	1	1		2	2	0	0		1	0	0	0	
	%	5.7	28.9	14.3	20.0	6.0	0.7	28.9	0.0	0.0	1.2	0.4	0.0	0.0	0.0	0.3
P12EAYOT	#	6	1	0	0											
	%	8.8	9.1	0.0	0.0	8.2										
Unmixed	#	97	13	1	5		13	6	1	0		14	2	2	0	
Totals	%	7.3	5.7	1.4	15.6	7.0	1.0	2.6	1.4	0.0	1.2	1.1	0.9	2.9	0.0	1.1

Table 4.9 (Cont.)

	FINE					BLADES					Totals			
	U1	U2	U3	U4	MT	U1	U2	U3	U4	MT	U1	U2	U3	U4
E47UCUAU #						8	9	3	0		48	21	8	4
%						16.7	42.9	37.5	0.0	24.7				
A37ATOTO #	2	1	0	0		8	8	2	0		136	27	12	5
%	1.5	3.7	0.0	0.0	1.7	5.8	29.6	16.7	0.0	10.0				
A30UNKNO #						2	0		0		22	6	0	1
%						9.1	0.0		0.0	6.9				
A36TOTOL #	3	0	0			5	4	0			141	18	4	1
%	2.1	0.0	0.0		1.8	3.5	22.2	0.0		5.5				
L56UPAST #						7	5	1	1		132	22	5	6
%						5.2	22.7	20.0	50.0	8.5				
L55ARBOL #						4	8	2	0		82	15	9	4
%						4.9	53.3	22.2	0.0	12.7				
P14BOMBA #	2	0	0	0		37	22	6	1		411	71	20	10
%	0.5	0.0	0.0	0.0	0.4	9.0	31.0	30.0	11.1	12.9				
P13LAYOT #						26	9	2	0		282	38	7	6
%						9.2	23.7	28.6	0.0	11.1				
P12EAYOT #						6	4	0	0		67	11	5	2
%						8.8	36.4	0.0	0.0	11.8				
Unmixed Totals #	7	1	0	0		103	69	16	2		1321	229	70	39
%	0.5	0.4	0.0	0.0	0.5	7.8	30.1	22.9	6.3	11.5				

same percentage should be found for its use subdivisions vis-a-vis use totals. However, for the manufacturing category being discussed, the U1 is 45.8% of the total U1, while the U2 is 28.6% of the total U2. Thus there is more U1 than expected but less U2. Are there any patterns of departures from expectations?

One obvious, but somewhat tautological, departure is the higher than expected percentages for the various UNCERTAINs' U4s. These pieces, most often, were coded as UNCERTAIN because the clues to their manufacturing origins were obscured or obliterated by the subsequent retouching that resulted in their being coded as U4.

As for U1, the overall pattern supports the impression that U1 represents pieces that either were used casually or not at all. Since the observed U1 percentages for each manufacturing category virtually match the expectations, no selectivity is manifested--this is reasonably interpreted as indicating that U1 items were used little if at all. One noteworthy anomalous tendency is for the observed U1s of blades to be on the low side.

As for U2, the overall pattern supports the impression that the edge scarring involved represents use. Generally, the observed U2s for blades are considerably higher than expected while the observed U2s for the crude manufacturing categories are on the low side.

Finally, the U3 pattern is similar to that for U2. Namely, there are more blade U3s than expected while fewer crude items have U3 modification than expected. However, the pattern is not quite so clear-cut since there are more UNCERTAIN U3s than expected.

In sum, evidence from or for use tends to show up more in blades than in non-blades.

Table 4.10a-b: Slightly Modified Blades and Non-blades.

Table 4.10 focusses on the slightly modified obsidian specimens of unmixed assemblages that were earlier summarized as "SLIGHT" in Table 4.8. Almost all (226 of 261 or 87%) of the slightly modified pieces are of obsidian. Part "a" of the Table deals with various modifications of blades and Part "b" with non-blade modifications. (21 pieces trace analyzed by Cobean were not subjected to detailed examination and are therefore omitted from this table, although they were coded as SLIGHT.)

Regarding Table 4.10a, while keeping in mind that the number of specimens is small, it appears that slightly modified blades are usually modified on both lateral edges (49 of 61 or 80.3%), and most of these exhibit similar modification on both edges, especially of the "edge-on" type (35 of 49 or 71.4%).

The values distinguished here focus on the direction of retouch on the long, lateral edges of blades. "UNI" refers to unidirectional modification, i.e., where scarring of an edge is in only one direction (some refer to this as "unifacial"). "ED" refers to edge-on modification, i.e. where the edge is blunted or abraded, scarring not extending onto either face. "ALT" refers to alternation in the direction of modification of an edge. "OPP" refers to unidirectional retouch that is in opposite directions on opposite sides. "BI" refers to bidirectional modification, i.e, where scarring of an edge is in both directions (some refer to this as "bifacial"). "UNI-ED" and "UNI-BI" refer to blades with different types of modification on opposite edges, "UNI-ED" meaning unidirectional on one edge vs. edge-on

Table 4.10a. SLIGHT Modification of Blades (all Obsidian) in Unmixed Assemblages.

	Single Edge		Both Lateral Edges						Total
	UNI	ED	UNI	OPP	ALT	UNI-ED	ED	UNI-BI	
E47OCUAU #			2			2	4		8
%			25.0			25.0	50.0		
A37ATOTO #						1	5		6
%						16.7	83.3		
A30UNKNO #									0
%									
A36TOTOL #			1	1		1	1		4
%			25.0	25.0		25.0	25.0		
L56UPAST #	2		1		1		1		5
%	40.0		20.0		20.0		20.0		
L55ARBOL #	2	1				1	4		8
%	25.0	12.5				12.5	50.0		
P14BOMBA #	2	1		1		1	15		20
%	10.0	5.0		5.0		5.0	75.0		
P13LAYOT #	4						3		7
%	57.1						42.9		
P12EAYOT #							2	1	3
%							66.7	33.3	
Unmixed Totals #	10	2	4	2	1	6	35	1	61
%	16.4	3.3	6.6	3.3	1.6	9.8	57.4	1.6	

Table 4.10b. SLIGHT Modification of Obsidian Non-blades in Unmixed Assemblages.

		BACKED		UNI			ED			NTCH	BUL-KYWE	RE-U	E-MISC	SEV-ESEG	P-SHPD	To-tal
		ACU	SS	ACU	SS	BLN	ACU	SS	BLN							
E47UCUAU	#	2		1	1	1	1	2							1	9
	%	22.2		11.1	11.1	11.1	11.1	22.2							11.1	
A37ATOTO	#			2	3	1	3	3	1			1		1		15
	%			13.3	20.0	6.7	20.0	20.0	6.7			6.7		6.7		
A30UNKNO	#	1		2			2							1		6
	%	16.7		33.3			33.3							16.7		
A36TOTOL	#	2		3	2		2						2	3		14
	%	14.3		21.4	14.3		14.3						14.3	21.4		
L56UPAST	#	2	2		2		2	3	2					1	1	15
	%	13.3	13.3		13.3		13.3	20.0	13.3					6.7	6.7	
L55ARBOL	#	1			2		2		1							6
	%	16.7			33.3		33.3		16.7							
P14BOMBA	#	12		2	6	4	4	5	1	3	2	1	1	4	1	46
	%	26.1		4.3	13.0	8.7	8.7	10.9	2.2	6.5	4.3	2.2	2.2	8.7	2.2	
P15LAYOT	#	3		1	4	2	2	2		2	1			9		26
	%	11.4		3.8	15.4	7.7	7.7	7.7		7.7	3.8			34.6		
P12EAYOT	#	2			2						2			1		7
	%	28.6			28.6						28.6			14.3		
Unmixed Totals	#	25	2	11	22	8	18	15	5	5	5	2	3	20	3	144
	%	17.4	1.4	7.6	15.3	5.6	12.5	10.4	3.5	3.5	3.5	1.4	2.1	13.9	2.1	

on the opposite edge and "UNI-BI" meaning unidirectional on one edge vs. bidirectional on the opposite edge.

Edge-on modification, perhaps indicating a sawing or incising action, is most frequent. Uni-directional modification, perhaps indicating a scraping or peeling action, constitutes a large minority. OPP, ALT, and BI are very rare.

Table 4.10b suggests that single edge modification is the predominant approach to non-blade artifacts, at least 121 (84.0%) of the 144 slightly modified non-blades having modification of only one edge.

The values distinguished here focus on the direction of retouch, the configuration of the piece, and the angle of the presumed working edge. "BACKED" refers to backed items, i.e., the morphology of the edge opposite the working edge is "blunt" (e.g. has flat facets approximately perpendicular to both adjacent faces). "UNI" and "ED" have the same unidirectional and edge-on meanings discussed above for blades. "ACU," "SS," and "BLN" refer to the angle of the working edges (for BACKED, UNI and ED artifacts)--"ACU" refers to angles between 15° and 45", "SS" to angles between 45° and 75°, and "BLN" to angles greater than 75°. "SEVESEG" refers to specimens with modification of either several edges or several segments of one edge. As to the various minor forms: "NTCH" refers to notched specimens, "BULKYWE" to bulky items with a working wedge, "RE-U" to rejuvenation flakes with evidence of re-use, "EMISC" to flakes with some unusual working edge characteristic, and "PSHPD" to fragments of possible shaped-over-all items.

Of the 106 items whose edge angle was taken into consideration, 54 (or 50.9%) have edges of less than 45°--most of these being backed items. 39 (or 36.8%) have edges between 45° and 75"--most of these being unidirectional items. Only 13 (12.3%) have angles greater than 75°.

The sample size is too small to examine inter-assemblage variability. However, it may be of significance that the early assemblages (those of Tlapacoya) have the few bulky items with working edges and that L56U and A37A have relatively high proportions of edge-on modification (especially A37A, since it also has a high proportion of edge-on blade modification).

Table 4.11: Heavy Edge Modification

Table 4.11 shows the small number of heavily used and/or crudely shaped obsidian specimens of unmixed assemblages that were earlier indicated as EDGE artifacts in Table 4.8 (70 of 76 or 92% of EDGE items are obsidian). There are too few EDGE items to make any generalizations from their variations, but some of the particulars are suggestive.

I have combined the blade varieties into several groups which perhaps reflect different combinations of usages. The "SAME" grouping comprises artifacts with the same type of retouch on both edges (including heavy edge-on retouch, heavy abrasion, unidirectional heavy semi-steep retouch on multi-notched edges). These may be single purpose tools. One specimen seems to be thinned on one end, perhaps to facilitate hafting. It is possible that other of these items were end-hafted.

The single ALT1-OPP specimen seems to have been hand held, for each edge shows an opposite pattern of single-cycle retouch, suggesting that the artifact was used on both edges in similar fashion, the artifact being held in the hand in any one of four positions (see Fig. 4.11a).

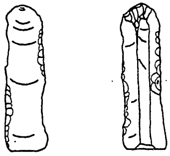
The ALT1-OTH and DIF-OTH artifacts are perhaps multi-purpose tools (and end-hafted or hand-held) or edge-hafted single purpose tools, the "retouch" on one edge being the result of inserting that edge into a slot for hafting purposes. Both of these groups have different types of retouch on their opposite edges. The ALT1-OTH pieces have a single cycle of alternating retouch on one edge and some other retouch patterns on the other (unidirectional "denticulate"-like

Table 4.11. EDGE modification of Obsidian Artifacts in Unmixed Assemblages.

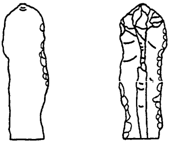
	blades						non-blades							
	SAME	ALT1 -OPP	ALT1 -OTH	DIF-OTH	IN-DET	Total	PLNO -CVX	PLNO -CCV	BUL-KY	MULT	OPP	ESQL	BI-FTD	Total
E47UCUAU #	2			1		3	2	2				1		5
A37ATOTO #	1		1			2	2	2	2	3				9
A30UNKNO #						0								0
A36TOTOL #						0	1	2	1					4
I56UPAST #				1		1	2	1		1				4
I55ARBOL #	1			1		2		4		3				7
P14POMPA #	1	1	1	2	1	6	1	2	3	5		1	1	13
P13LAYOT #	1		1			2		1		3		1		5
P12EAYOT #						0		1		2	1		1	5
Unmixed Totals #	6	1	3	5	1	16	8	15	6	17	1	3	2	52

Figure 4.11. EDGE modified obsidian artifacts.

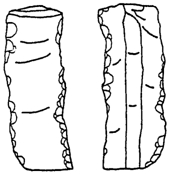
a. ALT1-OPP, single cycle of alternating retouch on opposite edges (P17#14 from Tlapacoya).



b. ALT1-OTH, single cycle of alternating retouch on one edge vs. unidirectional "denticulate"-like on opposite edge (P31#36 from Tlapacoya).



c. ALT1-OTH, single cycle of alternating retouch on one edge vs. edge-on blunting of opposite edge (A36#7 from Loma de Atoto).



on one of them--see Fig. 4.11b, edge-on blunting on another--see Fig. 4.11 c). The DIF-OTH items have other combinations of retouch on opposing edges (unidirectional "denticulate"-like vs. edge-on blunting and vs. heavy abrasion, raclette-like vs. edge-on blunting and vs. light edge-on nibbling).

The non-blade EDGE items have also been combined into a number of groups. Most of the groups have fairly clear-cut evidence of modification. "PLNO-CVX" are artifacts that have a plano-convex morphology and working edges; "PLNO-CCV" have plano-concave working edges; "BULKY" comprises various thickish pieces with retouched edges and/or other indications of shaping; "MULT" are flakes whose several retouched edges differ in type and/or direction; "OPP" are flakes with unidirectional retouch in opposite directions on opposite edges.

Two additional groups are problematic. Their "modification" may reflect accidental patterning as the by-product of nodule-smashing. One, "ESQL," comprises fluted, chisel-like items with battering of opposite ends (these are sometimes referred to as "pièce esquillée" in the literature). Given the brittleness of obsidian, it seems unlikely that these were used as chisels and, therefore, it seems more likely that they are remnants of nodule smashing. So too for the one piece coded as "BIFTD" (bifacetted). It has numerous facets (scars) on both faces but the concentric ripples in the scars do not start at the edges of the artifact. Rather, the ripples appear to have begun farther out--hence, the facets do not appear to be evidence of bifacial working.

Table 4.12: Shaped Obsidian Artifacts

Table 4.12 deals with shaped obsidian specimens of unmixed assemblages (summarized in Tables 4.8 and 4.9). Both non-point and point-like modifications are indicated.

The non-point pieces (not "point-like" in appearance) are rare —less than 1% of the chipped stone. Almost all NONPTs are of obsidian (14 of 16 or 88%). The three possible use categories are: knives, piercing tools (fine, sharp-pointed items), and drills (sturdy boring tools).

The possible knives include two specimens with convex cutting edges opposite straight or concave "backs" (KNF) and one specimen whose cutting edge is the straight edge on a wedge-shaped semi-circle (WDG). The possible piercing tools include one small, delicately-pointed item (PCR, such have been referred to as "gravers" or "perçoirs") as well as one retouched blade (PCR-BLD). The possible drills include one non-blade (DRL) and one on a blade (DRL-BLD). There are also some items of indeterminate (at least to me) functional interpretation: RECT--a corner of a flat, thin rectangular flake with retouched margins; PTD-IND--a small, crudely-shaped, irregular pointed item; and FRG-SHPD--fragments of shaped items.

Point-like shaped pieces are almost as rare (a little more than 1% of the chipped stone). Almost all points are of obsidian (25 of 28 or 89%). Two of the non-obsidian points (one large stemmed point fragment and one basalt small tanged point) are from FI-1 Bomba subphase at Tlapacoya and the third (the tip of a large point) is from FI-3 Atoto subphase at Loma de Atoto).

Table 4.12. NONPT and POINT Shaped Obsidian Artifacts in Unmixed Assemblages.

	NONPT										POINT										
	KNF	WDG	PCR	PCR-BLD	DRL-BLD	DRL	RECT	PTD-IND	FRG-SHPD	Totals	TNG	TNG-TRN	TRI	DRP	FRG-LPT	KNB	XPND	CNTR	SIDE	FRG-IND	Totals
E47UCUAU #	1							1		2				1			1				2
A37ATOTO #										0	1[a]				1			1	1	1	5
A30UNKNO #						1				1											0
A36TOTOL #										0										1	1
L56UPAST #				1					1	2	1	1								2	4
L55ARBOL #									1	1	2		1								3
P14BOMBA #	1	1	1		1				1	5	3		1		1						5
P13LAYOT #							1		2	3	2				1						3
P12EAYOT #										0					1	1					2
Unmixed Totals #	2	1	1	1	1	1	1	1	5	14	9	1	2	1	4	1	1	1	1	4	25

a. Fragment with most of basal portion missing, but may be a small tanged point.

Figure 4.12. POINTS: The Small Tanged Type (a,b,c); and the "Tear-drop" Type (d,e,f). Actual size.

a. Bomba Subphase, Tlapacoya

b. Bomba Subphase, Tlapacoya

c. Late Ayotla Subphase, Tlapacoya

d. Cuautepec Subphase, El Arbolillo West

e. Upper La Pastora levels, El Arbolillo East

f. Upper La Pastora levels, El Arbolillo East

As was found in earlier studies of Preclassic debitage in the Basin of Mexico, several types of small obsidian points occur in the assemblages of this time period. While the sample size is too small to make definitive statements, some of the distributional data are suggestive. TNG (and variant TNG-TRN, with truncated corners, apparently for hafting purposes), a small tanged point type with triangular "blade" (Figure 4.12 a, b, c--also see Tolstoy 1971: fig. 2b, "Perdiz" point) is found only from the Early Preclassic through the early part of the Middle Preclassic (i.e. EH-3 through the beginning of FI-3), for no points of this type have been recovered from the upper levels at El Arbolillo East, at El Arbolillo West, or at Loma de Atoto (with the exception of one point fragment whose basal portion is almost entirely missing but which appears to be of the tanged type). Two small stemless triangular points (TRI) also occur during FI-1 and FI-2. An oval or "tear-drop" shaped type of point (DRP, Figure 4.12 d, e, f) is not found before the later part of the Middle Preclassic (i.e., not before the end of FI-3). Four fragments of large obsidian points have been found (FGT-LPT), one in each of the subphases at Tlapacoya and one in FI-4 A37ATOTO.

Additionally, in the early part of the sequence, there is one small point, somewhat tear-drop in outline, that has small knobs on either side separating the haft from the blade element of the point (KNB). In the later part of the sequence are several points that have stems: one, XPND, with expanding stem (or corner-notched) similar to the Ensor Point type (cf. Tolstoy 1971); one, CNTR, with contracting stem similar to the Tlatilco point type; and finally, a side-notched point (SIDE) similar to the Post-Classic type referred to as Texcoco. Finally, there are several indeterminate fragments (FGT-IND).

Table 4.13a-g: Use-related Attributes of Lamellar Flakes

Table 4.13 presents some of the use-related attributes for lamellar flakes (blades and the small number of morphologically-similar ridged flakes) found in the unmixed assemblages. All such items are of obsidian. The overall perspective being documented here is the minimal degree of modification evidenced.

Table 4.13a deals with the ends of the lamellar flakes. The proximal end has the cap (CAP) or, if the cap has been removed, the fracture (FRC) or the retouch truncation (TRNC) that resulted in the cap's removal. The distal end has the tip (TIP) or, if the tip has been removed, the fracture or the retouch truncation that resulted in the tip's removal. Indicated also, for both ends, is the situation in which lateral retouch has partially removed end fracture, and thus in which lateral retouch occurred after the blade was snapped (LRET).

For the retouch variable indicated, the values are: "NONE," no retouch or slight nibbling; "WE-PV," the possible working edge, as evidenced by some degree of scarring, is the proximal-ventral edge; "WE-PD," the possible working edge is the proximal-dorsal edge; "ABR," the PV and/or PD edge is abraded; "BURIN" is self-explanatory; "OTHR," any other or uncertain condition.

Clearly, most pieces show no evidence of working. Only 4 of 197 (2%) of proximal ends and only 7 of 197 (4%) of distal ends are shaped by retouch. Of the 11 that are shaped, 6 are concave, 2 are truncated perpendicular to the long axis, 2 are oblique, and only 1 is convex--one need not wonder about "end-scrapers on blades" here.

Table 4.13a. Retouch on Proximal and Distal Ends of Lamellar Flakes in Unmixed Assemblages.

		Retouch						
		NONE	WE-PV	WE-PD	ABR	BU-RIN	OTHR	Totals
Proximal End	CAP	57			1			58
	FRC	117	2	5	7		1	132
	LRET	3						3
	TRNC		4					4
	Total	177	6	5	8	0	1	197
Distal End	TIP	5						5
	FRC	157	3	4	15	1	2	182
	LRET	3						3
	TRNC		5	2				7
	Total	165	8	6	15	1	2	197

Table 4.13b. Outline of Left Edge vs. Direction of Retouch for Lamellar Flakes in Unmixed Assemblages.

		Direction of Retouch											
		NONE	UNI-V	UNI-D	ALT	BI-V	BI-D	BI	ND-V	NV-D	NUNI-BI	ED	Total (% of 197)
Concave Segments	# %	8 30.8	4 15.4	6 23.1	3 11.5	3 11.5						2 7.7	26 (13.2)
Straight Segments	# %	43 62.3	5 7.2	11 15.9	1 1.4	1 1.4		1 1.4				7 10.1	69 (35.0)
Convex Segments	# %	4 57.1		2 28.6								1 14.3	7 (3.6)
Craggy	# %	26 37.7	6 8.7	6 8.7	9 13.0	2 2.9	2 2.9	2 2.9				16 23.2	69 (35.0)
Notch	# %			1 50.0	1 50.0								2 (1.0)
Notch: In and Out	# %		2 33.3						1 16.7	1 16.7	2 33.3		6 (3.0)
Edge Removed	# %	1 33.3	1 33.3		1 33.3								3 (1.5)
Other	# %	6 40.0	1 6.7	3 20.0	2 13.3							3 20.0	15 (7.6)
Unmixed Totals	# %	88 44.7	19 9.6	29 14.7	17 8.6	6 3.0	2 1.0	3 1.5	1 0.5	1 0.5	2 1.0	29 14.7	197

Table 4.13c. Kinds of Retouch on Ventral and Dorsal Surfaces of the Left Edge of Lamellar Flakes in Unmixed Assemblages.

		Dorsal Surface								
		NONE	NIBL	SCAT	SMAL	BATT	BEVL	TIER -SML	TIER -ABR	Total
Ventral Surface	NONE	43	14	2	8		3	4		74
	NIBL	16	38	2	3	2		2		63
	SCAT	1	3	8	2			1		15
	SMAL	7	4	1	9		1			22
	BATT								1	1
	BEVL			1			2			3
	TIER-SML	3	1	1	1		1	5	1	13
	TIER-ABR	3	2						1	6
	Total	73	62	15	23	2	7	12	3	197

Table 4.13d. Outline of Right Edge vs. Direction of Retouch for Lamellar Flakes in Unmixed Assemblages.

		Direction of Retouch											
		NONE	UNI-V	UNI-D	ALT	BI-V	BI-D	BI	ND-V	NV-D	NUNI-BI	ED	Total (% of 197)
Concave Segments	#	5	4	6	1		2	1				2	21
	%	23.8	19.0	28.6	4.8		9.5	4.8				9.5	(10.7)
Straight Segments	#	46	2	9	1		1	3				7	69
	%	66.7	2.9	13.0	1.4		1.4	4.3				10.1	(35.0)
Convex Segments	#	4	3	1	1	1						1	11
	%	36.4	27.3	9.1	9.1	9.1						9.1	(5.6)
Craggy	#	20	5	12	7	1	2	2				20	69
	%	29.0	7.2	17.4	10.1	1.4	2.9	2.9				29.0	(35.0)
Notch	#	1	4				1						6
	%	16.7	66.7				16.7						(3.0)
Notch: In and Out	#			1					1	1	1		4
	%			25.0					25.0	25.0	25.0		(2.0)
Edge Removed	#											1	1
	%											100.0	(0.5)
Other	#	10	1	1	1							3	16
	%	62.5	6.3	6.3	6.3							18.8	(8.1)
Unmixed Totals	#	86	19	30	11	2	6	6	1	1	1	34	197
	%	43.7	9.6	15.2	5.6	1.0	3.0	3.0	0.5	0.5	0.5	17.3	

Table 4.13e. Kinds of Retouch on Ventral and Dorsal Surfaces of the Right Edge of Lamellar Flakes in Unmixed Assemblages.

		Dorsal Surface									
		NONE	NIBL	SCAT	SMAL	BATT	STEP	BEVL	TIER-SML	TIER-ABR	Total
Ventral Surface	NONE	48	19		8		1	2	3	2	83
	NIBL	9	32	1	5	1		1	5	2	56
	SCAT	1	1	9	1	1	1	1	4		19
	SMAL	7	4	1	5					1	18
	SHAL		1								1
	STEP			1							1
	BEVL	1						2	1		4
	TIER-SML	4						2	3		9
	TIER-ABR	3						1		2	6
	Total	73	57	12	19	2	2	9	16	7	197

Table 4.13f. Direction of Retouch on Left and Right Edges of Lamellar Flakes in Unmixed Assemblages.

Left Edge: Direction of Retouch	Right Edge: Direction of Retouch											
	NONE	UNI-V	UNI-D	ALT	BI-V	BI-D	BI	ND-V	NV-D	NUNI-BI	ED	Total
NONE	67	7	5	1	1	1	1	1			4	88
UNI-V	4	2	5	2		1	1				4	19
UNI-D	10	3	7	1		2	1		1		4	29
ALT	3	3	4	4		1				1	1	17
BI-V		1		2			1				2	6
BI-D				1	1							2
BI			1			1	1					3
ND-V			1									1
NV-D							1					1
NUNI-BI			1								1	2
ED	2	3	6								18	29
Total	86	19	30	11	2	6	6	1	1	1	34	197

Figure 4.13g. Lateral Edge Angles, Unchanged by Retouch, of the Medial Elements of Lamellar Flakes, Measured to the Nearest 10 Degrees, in Unmixed Assemblages.

		Right Edge					
		20°	30°	40°	50°	60°	Total
Left Edge	20°	2		1	2		5
	30°	4	25	23	5		57
	40°	2	26	38	6	3	75
	50°		3	7	1	3	14
	60°			5	1	2	8
	Total	8	54	74	15	8	159

And only one piece has burin morphology. Apparently the focus of use attention was on the sharp lateral margins of lamellar flakes. Tables 4.13b-c deal with the left lateral edge; Table 4.13d-e with the right edge; and Table 4.13f-g with left vs. right edges.

The contingency table in 4.13b compares the outline of the left edge with the direction of retouch scarring. Most edges have straight or craggy segments, concave segments next, and a number of minor outlines complete the list.

As for the "retouch" on the left edge, about 45% have either no edge scarring or only slight nibbling (NONE), 24% are unidirectionally scarred--15% dorsally (UNI-D) and 10% ventrally (UNI-V). 15% have edge-on scarring, including edge abrasion (ED); 9% have cycles of alternating scarring directions (ALT); and only 6% have bidirectional edge scarring (BI-V is mostly ventral, BI-D is mostly dorsal, and BI has balanced ventral and dorsal scarring). 2% have notches with different retouch directions inside than out (NUNI-BI is unidirectional in notch, bidirectional out; ND-V, dorsal in notch, ventral out; NV-D, ventral in notch, dorsal out).

Table 4.13c indicates the kind of scarring found on ventral and dorsal faces forming the left edge. 127 (64.5%) of the lamellar flakes have either no scarring (NONE), only nibbling (NIBL), or scattered scars of varying sizes (SCAT), in either or both directions.

Of the 34 (17.3%) specimens with SMAL but no more than SMAL (small, overlapping scars perhaps resulting from use) scarring, 25 are SMAL vs. NONE or NIBL or SCAT (12 with SMAL scars ventral, 13 dorsal) and only 9 are SMAL vs. SMAL. There are also 2 specimens (1.0%) that are NIBL vs. BATT (battered).

As for more defined scarring (perhaps resulting from more intensive use or from design), "BEVL" refers to scarring which results in a beveled edge, "TIER-SML" refers to a tiered formation with small scars made onto larger, bevel-type scars, and "TIER-ABR" refers to a tiered formation in which the edge is abraded on the face opposite the bevel (indicating that the face opposite the bevel was making contact with the item being scraped or peeled or whittled).

Of the 7 specimens (3.6%) with BEVL but no more than BEVL, 4 are BEVL vs. NONE or NIBL or SCAT (1 with BEVL scars ventral, 3 dorsal), only 1 BEVL (dorsal) vs. SMAL, and 2 BEVL vs. BEVL (1 BI and 1 ALT).

Of the 19 (9.6%) lamellar flakes with TIER-SML but no more than TIER-SML, 12 are TIER-SML vs. NONE or NIBL or SCAT (5 with bevel scars ventral, 7 dorsal), 1 TIER-SML (ventral) vs. SMAL, 1 TIER-SML (dorsal) vs. BEVEL (the overall pattern being BI-D), and 5 TIER-SML vs. TIER-SML (4 ALT and 1 almost all V). Hence, TIER-SML is not likely to be the retouch on a cutting tool.

As for the 8 pieces (4.1%) with TIER-ABR, 5 are TIER-ABR (all ventral) vs. NONE or NIBL, 1 is TIER-ABR (dorsal) vs. BATT, 1 is TIER-ABR vs. TIER-SML (alternating), and 1 is TIER-ABR vs. TIER-ABR (bidirectionally beveled on an abraded edge). TIER-ABR seems also to be unlikely on a cutting tool except as TIER-ABR vs. TIER-ABR.

The contingency table in 4.13d compares the outline of the right edge with the direction of retouch scarring. The results are virtually identical with those for the left edge. About 44% have either no edge scarring or only slight nibbling, 25% are unidirectionally scarred—15% UNI-D and 10% UNI-V. 17% are ED; 6% are ALT; 7% are bidirectional; and 2% have notches with retouch differently directed in them than out.

Table 4.13e indicates the kind of scarring found on ventral and dorsal surfaces forming the right edge. Again, the results are virtually the same as those for the left edge. 120 (60.9%) of the lamellar flakes have either NONE or NIBL or SCAT in either or both directions.

Of the 31 (15.7%) with SMAL but no more than SMAL scarring, 26 are SMAL vs. NONE or NIBL or SCAT (12 with SMAL scars ventral, 14 dorsal) and 5 are SMAL vs. SMAL. There are also 2 specimens (1.0%) that are BATT vs. NIBL or SCAT, 3 (1.5%) that are STEP (deep, step flake scars) vs. NONE or SCAT, and 1 (0.5%) that is SHAL (shallow, relatively long retouch scarring) vs. NIBL.

Of the 7 specimens (3.6%) with BEVL but no more than BEVL, 5 are BEVL vs. NONE or NIBL or SCAT (1 with BEVL scars ventral, 4 dorsal) and 2 BEVL vs. BEVL (1 BI discontinuously with scattered abrasion, 1 NV-D).

Of the 22 (11.2%) lamellar flakes with TIER-SMAL but no more than TIER-SMAL on their right edges, 16 are TIER-SML vs. NONE or NIBL or SCAT (4 with bevel scars ventral, 12 dorsal), 3 TIER-SML (2 ventral, 1 dorsal) vs. BEVL (2 ALT, 1 BI but discontinuously), and 3 TIER-SML vs. TIER-SML (2 ALT, 1 BI discontinuously with scattered abrasion). Thus, only 2 of the 22 specimens (those discontinuous BIs) suggest a cutting action.

Of the 11 pieces (5.6%) with TIER-ABR, 7 are TIER-ABR vs. NONE or NIBL (3 with bevel scars ventral, 4 dorsal), 1 is TIER-ABR (dorsal) vs. SMAL, 1 is TIER-ABR (ventral) vs. BEVL (ALT), and 2 are TIER-ABR vs. TIER-ABR (1 almost all dorsal, 1 BI). Again, most do not suggest a cutting action.

The contingency table in 4.13f compares the direction of retouch on the left and right edges for all 197 lamellar flakes in unmixed assemblages. For 102 (51.8%), the 2 edges cannot be distinguished on the basis of the direction of retouch--67 have no retouch on either edge and 35 have the same direction of retouch on both edges. For the other 95 (48.2%), the edges can be distinguished--40 have retouch on only one edge, 8 have unidirectional retouch in opposite directions on opposite edges, and 37 have different direction types on opposite edges.

The contingency table in 4.13g compares the edge angle (unchanged by retouch) of the medial elements of lamellar flakes in unmixed assemblages. Most (112 of 159 or 70.4%) measure between 25 and 45° on both edges; 36 (22.6%) measure between 25 and 45° on only one edge (7 measure less than 25° on the other, 29 measure more than 45°). Two (1.3%) measure less than 25° on both edges, 1 (0.6%) measures less than 25° on one edge and more than 45° on the other, and 7 (4.4%) measure more than 45° on both edges. There are 38 missing cases--either or both edges have no medial element, the medial element is completely retouch modified, or the edge is missing. These are sharp angled pieces.

Most lamellar flakes have edge angles which are unchanged by retouch. When retouch does affect the edge angle (e.g., in producing a bevel), the change seems to be on the order of a 30° increase. For example, edge angles of some of the beveled edges are on the order of 55 to 85° (most are too irregular to represent by a single summary measure).

Table 4.14: Breakage Classes for Blades

Table 4.14 indicates the breakage class information for blades. A fragment of a blade might include parts of the medial, proximal or distal elements. The medial element, the largest portion of the blade, is the flattest, most parallel-sided, most regular portion of a blade. The proximal and distal elements have various irregularities. The proximal element varies in thickness and outline because of the bulb, nape preparation, and the nature of the blade-core's surface. The distal element varies in thickness, outline and curvature. If the blade fragments were the result of intentional snapping for the purpose of deriving regular items for hafting into slots (or for providing flat "blanks" for projectile points), then one would expect differential selection for medial element fragments.

Considering the unmixed assemblages, the most frequent portion of blade found is a part of the medial element (57 items or 30.0% are MED). However, 51 items (26.8%) have parts of the proximal and medial elements (PRX-MED) and 40 (21.1%) contain portions of medial and distal elements (MED-DIST). Fragments which are just end elements are fairly rare: there are 19 (10.0%) proximal fragments (PROX) and only 2 (1.1%) tip fragments (DIST). Whole or almost whole blades (WHOL) are also rare (5 items or 2.6%). There are some irregular or small fragments (INDT) which are indeterminate (14 items or 7.4%). (Data is missing on two fragments, FRG-COB, analyzed by Cobean.)

Considering the small size of assemblage samples, there is little variation among assemblages, except perhaps for A37ATOTO which has a high proportion of fragments with proximal elements (both PROX and PRX-MED).

Table 4.14. Breakage Class for Blades.

		WHOL	PROX	PRX-MED	MED	MED-DIST	DIST	INDT	FRG-COB	Total
E47MCUAU	#	2	5	16	42	7	2	1		75
	%	2.7	6.7	21.3	56.0	9.3	2.7	1.3		
E47UCUAU	#		3	6	6	4		1		20
	%		15.0	30.0	30.0	20.0		5.0		
A37ATOTO	#		3	8	2	3		1	1	18
	%		16.7	44.4	11.1	16.7		5.6	5.6	
A30UNKNO	#				1	1				2
	%				50.0	50.0				
A36TOTOL	#		1	3	4				1	9
	%		11.1	33.3	44.4				11.1	
L56MPAST	#	1	21	21	87	30	3	19		182
	%	0.6	11.5	11.5	47.8	16.5	1.6	10.4		
L56UPAST	#	1		4	4	3		2		14
	%	7.1		28.6	28.6	21.4		14.3		
L55ARBOL	#		4	2	5			3		14
	%		28.6	14.3	35.7			21.4		
P14BOMBA	#	2	5	14	23	15		7		66
	%	3.0	7.6	21.2	34.8	22.7		10.6		
P13LAYOT	#	1	3	12	8	12	1			37
	%	2.7	8.1	32.4	21.6	32.4	2.7			
P12EAYOT	#	1		2	4	2	1			10
	%	10.0		20.0	40.0	20.0	10.0			
Mixed Totals	#	3	26	37	129	37	5	20		257
	%	1.2	10.1	14.4	50.2	14.4	1.9	7.8		
Unmixed	#	5	19	51	57	40	2	14	2	190
	%	2.6	10.0	26.8	30.0	21.1	1.1	7.4	1.1	

Considering the overall pattern for unmixed assemblages, there is little to suggest differential selection of the different portions of the blade. That there are more medial fragments can perhaps be attributed to the medial element's being the largest portion of a blade. By contrast, the mixed assemblages have a pronounced bias toward the medial element.

Table 4.15: Breakage Classes for Thin Obsidian Items

Table 4.15 presents breakage class data for thin obsidian items in the various manufacturing classes (unmixed assemblages). One purpose of this table is to assess the intentionality of the breakage of blades. One hypothesis is that blade fragments are simply the result of accidental, post-use events. Since blades are thin and made of a brittle material, their breakage need not be the result of intentional snapping for use. Thus blades were compared with other thin items of obsidian.

While no other manufacturing class' data are as extreme as those for blades, all categories have fairly high proportions of broken specimens. Indeed, of the 29 shaped items, 45% are fragments, and shaped items were clearly not broken intentionally. Thus, while some blades may have been snapped intentionally, a large proportion of them seem to have resulted from accidental breakage.

Table 4.15. Comparison of Breakage Class Data for Thin Obsidian Items in the Various Manufacturing Classes (Unmixed Assemblages).

		Whole or Almost Whole	Fragment	Total
SMASH/ PSMASH	#	87	280	367
	%	23.7	76.3	
MULT/ PMULT	#	59	103	162
	%	36.4	63.6	
UNCERTAIN	#	22	250	272
	%	9.1	91.9	
SIMPLE	#	42	66	108
	%	38.9	61.1	
RIDGED	#	2	18	20
	%	10.0	90.0	
REJUV/ PREJUV	#	7	10	17
	%	41.2	58.9	
FINE	#	2	6	8
	%	25.0	75.0	
SHAPED	#	16	13	29
	%	55.2	44.8	
BLADE	#	5	185	190
	%	2.6	97.4	

Table 4.16: Artifacts Made up of Two or More Fragments

Table 4.16 shows the distribution of obsidian artifacts found as two or more fragments (in the same or adjacent lots) in unmixed assemblages. There are only 10 such items: 7 blades, 2 smash flakes, and 1 uncertain item. All of them show no evidence of post-breakage use, while there is some evidence of pre-breakage use. The implication for this small number of artifacts is that breakage occurred accidentally after use.

Table 4.16. Obsidian Artifacts Found as Two or More Fragments (in the Same or Adjacent Lots) in Unmixed Assemblages.

	SMASH	UNCERTAIN	BLADE	Total
E47UCUAU				0
A37ATOTO			1	1
A30UNKNO				0
A36TOTOL			2	2
L56UPAST			1	1
L55ARBOL				0
P14BOMBA	1	1		2
P13IAYOT			3	3
P12EAYOT	1			1
Unmixed Totals	2	1	7	10

Table 4.17: Length of Blade Fragments

Table 4.17 indicates the mean, minimum, maximum, standard deviation, and number of specimens used in measuring the length of blade fragments. Again, the question of whether or not blades were intentionally snapped is one involved issue. Standardization of length would support the intentionality of breakage, whereas lack of standardization would be more ambiguous. Standardization would make sense if blade portions were used in composite implements. However, as the table indicates, there is little evidence of standardization.

Considering PROX/PRX-MED fragments (perhaps "undesirable" because of outline and thickness variability), the mean length in each assemblage varies from such lows as 18.9 mm (N=21) and 18.3 mm (N=3) to such highs as 37.9 (N=10) and 42.0 mm (N=4)--the standard deviation for such fragments taken as a whole is 11.7 mm. Within assemblages, the standard deviation is rather high, in the teens, except for one of the mixed assemblages with a sizeable N (L56MPAST) and two early assemblages with small Ns.

Considering MED fragments (the perhaps "desirable," regular portions), the mean length in each assemblage varies somewhat less than for PROX/PRX-MED. It has such lows as 16.9 mm (N=7) and 18.7 mm (N=87) and such highs as 25.3 mm (N=22) and 32.0 mm (N=3)--the standard deviation for such fragments taken as a whole is 8.3 mm. And, in general, the standard deviation within each assemblage is less than 10.

However, considering MED-DIST/DIST fragments, another supposedly "undesirable" segment type, the variation between and within

Table 4.17. Length of Blade Fragments: Mean, Minimum (Min), Maximum (Max), Standard Deviation (s), Number of Specimens (N), in mm.

	PRCX/PRX-MED					MED					MED-DIST/DIST				
	Mean	Min	Max	s	N	Mean	Min	Max	s	N	Mean	Min	Max	s	N
E47MCUAU	28.5	13	51	10.2	21	22.2	9	47	7.5	41	29.6	20	49	8.8	9
E47UCUAU	26.3	17	42	9.7	9	22.8	15	28	6.3	5	24.0	17	29	5.3	4
A37ATOTO	37.9	18	76	18.1	10	28.0	17	39	15.6	2	22.0	13	33	10.1	3
A30UNKNO					0	15.0				1	17.0				1
A36TOTOL	30.0	12	48	15.8	4	32.0	16	54	19.7	3					0
I56MPAST	18.9	12	30	4.7	21	18.7	10	52	7.1	87	23.9	12	49	7.9	33
I56UPAST	42.0	32	59	11.8	4	23.3	16	33	8.7	3	46.7	28	57	16.2	3
I55ARBOL	35.8	16	74	21.4	6	25.3	16	32	7.0	4					0
P14BOMBA	29.5	14	47	10.0	18	25.3	11	43	10.5	22	24.2	13	37	7.0	15
P13LAYOT	18.3	17	19	1.2	3	16.9	10	24	4.4	7	25.9	15	38	8.9	13
P12EAYOT	33.0	31	35	2.8	2	19.0	14	24	7.1	2	29.7	21	46	14.2	3
Total	28.6	12	76	11.7	130	19.0	9	54	8.3	177	25.7	12	57	9.3	84

assemblages is rather like the supposedly "desirable" MED fragments.

One might also consider the absolute sizes of these different segments as compared with estimates of their respective elements. One might estimate that whole, fine blades in these collections would vary between 75 and 100 mm, that the irregular PROX element varied between 15 and 20 mm in length, that the irregular DIST element varied between 20 and 30 mm, and that the regular MED element varied between 40 and 50 mm. The observed PROX/PRX-MED fragments are "too" long (mean length of 28.6 mm), incorporating portions of the regular MED segment. The observed MED-DIST/DIST fragments seem to be using the material more efficiently (average of 25.7 mm). As for MED pieces, if there were intentional snapping, it might be that each medial element was snapped into 2 or 3 medial fragments (average of 19.0 mm), but then it is hard to explain why fragments with portions of PROX or DIST weren't trimmed (shortened) more to match MED pieces, since the shorter the fragment, the better each piece would approximate a flat rectangle.

Table 4.18: Numbers of Obsidian and Non-Obsidian Artifacts Co-occurring in Excavation Lots

Table 4.18 is the first of several tables presenting data on the sets of artifacts found together in the same excavation provenience unit (i.e., the same "lot"). The sets of artifacts coming from the same lot (lots, as mentioned earlier, were about 1 1/2 by 1 1/2 meters horizontally and 10 or 20 cm. deep) can, as a starting point in interpretation, be treated as roughly contemporaneous and examined to see if their association provides any insights.

I am dealing here only with the chipped stone. It will be interesting to compare the results obtained for this material with the results of ceramic analysis (still in progress).

The contingency table in 4.18 compares the number of obsidian artifacts with the number of non-obsidian artifacts for the lots in each of the 9 unmixed assemblages. The numbers of artifacts are presented as grouped data (in groups of 5). Thus one can quickly assess the quantity of items involved. And, since samples are so small, grouping tends to minimize sampling error (since the units are not very fine-scaled, small variations are ignored).

Four assemblages have some lots with no chipped stone at all. These assemblages are also the only ones to have some lots with non-obsidian but no obsidian artifacts.

E47UCUAU has 52 lots, but 16 have no chipped stone. Of the 36 with chipped stone, 31 (86%) have 5 or less obsidian artifacts and 5 or less non-obsidian artifacts. The lot with maximum concentration of chipped stone has between 11 and 15 obsidian artifacts and between 6 and 10 of non-obsidian. The general impression is of a light

Table 4.18. Numbers of Obsidian and Non-Obsidian Artifacts in Excavation Lots (Unmixed Assemblages).

Number of Obsidian Artifacts	Lot	Number of Non-obsidian Artifacts: 0	1-5	6-10	11-15	16-20	21-25	Total
0	E47UCUAU	16	6					22
	A30UNKNO	9	2					11
	I55ARBOL	5	2					7
	P12EAYOT	3	1					4
		33	11					44
1-5	E47UCUAU	10	15	1	1			27
	A37ATOTO	4	6	1				11
	A30UNKNO	8	3					11
	A36TOTOL	4	3					7
	I56UPAST		7	7	1			15
	I55ARBOL	3	16	1				20
	P12EAYOT	2	3	1				6
		31	53	11	2			97
6-10	E47UCUAU		2					2
	A37ATOTO	1	6	1				8
	A30UNKNO	1						1
	A36TOTOL	2	5	1				8
	I56UPAST		2	5	2	1		10
	I55ARBOL		4	3				7
	P12EAYOT		2					2
		4	21	10	2	1		38
11-15	E47UCUAU			1				1
	A37ATOTO		1	3				4
	A36TOTOL	1		1				2
	I56UPAST		1		1			2
	P13LAYOT		1					1
	P12EAYOT			1				1
		1	3	6	1			11
16-20	A37ATOTO		1	1				2
	A36TOTOL			2				2
			1	3				4
21-25	P14BOMBA			1				1
	P13LAYOT			1				1
				2				2
26-30	A36TOTOL			1				1
31-35	P14BOMBA					1		1
	P13LAYOT			1	2	2		5
				1	2	3		6

Table 4.18 (Cont.)

Number of Obsidian Artifacts		Number of Non-Obsidian Artifacts: 0	1- 5	6-10	11-15	16-20	21-25	Total
36-40	P14BOMEA		2	1				3
	P13LAYOT						1	1
	P12EAYOT				1			1
			2	1	1		1	5
41-45	P13LAYOT				1	1		2
46-50	P14BOMBA				1			1
65-70	P14BOMBA					1		1
95-100	P14BOMBA					1		1
120-125	P14BOMBA				1			1
Totals	E47UCUAU	26	23	2	2			52
	A37ATOTO	5	14	6				25
	A30UNKNO	18	5					23
	A36TOTOL	7	8	5				20
	L56UPAST		10	12	4	1		27
	L55ARBOL	8	22	4				34
	P14BOMBA		2	2	2	3		9
	P13LAYOT		1	2	3	3	1	10
	P12EAYOT	5	6	2	1			14
		69	91	35	11	7	1	214

scattering of chipped stone, with obsidian and non-obsidian co-occurring (in about equal proportions) about half the time. Little associative evidence is thus available.

A37ATOTO has 25 lots, all with obsidian. 10 (40%) have 5 or less obsidian artifacts and 5 or less of non-obsidian. There thus seems to be a somewhat greater concentration of chipped stone. Most lots have somewhat more obsidian than non-obsidian (17 or 68% of the lots) and in most of the rest, obsidian and non-obsidian quantities are roughly the same (7 or 28% of the lots).

A30UNKNO has 23 lots, but 9 of these have no chipped stone. Of the 14 with chipped stone, 13 have 5 or less obsidian artifacts and 5 or less of non-obsidian. The one lot with more obsidian has only between 6 and 10 obsidian artifacts and no non-obsidian. The lots tend to favor obsidian, 9 lots having obsidian but no non-obsidian, 3 having roughly the same of each, and 2 having non-obsidian but no obsidian.

A36TOTOL has 20 lots, all with obsidian. Seven (35%) have lots with 5 or less obsidian artifacts and 5 or less of non-obsidian. There is one lot with between 26 and 30 obsidian artifacts and between 6 and 10 non-obsidian artifacts. As with A37ATOTO, most lots have somewhat more obsidian than non-obsidian (16 or 80% of the lots) and in the rest, obsidian and non-obsidian are roughly in the same quantities (4 or 20% of the lots). Seven lots (35%) have obsidian but no non-obsidian.

L56UPAST has 27 lots, all with obsidian. There are no lots that have only obsidian. Seven (26%) have 5 or less obsidian artifacts and 5 or less of non-obsidian. Lots tend to have roughly the same amount of obsidian and non-obsidian--7 lots match at 1 to 5, 5 match at 6 to 10, and 1 at 11 to 15, for a total of 13 (48%) of the lots. There tends to be more non-obsidian than obsidian in the remainder--11 (41%) of the lots have more non-obsidian and only 3 (11%) have more obsidian. The two lots with the most items have no more than 30 chipped stone pieces (one has between 11 and 15 obsidian and 11 and 15 non-obsidian artifacts, the other has been 6 and 10 obsidian and 16 and 20 non-obsidian).

L55ARBOL has 34 lots, but 5 have no chipped stone. Of the remaining 29 lots, 21 (72%) have 5 or less obsidian and 5 or less non-obsidian items. The 3 lots with the most items have between 6 and 10 items of obsidian and between 6 and 10 of non-obsidian. Most lots have roughly the same amount of obsidian and non-obsidian (21 or 72%). Otherwise, there is a slight bias toward obsidian (7 lots have more obsidian and 3 have more non-obsidian).

The 6 assemblages discussed up to this point all have relatively even scatters of small amounts of obsidian and non-obsidian. The assemblages at Tlapacoya are rather different.

P14BOMBA has 9 lots all with relatively large amounts of obsidian. The smallest lot has between 21 and 25 obsidian items and between 6 and 10 non-obsidian items, while the largest has between 120 and 125 of obsidian and between 11 and 15 of non-obsidian. In all lots, obsidian is considerably more prevalent than is non-obsidian, the most non-obsidian found in one lot coming to no more than 20 items. Obviously, the deposit has dense concentration of chipped stone.

P13LAYOT's pattern is not quite as pronounced. The smallest of its 10 lots has between 11 and 15 obsidian items and between 1 and 5 of non-obsidian, while its largest has between 41 and 45 of obsidian and 16 and 20 of non-obsidian. Most lots have between 31 and 45 obsidian items and between 6 and 20 of non-obsidian. All lots have considerably more obsidian than non-obsidian, although the contrast is not so extreme as for P14BOMBA.

P12EAYOT has 14 lots, but 3 of them have no chipped stone. Of the remaining 11, 6 (55%) have 5 or less obsidian artifacts and 5 or less of non-obsidian. Except for one lot, obsidian (constituting no more than 15 items in any lot) and non-obsidian (constituting no more than 10 items in any lot) are relatively thinly scattered. The exceptional lot has between 36 and 40 obsidian items and between 11 and 15 of non-obsidian. (Integrating the chipped stone data with information regarding other materials will be of considerable interest. For example, the exceptional lot, P48, is perhaps sampling material from the floor of a dwelling since a considerable number of "bajareque" fragments--bits of wall-fall--are found in P48.)

Table 4.19a-d: Obsidian Manufacturing Classes
Co-occurring in Excavation Lots

Table 4.19 presents data which indicates the obsidian manufacturing classes presence in lots. To take into account sample size, the table is presented in 4 parts ("a" to "d") for 1 to 5, 6 to 10, 11 to 15, and 16 or more obsidian artifacts, respectively. The contingency tables presented compare low quality manufacturing classes--smash or possible smash flakes (P-SMASH), multiple/split flakes or possibles (P-MULT), UNCERTAINs, and combinations of them—against high quality manufacturing classes--simple flakes (SIM), ridged or rejuvenation or fine flakes (SPL), BLADEs, or combinations of them.

A general observation that can be made is that the more specimens, the more likely it is that all manufacturing classes will be found together. In Table 4.19a, with only 1 to 5 obsidian artifacts in each lot, we find lots with only this or that manufacturing class present--indeed, 50 (52%) of these lots have only low quality classes and 12 (12%) have only high quality items. This variability seems to be attributable to the small sample size, for in Table 4.19b, the low quality only lots drop to 18% (7 of 38) and the high quality only to 8% (3 of 38), and in Table 4.19c, the low quality only lots are at 19% (2 of 11) and there are no high quality only lots, and in Table 4.19d, there are no low or high quality only lots, whereas lots with combinations of low quality and combinations of high quality manufacturing classes increase reaching the point where 17 (71%) of the 24 lots with 16 or more obsidian artifacts have all low and high manufacturing classes. Thus, there is little evidence here for specialized work areas (either

Table 4.19a. Manufacturing Class Artifacts of Obsidian in Excavation Lots with 1 to 5 Obsidian Artifacts (Unmixed Assemblages).

Lots with 1 to 5 obsidian artfacts		Lots With High Quality Manufacturing Class Obsidian Artifacts								
Lots With Low Quality Manufacturing Class Obsidian Artifacts		NONE	SIM	SPL	SIM + SPL	BLADE	BLADE + SIM	BLADE + SPL	ALL	Total
NONE	E47UCUAU					3	2			5
	A30UNKNO					1				1
	L56UPAST		1							1
	L55ARBOL		1	2						3
	P12EAYOT		1							1
			3	2		4	2			11
P-SMASH	E47UCUAU	5		2		2				9
	A37ATOTO	3	1						1	5
	A30UNKNO	4								4
	A36TOTOL	2								2
	L56UPAST	1		1			1	1		4
	L55ARBOL	4	1	1		1				7
	P12EAYOT		1							1
		19	3	4		3	1	1	1	32
P-MULT	E47UCUAU	2								2
	L55ARBOL	1								1
		3								3
UN-CER-TAIN	E47UCUAU	3								3
	A37ATOTO	2								2
	A30UNKNO	1								1
	A36TOTOL	1	1							2
	L55ARBOL					1				1
		7	1			1				9
P-SMASH + P-MULT	E47UCUAU	1	1							2
	A37ATOTO					1				1
	A36TOTOL	1	1							2
	L56UPAST					2				2
	P12EAYOT	1		1		1				3
		3	2	1		4				10
P-SMASH + UN-CERTN	E47UCUAU	2	1			2				5
	A37ATOTO			1			1			2
	A30UNKNO	4								4
	A36TOTOL	1								1
	L56UPAST	4		2						6
	L55ARBOL	2	1	1		2				6
		13	2	4		4	1			24
MULT + UN-CERTN	E47UCUAU	1								1
	A37ATOTO		1							1
		1	1							2
ALL	A30UNKNO	1								1
	L56UPAST	1				1				2
	L55ARBOL	2								2
	P12EAYOT		1							1
		4	1			1				6
Totals	E47UCUAU	14	2	2		7	2			27
	A37ATOTO	5	2	1		1	1		1	11
	A30UNKNO	10				1				11
	A36TOTOL	5	2							7
	L56UPAST	6	1	3		3	1	1		15
	L55ARBOL	9	3	4		4				20
	P12EAYOT	1	3	1		1				6
		50	13	11		17	4	1	1	97

Table 4.19b. Manufacturing Class Artifacts of Obsidian in Excavation Lots with 6 to 10 Obsidian Artifacts (Unmixed Assemblages).

Lots with 6 to 10 obsidian artifacts			Lots With High Quality Manufacturing Class Obsidian Artifacts								
			NONE	SIM	SPL	SIM + SPL	BLADE	BLADE + SIM	BLADE + SPL	ALL	Total
Lots With Low Quality Manufacturing Class Obsidian Artifacts	P-SMASH	A37ATOTO						1		1	2
		L55ARBOL							1		1
								1	1	1	3
	P-SMASH + P-MULT	A37ATOTO							1		1
		L56UPAST		1					1		2
		L55ARBOL	1								1
			1	1					2		4
	P-SMASH + UN-CERTN	E47UCUAU					1				1
		A37ATOTO		1	1			1			3
		A30UNKNO								1	1
		A36TOTOL	1	2				1			4
		L56UPAST	3				2			1	6
		L55ARBOL		1				2			3
		P12EAYOT					1				1
			4	4	1		4	4		2	19
	ALL	E47UCUAU					1				1
		A37ATOTO	1					1			2
		A36TOTOL	1	1		1		1			4
		L56UPAST		2							2
		L55ARBOL						1	1		2
		P12EAYOT							1		1
			2	3		1	1	3	2		12
	Totals	E47UCUAU					2				2
		A37ATOTO	1	1	1			3	1	1	8
		A30UNKNO								1	1
		A36TOTOL	2	3		1		2			8
		L56UPAST	3	3			2		1	1	10
		L55ARBOL	1	1				3	2		7
		P12EAYOT					1		1		2
			7	8	1	1	5	8	5	3	38

Table 4.19c. Manufacturing Class Artifacts of Obsidian in Excavation Lots with 11 to 15 Obsidian Artifacts (Unmixed Assemblages).

Lots with 11 to 15 obsidian artifacts			Lots With High Quality Manufacturing Class Obsidian Artifacts								
			NONE	SIM	SPL	SIM + SPL	BLADE	BLADE + SIM	BLADE + SPL	ALL	Total
Lots With Low Quality Manufacturing Class Obsidian Artifacts	P-SMASH + UN-CERTH	A37ATOTO		2						1	3
		A36TOTOL								1	1
		L56UPAST								1	1
				2						3	5
	ALL	E47UCUAU								1	1
		A37ATOTO							1		1
		A36TOTOL				1					1
		L56UPAST							1		1
		P13IAYOT				1					1
		P12EAYOT							1		1
						2			3	1	6
	Totals	E47UCUAU								1	1
		A37ATOTO		2					1	1	4
		A36TOTOL				1				1	2
		L56UPAST							1	1	2
		P13IAYOT				1					1
		P12EAYOT							1		1
				2		2			3	4	11

Table 4.19d. Manufacturing Class Artifacts of Obsidian in Excavation Lots with more than 15 Obsidian Items (Unmixed Assemblages).

Lots With Low Quality Manufacturing Class Obsidian	Lots with more than 15 obsidian artifacts	Lots With High Quality Manufacturing Class Obsidian Artifacts: NONE	SIM	SPL	SIM +SPL	BLADE	BLADE + SIM	BLADE + SPL	ALL	Total
P-SMASH + UN-CERTN	A36TOTOL								1	1
ALL	A37ATOTO							1	1	2
	A36TOTOL								2	2
	P14BOMBA							2	7	9
	P13LAYOT		1				2		6	9
	P12EAYOT								1	1
			1				2	3	17	23
Totals			1				2	3	18	24

of "tool kits" or of the locations of manufacture).

One possible distinction might be between lots with and without blades. In Table 4.19c, 4 (36%) of the 11 lots lack blades and even in Table 4.19d, 1 (4%) of the 24 lots lack blades. However, considering that blades constitute only about 10% of the assemblage, that they are as ubiquitous as they are rather indicates their general importance.

Table 4.20a-d: Obsidian Use Classes Co-occuring in Excavation Lots

Table 4.20 presents co-occurrence data for obsidian use classes present in each lot (in unmixed assemblages). Again, to take into account sample size, the table is presented in 4 parts ("a" to "d") for 1 to 5, 6 to 10, 11 to 15, and 16 or more obsidian artifacts respectively. The contingency tables presented compare unmodified classes--none (completely unmodified) and/or nibbled (NINE+NIBLD), SLIGHT, and the combination of these--against modified classes--EDGE, NONPT, POINT, and combinations of these.

In Table 4.20a, with only 1 to 5 obsidian artifacts in each lot, we find that 70 (72%) have only "unmodified" items (indeed, 41 or 59% of these lots have only NINE+NIBLD items). As for the 27 lots (28%) with modified artifacts, 19 (70%) of them have EDGE items, 7 (26%) have POINTS, and 1 (4%) has NONPTS--most modified artifacts occur with NON+NIBLD (17 lots or 63% of 27).

In Table 4.20b, we find that 21 (55%) of the 38 lots have only unmodified items (11 or 52% of these have only NONE+NIBLD). As for the 17 lots (45%) with modified items, 11 (65%) of them have EDGE items, 3 (18%) have NONPTs, and there's one lot each (6%) with POINT, POINT+EDGE, and POINT+NONPT--most modified items here occur with combinations of all unmodified classes.

In Table 4.20c, with 11 to 15 obsidian artifacts in each lot, we find that 3 (27%) of the 11 lots have only unmodified items (in combination in all three lots). As for the 8 lots (73%) with modified artifacts, 2 (25%) of them have EDGE items, 1 (13%) has NONPTs, 4 (50%) have POINTs, and 1 (13%) has POINT+EDGE artifacts--almost all modified

Table 4.20a. Obsidian Use Class Artifacts in Excavation Lots With 1 to 5 Obsidian Artifacts (Unmixed Assemblages).

Lots with 1 to 5 obsidian artifacts			Lots With Modified Obsidian Artifacts								
			NO MOD	EDGE	NONPT	EDGE+ NONPT	POINT	POINT +EDGE	POINT +NONP	ALL	Total
Lots With Unmodified Obsidian Artifacts	NO UNMOD	E47UCUAU		3							3
		L55ARBOL					2				2
		(subtotal)		3			2				5
	NONE+ NIBLD	E47UCUAU	10	3			1				14
		A37ATOTO	6	2			2				10
		A30UNKNO	7								7
		A36TOTOL	5								5
		L56UPAST	4	2			1				7
		L55ARBOL	7	3			1				11
		P12EAYOT	2	2							4
		(subtotal)	41	12			5				58
	SLIGHT	E47UCUAU	5	1							6
		A30UNKNO	1								1
		L55ARBOL		1							1
		(subtotal)	6	2							8
	NONE+ NIBLD+ SLIGHT	E47UCUAU	3		1						4
		A37ATOTO	1								1
		A30UNKNO	3								3
		A36TOTOL	2								2
		L56UPAST	7	1							8
		L55ARBOL	5	1							6
		P12EAYOT	2								2
		(subtotal)	23	2	1						26
	Totals	E47UCUAU	18	7	1		1				27
		A37ATOTO	7	2			2				11
		A30UNKNO	11								11
		A36TOTOL	7								7
		L56UPAST	11	3			1				15
		L55ARBOL	12	5			3				20
		P12EAYOT	4	2							6
		(subtotal)	70	19	1		7				97

Table 4.20b. Obsidian Use Class Artifacts in Excavation Lots with 1 to 5 Obsidian Artifacts (Unmixed Assemblages).

Lots with Unmodified Obsidian Artifacts	Lots with 6 to 10 obsidian artifacts		Lots with Modified Obsidian Artifacts: NO MOD	EDGE	NONPT	EDGE+ NONPT	POINT	POINT +EDGE	POINT +NONP	ALL	Total
	NONE+ NIBLD	E47UCUAU	1								1
		A37ATOTO						1			1
		A36TOTOL	3	1							4
		L56UPAST	3				1				4
		L55ARBOL	3	1							4
		P12EAYOT	1								1
			11	2			1	1			15
	NONE+ NIBLD+ SLIGHT	E47UCAU							1		1
		A37ATOTO	3	4							7
		A30UNKNO			1						1
		A36TOTOL	4								4
		L56UPAST	3	2	1						6
		L55ARBOL		2	1						3
		P12EAYOT		1							
			10	9	3				1		23
	Totals	E47UCUAU	1						1		2
		A37ATOTO	3	4				1			8
		A3CUNKNO			1						1
		A36TOTOL	7	1							8
		L56UPAST	6	2	1		1				10
		L55ARBOL	3	3	1						7
		P12EAYOT	1	1							2
			21	11	3		1	1	1		38

Table 4.20c. Obsidian Use Class Artifacts in Excavation Lots with 11 to 15 Obsidian Artifacts (Unmixed Assemblages).

Lots with 11 to 15 obsidian artifacts			Lots with Modified Obsidian Artifacts								
			NO MOD	EDGE	NONPT	EDGE+ NONPT	POINT	POINT +EDGE	POINT +NONP	ALL	Total
Lots with Unmodified Obsidian Artifacts	NONE+ NIBLD	A37ATOTO						1			1
	NONE+ NIBLD+ SLIGHT	E47UCUAU	1								1
		A37ATOTO	1	2							3
		A36TOTOL	1				1				2
		I56UPAST			1		1				2
		P13IAYOT					1				1
		P12EAYOT					1				1
			3	2	1		4				10
	Totals		3	2	1		4	1			11

Table 4.20d. Obsidian Use Class Artifacts in Excavation Lots with more than 15 Obsidian Artifacts (Unmixed Assemblages).

Lots with 16 or more obsidian artifacts			Lots with Modified Obsidian Artifacts								
			NO MOD	EDGE	NONPT	EDGE+ NONPT	POINT	POINT +EDGE	POINT +NONP	ALL	Total
Lots with Unmodified Obs. Artifts	NONE+ NIBLD	A36TOTOL		1							1
	NONE+ NIBLD+ SLIGHT	A37ATOTO	1	1							2
		A36TOTOL	1	1							2
		P14BOMBA	1		1	3		3		1	9
		P13LAYCT		5	1	1	2				9
		P12EAYOT						1			1
			3	7	2	4	2	4		1	23
	Totals		3	8	2	4	2	4		1	24

artifacts occur with combinations of all unmodified classes.

In Table 4.20d, only 3 (13%) have unmodified artifacts only (in combination in all three lots). As for the 21 lots (88%) with modified artifacts, 8 (38%) of them have EDGE items, 2 (10%) have NONPTs, 4 (19%) have EDGE+NONPT, 2 (10%) have POINTs, 4 (19%) have POINT+EDGE, and 1 (5%) has all of the modified classes.

The general pattern is that the greater the number of specimens in a lot, the more likely it is: that one of the rare modified pieces will be included, that combinations of modified classes will occur, and that combinations of all unmodified pieces will be universal. This is plausibly interpreted as meaning that the modified items are not clustered, but are rather evenly dispersed throughout the lots.

Table 4.21: Obsidian Breakage Classes Co-occurring in Excavation Lots

Table 4.21 is an attempt to use breakage of obsidian artifacts as one measure of the nature of the deposit. In particular, the finding of small blade fragments, broken flakes and broken shaped pieces (POINTs and NONPTs) would suggest that the artifacts co-occurring in a lot were not the coherent residue of a past cultural system. Again, the size of the lot sample is used as a dimension so as to control variation that is perhaps due to the smallness of the sample.

In lots with 5 or less obsidian items, 43 (44%) of the 97 lots are composed of fragments, 46 (47%) have both fragmentary and whole items, while only 8 (8%) have whole items only ("whole" means that more than about 80% of a non-lamellar flake or a shaped piece is present and that more than about 20%--since intentional snapping is a possibility--of a lamellar flake is present). Three lots have fragments of shaped pieces and 4 have whole shaped pieces (3 with no other whole items and 1 with).

In lots with 6 to 10 obsidian artifacts, most lots (32 of 38 or 84%) have both fragmentary and whole items, 16 (16%) have fragments only, and none have only whole items. Two lots have fragments of shaped pieces and 2 have whole shaped pieces but no other whole items.

In lots with 11 or more obsidian artifacts, all lots have fragments and whole items. Seven lots have fragments of shaped pieces and 7 have whole shaped pieces (5 with no other whole items and 2 with).

Given that so many lots have fragments, that broken shaped pieces are so widespread (given the rarity of shaped pieces altogether), that even the whole shaped pieces tend to occur with fragments, and

Table 4.21. Obsidian Artifact Breakage in Excavation Lots (Unmixed Assemblages).

		Fragments[a] Only			Fragments[a] + Whole[b]:				Whole Only[b]	Total
		No SHPD	Only SHPD	Both	Flake (NS[c])	Flake (IS[d])	SHPD	Both	Flake	
Lots with 1 to 5 obsidian artifacts	E47UCUAU	15			9		1		2	27
	A37ATOTO	4			4		1	1	1	11
	A30UNKNO	9			2					11
	A36TOTOL	3			3				1	7
	L56UPAST	3			9		1		2	15
	L55ARBOL	5	2	1	11				1	20
	P12EAYOT	1			4				1	6
		40	2	1	42		3	1	8	97
Lots with 6 to 10 obsidian artifacts	E47UCUAU				1		1			2
	A37ATOTO	1			6	1				8
	A30UNKNO			1						1
	A36TOTOL	1			7					8
	I56UPAST	2			7		1			10
	I55ARBOL	1			6					7
	P12EAYOT				2					2
		5		1	29	1	2			38
Lots with 11 to 15 obsidian artifacts	E47UCUAU				1					1
	A37ATOTO				2	1		1		4
	A36TOTOL				1	1				2
	I56UPAST					1	1			2
	P13LAYOT					1				1
	P12EAYOT					1				1
					4	5	1	1		11
Lots with 16 or more obsidian artifacts	A37ATOTO				2					2
	A36TOTOL				3					3
	P14BOMBA				5	1	2	1		9
	P13LAYOT				7	1	1			9
	P12EAYOT						1			1
					17	2	4	1		24

a. "Fragment" means: less than about 80% of non-lamellar flakes or shaped pieces (SHPD); a small fragment (less than approximately 20%) of a lamellar flake.

b. "Whole" means: more than about 80% of non-lamellar flakes or shaped pieces; more than about 20% of a lamellar flake.

c. "NS" means no shaped fragments are present.

d. "IS" means shaped fragments are included in the lot.

that as sample size increases lots tend to include some whole items, one can plausibly infer that at least for most lots the co-occurring artifacts are not a coherent residue of a past cultural system. They may represent garbage, "fill," or the disruption of natural processes.

Table 4.22: Weights of Artifacts

Table 4.22 presents the Mean ($\bar{M}$), minimum (Min), and maximum (Max) weight of whole (W) and of fragmentary (F) artifacts of obsidian and of non-obsidian for the different manufacturing classes found in each unmixed assemblage, thus serving to give both relative and absolute size data ("N" refers to the number of specimens).

In absolute terms, the sizes of specimens in the assemblages are small. The average weight of an obsidian item is about the same as that of a small whole obsidian point, i.e., about 2 grams.

Comparing obsidian and non-obsidian specimens within the same manufacturing class, we see that obsidian specimens are generally smaller. For example, P-SMASH (smash flakes and possibles), the mean assemblage weights for whole and fragmentary obsidian specimens (1st page of the table) are consistently less than 3 grams, while for non-obsidian (2nd page) they are consistently greater than 4 grams, often greater than 4 grams, and reaching to over 10 grams. Similar differences are found for P-MULT, DREGS, and SIMPLE.

Comparing whole and fragmentary specimens, we find that fragments are often larger than whole specimens within the same manufacturing class. For (an extreme) example, except for Loma de Atoto assemblages, the mean assemblage weights for P-SMASH obsidian fragments are greater than for whole items. This lends support to the notion of accidental breakage, since it is plausible that accidental post-use fracturing would tend to break larger (flattish) items down in a kind of homogenizing "pulverization." Certainly, the few examples of whole blades (3rd page) include the few "micro-blades" in the collections.

Table 4.22. Weight of Whole and Fragmentary Artifacts by Manufacturing Class in Unmixed Assemblages (in grams).

		OBSIDIAN															
		P-SMASH				P-MULT				DREGS				SIMPLE			
		$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N
E47-	W	0.79	0.2	1.8	11	3.05	0.4	5.7	2	0.57	0.2	1.1	3				0
UCUAU	F	2.39	0.3	9.7	19	1.75	0.4	3.1	2	1.88	0.2	11.5	10	0.53	0.2	1.1	3
A37-	W	1.11	0.1	4.7	19	2.03	0.6	4.3	3	1.00	0.3	1.9	4	0.60	0.2	1.2	6
ATOTO	F	0.97	0.1	6.4	59	0.63	0.3	1.5	10	1.08	0.1	6.0	28	1.47	0.3	4.4	15
A30-	W	2.1			1	0.5			1				0				0
UNKNO	F	1.26	0.5	2.7	14				0	1.04	0.1	4.1	9	0.5			1
A36-	W	2.27	0.2	12.2	19	0.86	0.2	1.3	5	3.00	0.6	7.6	6	1.26	0.2	5.2	7
TOTOL	F	1.14	0.1	10.8	56	2.47	0.2	9.5	9	0.78	0.1	4.2	28	1.26	0.2	3.6	12
L56-	W	2.13	0.4	9.3	27	1.68	0.4	4.1	4	15.30	0.5	54.7	4	3.58	0.6	5.1	4
UPAST	F	2.61	0.3	35.8	63	1.17	0.2	4.2	7	2.94	0.3	11.7	29	2.23	0.3	6.8	4
U55-	W	1.40	0.5	3.3	17	1.80	0.6	3.0	2	1.6			1	1.5			1
ARBOL	F	2.24	0.3	15.9	34	0.90	0.3	2.1	4	1.79	0.3	7.0	15	1.18	0.3	3.0	6
P14-	W	2.13	0.1	13.5	78	1.46	0.2	8.2	32	1.31	0.3	3.1	17	0.95	0.3	2.8	12
BOMBA	F	2.60	0.2	56.0	108	1.52	0.2	13.4	46	2.88	0.1	25.7	109	2.00	0.4	11.7	15
P13-	W	1.36	0.2	3.9	39	1.75	0.3	7.6	11	2.94	0.5	27.8	18	1.74	0.2	5.9	8
LAYOT	F	2.03	0.2	24.8	79	1.03	0.2	3.5	26	1.36	0.1	8.8	92	1.24	0.3	3.0	11
P12-	W	2.00	0.7	6.3	10	1.87	0.8	2.9	3	1.80	0.9	2.9	3	4.80	0.3	7.9	4
EAYOT	F	3.15	0.5	20.9	20	2.83	0.4	8.0	6	2.36	0.3	10.0	21	1.73	0.3	3.7	3

Table 4.22 (Cont.)

		NON-OBSIDIAN															
		P-SMASH				P-MULT				DREGS				SIMPLE			
		$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N
E47-	W	4.06	0.4	15.9	5	2.58	1.3	6.0	6	16.45	0.6	36.7	11	5.88	2.8	11.7	4
UCUAU	F	6.70	1.2	10.6	6	2.78	1.2	5.8	4	4.70	0.2	37.0	28	4.40	0.9	10.5	3
A37-	W	3.91	0.5	10.5	10	3.05	0.3	8.5	6	8.18	0.6	27.0	10	2.41	0.6	7.4	10
ATOTO	F	6.08	0.3	44.6	12	2.01	0.6	7.4	9	7.71	0.5	38.7	22	4.90	1.1	9.1	4
A30-	W				0	2.95	2.3	3.6	2	4.10	1.6	6.6	2				0
UNKNO	F				0				0	8.33	0.5	23.8	3	15.7			1
A36-	W	4.56	0.7	13.1	7	12.21	0.3	56.9	7	8.73	4.6	20.5	4	7.69	0.8	24.8	8
TOTOL	F	4.02	0.9	10.4	6	1.73	0.3	3.1	4	4.42	0.3	12.2	18				0
I56-	W	12.74	0.6	78.9	37	2.75	0.5	15.2	15	20.74	0.6	321.5	21	5.26	0.5	27.4	18
UPAST	F	9.34	0.7	82.1	28	5.70	0.3	22.1	10	26.44	0.2	782.2	66	6.51	0.5	21.2	7
I55-	W	5.20	1.2	15.5	8	3.63	1.0	9.3	7	22.61	1.1	76.7	7	12.62	0.4	37.2	9
ARBOL	F	2.79	0.6	10.6	9	1.82	0.8	2.4	5	10.35	0.4	206.2	43	3.6			1
P14-	W	8.98	0.6	64.2	13	3.26	0.5	12.2	10	32.86	0.3	201.3	7	9.88	1.3	24.2	5
BOMBA	F	3.34	0.6	13.3	11	3.30	0.4	10.8	20	5.53	0.2	133.3	44	7.7			1
P13-	W	10.36	1.0	52.3	9	4.13	0.3	21.9	16	17.52	1.1	66.3	12	4.68	2.5	11.7	5
LAYOT	F	1.71	0.4	7.2	7	2.64	0.2	10.6	24	7.74	0.5	67.1	51	7.83	4.9	13.5	8
P12-	W	2.20	2.1	2.3	2	15.20	1.5	60.3	5	136.1	1.8	385.4	8	15.1			1
EAYOT	F	6.75	0.9	14.1	6	4.75	0.5	11.0	6	10.94	1.1	72.4	13	9.8			1

Table 4.22 (Cont.)

		OBSIDIAN															
		P-REJUV				FINE				RIDGED				BLADE			
		$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N
E47-	W	2.10	0.4	3.8	2				0				0				0
UCUAU	F	0.5			1				0				0	1.41	0.3	3.5	19
A37-	W	0.35	0.2	0.5	2				0	0.8			1				0
ATOTO	F	0.3			1	0.27	0.2	0.4	3	4.8			1	2.60	0.3	8.2	16
A30-	W				0				0				0				0
UNKNO	F				0				0				0	0.45	0.4	0.5	2
A36-	W	0.50	0.5	0.5	2	0.30			1				0				0
TOTOL	F	0.40	0.3	0.4	2	0.25	0.2	0.3	2	0.3			1	2.31	0.2	4.6	7
L56-	W	1.1			1				0				0				0
UPAST	F	0.7			1				0	2.25	1.5	3.0	2	2.08	0.4	4.1	13
L55-	W				0				0				0				0
ARBOL	F				0				0				0	1.45	0.4	2.7	11
P14-	W	0.4			1	0.1			1	4.7			1	0.80	0.7	0.9	2
BOMBA	F	3.27	1.0	7.4	3	0.4			1	1.79	0.5	3.2	10	1.40	0.3	11.3	62
P13-	W				0				0				0	2.8			1
LAYOT	F	0.6			1				0	0.70	0.6	0.9	3	0.73	0.1	1.5	34
P12-	W				0				0				0				0
EAYOT	F				0				0				0	1.17	0.5	2.2	7

Table 4.22 (Cont.)

		OBSIDIAN				NON-OBSIDIAN			
		SHAPED				SHAPED			
		$\bar{M}$	Min	Max	N	$\bar{M}$	Min	Max	N
E47-UCUAU	W	1.60	0.8	2.5	3				0
	F				0				0
A37-ATOTO	W	2.30	1.3	4.0	3				0
	F	1.90	1.3	2.8	3	4.9			1
A30-UNKNO	W				0				0
	F	2.1			1				0
A36-TOTOL	W				0	70.5			1
	F	0.7			1				0
L56-UPAST	W	2.57	1.6	4.1	3	43.5			1
	F	1.20	1.0	1.4	2				0
L55-ARBOL	W				0				0
	F	0.90	0.7	1.2	4				0
P14-BOMBA	W	1.45	0.6	2.9	4	7.7			1
	F	2.7			1	10.3			1
P13-LAYOT	W	1.6			1				0
	F	4.60	1.6	7.6	2				0
P12-EAYOT	W	2.0			1				0
	F	5.4			1				0

Comparison of the different manufacturing classes is difficult since whole specimens do not appear to be representative and since breakage may have been a homogenizing factor. P-REJUV and FINE (by definition) are the smallest types of items. Other than that, items are comparably small.

Comparing assemblages, we find little inter-assemblage variability, except for occasional inflation of averages because of single exceptionally large specimens included in the sample. One could establish a slight gradient of average weights with P12EAYOT having the largest average weights and the Loma de Atoto assemblages the smallest.

Table 4.23: Widths of Blades and Points

Table 4.23 presents mean ($\overline{W}$), minimum (Min), and Maximum (Max) widths of regular blades, of whole and of fragmentary points. In addition, the standard deviations for blade width measurements are also provided (s).

One question being addressed here concerns the likelihood that bifacially worked points were made from blades. Obviously, since points are shaped via a reduction strategy, they would have to have been made from larger objects. Especially since the edges of blades are very fine, any blades used in point production would have to have been several millimeters wider than the finished item.

There is little support here for the notion that points were produced from blades, at least from such blades as are found at these sites. For example, in P12EAYOT and P13LAYOT, the maximum blade width is under 17 mm (among 42 specimens) whereas the smallest point width is 22 mm (among 5 specimens, both whole and fragmentary). In P14BOMBA, there are a few large blades of sufficient width to represent a set of blanks that could be used in point production, but such large blades are rare (only 1 is over 30 mm and only 1 between 20 and 30 mm). Overall, average blade width in unmixed assemblages is only 12.6 mm whereas average whole point width is 17.6 and point fragments an even wider 20.2 mm (since these are not random samples, a rigorous testing using analysis of variance, such as is provided by the Student's _t_-test, is not justifiable).

Another question being addressed here concerns the variability of blades within lots. The greater the variability, the more likely

Table 4.23. Widths (Mean, Minimum, Maximum) of Regular Blades and of Points in Unmixed Assemblages (in mm).

	Regular Blades					Points:Whole				Points:Fragments			
	$\bar{W}$	Min	Max	s	N	$\bar{W}$	Min	Max	N	$\bar{W}$	Min	Max	N
E47UCUAU	13.4	9.0	18.3	2.56	19	15	15	15	2				0
A37ATOTO	15.1	9.0	24.5	4.02	16	16	14	18	2	19.5	19	20	2
A30UNKNO	8.6	7.9	9.3	0.99	2				0				0
A36TOTOL	15.6	10.5	20.5	3.99	7				0	12			1
L56UPAST	13.5	990	15.8	1.88	12	19.5	17	22	2	16.5	15	18	2
L55ARBOL	13.8	9.3	18.1	2.77	12	19	18	20	2	17			1
P14EOMEA	12.7	7.8	38.7	4.42	62	15	12	17	3	25			1
P13IAYOT	10.2	6.2	15.0	1.99	35	22			1	26.5	24	29	2
P12EAYOT	11.2	8.1	16.4	2.74	7	22			1	23			1
Total Unmixed	12.6	6.2	38.7		172	17.6	12	22	13	20.2	12	29	10

it is that blades were made locally; the greater the standardization, the more likely it is that blades of specific sizes were being imported. Using "s," the standard deviation (calculated using N-1 for an unbiased estimate), we find that A36TOTOL and A37ATOTO at Loma de Atoto and P14BOMBA at Tlapacoya have by far the most variability--over 1 mm separates the approximately 4 mm standard deviation of these from the less than 2.8 mm standard deviations of the others (A30UNKNO, with only 2 specimens should be ignored for these considerations). P13LAYOT's (at Tlapacoya) and L56UPAST's (at El Arbolillo East) blades have the least variation.

Also, considering $\overline{W}$, P12EAYOT and P13LAYOT have the smallest blades (and A30UNKNO's two blades are anomalously small at Loma de Atoto).

Table 4.24: Thickness of Blades and Points

Table 4.24 presents the mean ($\bar{\bar{T}}$), minimum (Min), and maximum (Max) thicknesses of regular blades, of whole points, and of point fragments in unmixed assemblages (N indicates the number of specimens). In addition, the standard deviation (s) is presented for blades.

Again, as in Table 4.23, comparison of blades and points enables one to consider the likelihood of points having been made from blades. As was the case for width, thickness provides little support for the use of blades as point blanks. Only if the largest blades were utilized (and in some assemblages even this may not have been possible) might points have been made from blades.

Considering blade variability, the standard deviation for thickness is largest for A37ATOTO and A36TOTOL (as it was for width). While still larger than most, P14BOMBA's standard deviation for thickness is not as distinctive as was its width, the thickness variation being fairly close to that of E37UCUAU. The smallest variation is found in P12EAYOT, P13LAYOT, and L56UPAST.

Also, P13LAYOT has the thinnest blades, with a mean of 2.3 mm.

Table 4.24. Thicknesses (Mean, Minimum, Maximum) of Regular Blades and of Points in Unmixed Assemblages (in mm).

	Regular Blades					Points: Whole				Points: Fragments			
	$\bar{T}$	Min	Max	s	N	$\bar{T}$	Min	Max	N	$\bar{T}$	Min	Max	N
E47UCUAU	3.2	2.0	4.7	0.78	19	4.0	3.1	4.8	2				0
A37ATOTO	3.6	1.9	5.0	1.01	16	4.4	3.7	5.0	2	5.6	4.5	7.8	3
A30UNKNO	2.8	2.7	2.8	0.07	2				0				0
A36TOTOL	3.6	1.5	5.0	1.14	7				0	2.9			1
L56UPAST	3.1	2.0	3.7	0.47	12	4.2	3.9	4.6	2	4.2	3.9	4.6	2
L55AREOL	3.2	1.9	4.2	0.66	12	3.6	3.4	3.7	2	3.9			1
P14BOMBA	2.9	1.9	7.2	0.89	62	3.7	3.0	4.2	3	5.8	4.6	7.1	2
P13LAYOT	2.3	1.6	3.1	0.43	35	4.0			1	6.3	3.7	8.9	2
P12EAYOT	2.8	2.2	3.5	0.47	7	4.3			1	8.3			1
Unmixed Totals	2.9	1.5	7.2		172	4.0	3.0	5.0	13	5.4	2.9	8.9	12

Table 4.25a-h: Cap Characteristics

Table 4.25 presents data regarding the cap of obsidian artifacts in unmixed assemblages. Such an be used for considering further the question of observable distinctions between manufacturing classes. Only specimens with cap present (or measurable) could be used. The number of missing cases (specimens with no caps) varies from manufacturing class to manufacturing class.

Table 4.25a presents data regarding the surface of the cap. The values of this variable are: flat or slightly concave (FLAT); deeply concave (NEG); dihedral or ridged (RIDG); facetted, a number of small scars (FCTT); crushed or partially crushed (CRSH); surface abraded (ABRA); original cortex of stone (CRTX); and various other (or indeterminate) surfaces (OTHR).

Considering the specimens with caps within the crude and simple manufacturing classes, we find that smash flakes and possibles (P-SMASH) have the most CRSH (50%), multiple and/or split flakes and possibles (P-MULT) are next (38%), then UNCERTN and SIMPLE flakes (22% and 21%, respectively). UNCERTN and SIMPLE have the most FLAT surfaces (51% and 49%, respectively), P-MULT is next with 38% and P-SMASH has 29%. P-MULT and UNCERTN are the only classes with NEG, SIMPLE is the only class with ABRA, and the CRUDE classes are the only ones with CRTX.

Regarding the specimens with caps within the more specialized manufacturing classes, we find that 82% of the BLADEs have FLAT surfaces and another 11% have some crushing. We find no abrasion nor any scratching (both of these are noted by Crabtree 1968). (Abrasion is

Table 4.25a. Surface of Cap by Manufacturing Class, Obsidian Artifacts, Unmixed Assemblages.

		FLAT	NEG	RIDG	FCTT	CRSH	ABRA	CRTX	OTHR	Totals
P-SMASH	#	57		9	6	98		4	21	195
	%	29.2		4.6	3.1	50.3		2.1	10.8	
P-MULT	#	44	1	3	9	44		3	13	117
	%	37.6	0.9	2.6	7.7	37.6		2.6	11.1	
UN-CERTN	#	30	3	3	2	13		2	6	59
	%	50.8	5.1	5.1	3.4	22.0		3.4	10.2	
SIMPLE	#	42		3	6	18	3	2	11	85
	%	49.1		3.5	7.1	21.2	3.5	2.4	12.9	
RIDGED	#	1				5				6
	%	16.7				83.3				
P-REJUV	#	4		3	3	4			4	18
	%	22.2		16.7	16.7	22.2			22.2	
FINE	#				1	3			4	8
	%				12.5	37.5			50.0	
BLADE	#	45			1	6			3	55
	%	81.8			1.8	10.9			5.5	
Unmixed Totals	#	223	4	21	28	191	3	11	62	543
	%	41.1	0.7	3.9	5.2	35.2	0.6	2.0	11.4	

Table 4.25b. Continuity of Cap Surface by Manufacturing Class, Obsidian Artifacts, Unmixed Assemblages.

		CONTINU	DISCON	PTLCRSH	SPLIT	INCOM	Totals
P- SMASH	# %	57 60.6	1 1.1	7 7.4	12 12.8	17 18.1	94
P- MULT	# %	37 50.0	3 4.1	7 9.5	13 17.6	14 18.9	74
UN- CERTN	# %	30 69.8		4 9.3	2 4.1	7 16.3	43
SIMPLE	# %	50 78.1	1 1.6	2 3.1	3 4.7	8 12.5	64
RIDGED	# %	1 50.0		1 50.0			2
P- REJUV	# %	14 93.3				1 6.7	15
FINE	# %	3 50.0		3 50.0			6
BLADE	# %	42 82.4	1 2.0	4 7.8		4 7.8	51
Unmixed Totals	# %	233 67.0	6 1.7	28 8.0	30 8.6	51 14.7	348

Table 4.25c. Prominence of Bulb by Manufacturing Class, Obsidian Artifacts, Unmixed Assemblages.

		Low			High					XHi	Total
		SMOO	WAVE	OTHR	SMOO	WAVE	FLAT	HALF	OTHR		
P-SMASH	#	3		9	69	1	6	18	56	27	189
	%	1.6		4.8	36.5	0.5	3.2	9.5	29.6	14.3	
P-MULT	#	2		6	55	1		13	26	15	118
	%	1.7		5.1	46.6	0.8		11.0	22.0	12.7	
UN-CERTN	#	2		1	33			6	7	8	57
	%	3.5		1.8	57.9			10.5	12.3	14.0	
SIMPLE	#	2		3	49			10	6	15	85
	%	2.4		3.5	57.6			11.8	7.1	17.6	
RIDGED	#			1	2	2			1		6
	%			16.7	33.3	33.3			16.7		
P-REJUV	#	1		1	10			4	2		18
	%	5.6		5.6	55.6			22.2	11.1		
FINE	#				3			4	1		8
	%				37.5			50.0	12.5		
BLADE	#	1	2		8	41			8		60
	%	1.7	3.3		13.3	68.3			13.3		
Unmixed Totals	#	11	2	21	229	45	6	55	107	65	541
	%	2.0	0.4	3.8	42.3	8.3	1.1	10.2	19.8	12.0	

Table 4.25d. Angle Cap Makes with Ventral Surface, by Manufacturing Class, Obsidian Artifacts, Unmixed Assemblages.

		64 OR LESS	75-84	85-95	96-105	106-115	116-125	126-135	136 OR MORE	Totals
P-SMASH	#	1	3	6	10	18	20	13	6	77
	%	1.3	3.9	7.8	13.0	23.4	26.0	16.9	7.8	
P-MULT	#	1	1	3	10	20	20	9	3	67
	%	1.5	1.5	4.5	14.9	29.9	29.9	13.4	4.5	
UN-CERTN	#	1	1	5	9	14	9	1		40
	%	2.5	2.5	12.5	22.5	35.0	22.5	2.5		
SIMPLE	#			9	7	13	13	6	2	50
	%			18.0	14.0	26.0	26.0	12.0	4.0	
RIDGED	#				1					1
	%				100.0					
P-REJUV	#			1		4	2	3		10
	%			10.0		40.0	20.0	30.0		
FINE	#				1	1			1	3
	%				33.3	33.3			33.3	
BLADE	#		3	20	14	9	1			47
	%		6.4	42.6	29.8	19.1	2.1			
Unmixed Totals	#	3	8	44	52	79	65	32	12	295
	%	1.0	2.7	14.9	17.6	26.8	22.0	10.8	4.1	

Table 4.25e. Bulbar Scars by Manufacturing Class, Obsidian Artifacts, Unmixed Assemblages.

		NONE	SMALL	LARGE	Total
P-SMASH	#	71	41	27	139
	%	51.1	29.5	19.4	
P-MULT	#	40	43	32	94
	%	45.7	34.0	20.2	
UN-CERTN	#	28	17	6	51
	%	54.7	33.3	11.8	
SIMPLE	#	44	23	7	74
	%	59.5	31.1	9.5	
RIDGED	#	3	2		5
	%	60.0	40.0		
P-REJUV	#	12	3	1	16
	%	75.0	18.8	6.2	
FINE	#	8			8
	%	100.0			
BLADE	#	24	21	14	59
	%	40.7	35.6	23.7	
Unmixed Totals	#	233	139	74	446
	%	52.2	31.2	16.6	

Table 4.25f. Ventral Lipping on Obsidian Artifacts with Cap Present, by Manufacturing Class, Unmixed Assemblages.

		NONE	LIP	LOCUS GONE	Totals
P-SMASH	#	47	21	71	139
	%	33.8	15.1	51.1	
P-MULT	#	31	9	54	94
	%	33.0	9.6	57.4	
UN-CERTN	#	20	6	25	51
	%	39.2	11.8	49.0	
SIMPLE	#	25	13	34	74
	%	33.8	17.6	45.9	
RIDGED	#	2		3	5
	%	40.0		60.0	
P-REJUV	#	6	2	8	16
	%	37.5	12.5	50.0	
FINE	#	4	2	2	8
	%	50.0	25.0	25.0	
BLADE	#	45	1	13	59
	%	76.3	1.7	22.0	
Unmixed Totals	#	182	54	210	446
	%	40.8	12.1	47.1	

Table 4.25g. Nape Characteristics of Obsidian Artifacts, Unmixed Assemblages.

		NONE	CHP	ABR	FLAK	FLAK +CHP	FLAK +ABR	BATT	BATT +CHP	BATT +ABR	Totals
P-SMASH	#	38	2			3		10		1	54
	%	70.4	3.7			5.6		18.5		1.9	
P-MULT	#	16	2			4		5	1	1	29
	%	55.2	6.9			13.8		17.2	3.4	3.4	
UN-CERTN	#	18			2	1	1	11		4	37
	%	48.6			5.4	2.7	2.7	29.7		10.8	
SIMPLE	#	28		4	1	3		11	1	1	49
	%	57.1		8.2	2.0	6.1		22.4	2.0	2.0	
RIDGED	#					1	2				3
	%					33.3	66.7				
P-REJUV	#	4						1	1		6
	%	66.7						16.7	16.7		
FINE	#					1		4			5
	%					20.0		80.0			
BLADE	#	2		2		7	7	7	18	11	54
	%	3.7		3.7		13.0	13.0	13.0	33.3	20.4	
Unmixed Totals	#	106	4	6	3	20	10	49	21	18	237
	%	44.7	1.7	2.5	1.3	8.4	4.2	20.7	8.9	7.6	

Table 4.25h. Symmetry of Flakes About Axis of Force for Roughly Linear Obsidian Artifacts, by Manufacturing Class (Unmixed Assemblages).

		SYM	ASYM	Total
P-SMASH	#	34	41	75
	%	45.3	54.7	
P-MULT	#	12	36	48
	%	25.0	75.0	
UN-CERTN	#	12	14	26
	%	46.2	53.8	
SIMPLE	#	22	29	51
	%	43.1	56.9	
RIDGED	#	2		2
	%	100.0		
P-REJUV	#	3	6	9
	%	33.3	66.7	
FINE	#	3		3
	%	100.0		
BLADE	#	24	18	42
	%	57.1	42.9	
Unmixed Totals	#	112	144	256
	%	43.8	56.3	

found on some blade caps in mixed assemblages, evidently attributable to later time periods.) A surprisingly large percentage of RIDGED (even with so small a sample) have CRSH surfaces--they may mean either that a number of ridged flakes are actually smash flakes that accidentally have the morphology of ridged flakes or that ridged flakes are not produced by the same pressure-flaking procedure that produces blades. Similar reasoning applies to the FINE flakes, since they also have a somewhat higher percentage of CRSH.

Table 4.25b presents data regarding the continuity of the cap surface. The values of the variable are: continuous (CONTINU); discontinuous, the cap surface being present in several isolated sections (DISCON); partial crushing and part a distinguishable cap surface (PTLCRSH); an incomplete cap surface, terminated by split-flaking (SPLIT); and incomplete cap surface, terminated by hinge or some other fracturing (INCOM). The highest occurrences of CONTINU are among BLADE and SIMPLE (and the small sample of P-REJUV), while the highest occurrences of SPLIT and INCOM are found in P-SMASH and P-MULT.

Table 4.25c indicates the prominence of the bulb for obsidian artifacts with proximal elements within each manufacturing class. Values are: Low, High, and XHi (Very high); and subdivisions are based on the contour of the bulbar surface--smooth surface (SMOO), pronounced rippling just below the bulb (WAVE), flattened top portion of the bulb (FLAT), and "half" bulb, i.e. where the point of applied force appears to be centered above the cap, this at times being attributed to soft hammer percussion. The crude and simple classes have the XHi bulbs. P-SMASH and P-MULT also have high percentages of

High bulbs with various unusual variations in their contours (OTHR). And P-SMASH has the FLAT bulbs. BLADES are unusual in having a large percentage of somewhat high bulbs with the WAVE transition.

Table 4.25d indicates the data for the angle between the cap and the ventral surface. For crude and simple flakes, the typical values appear to be between 106 and 125 degrees, whereas for BLADEs it is between 85 and 105 degrees. Also , there are 3 specimens (1 P-SMASH, 1 P-MULT, and 1 UNCERTN) that are less than 65 degrees.

Table 4.25e indicates bulbar scar data. The size coding (SMALL or LARGE) of the scar is relative to the size of the proximal element. BLADEs tend to have more large scars than other categories, but P-MULT and P-SMASH are close behind. P-REJUV and FINE have the least bulbar scarring and BLADES the most, with the crude flakes in the middle.

Table 4.25f presents data on ventral lipping. LOCUS GONE indicates that the cap-ventral edge, where lipping would be located if it were present, has probably been broken off during manufacturing (e.g. via crushing or the bulbar scar carrying through to the cap). Blades are fairly distinctive in having no lipping, the other manufacturing classes having either LIP or LOCUS GONE.

Table 4.25g presents data on the nape area (sometimes referred to as the area of battering), i.e. the dorsal surface adjacent to the cap-dorsal surface edge. This variable relates to the possibility of core-edge preparation, i.e. the removal of dorsal lipping or overhang. Crude and simple flakes tend to have none--indicating no core-edge preparation. That battering (BATT) is relatively high for crude and simple flakes suggests that some battering occurs during or after the application of force (rather than preparatory to it)--indeed it has been suggested that as flakes detach from cores, a fine spray of crushed stone comes off the cap-dorsal surface edge. BLADEs (see Table 4.26c) and RIDGED tend to show a couple of levels of modification--cap-dorsal edge abrasion or chipping on flaked or battered napes (FLAK+CHP, FLK+ABR, BATT+CHP, BATT+ABR), whereas such tends to be fairly rare in other manufacturing categories. That the few ridged flakes with cap data have such characteristics supports the idea that ridged flakes are not the accidental by-products of smashing. Only a few simple flakes and blades have only cap-dorsal edge abrasion (ABR).

Table 4.25h presents data regarding the symmetry of the flake about the axis of force for roughly linear artifacts. For symmetrical pieces (SYM) the angle between the longitudinal axis of the piece and the axis of force (perpendicular to the cap) is between 90 and 110 degrees, whereas for asymmetrical pieces (ASYM), the angle is larger than 110 or less than 90 degrees. BLADEs tend to be more symmetrical than are crude or simple flakes. However, the differences are not very great and given that many flakes are non-linear (and therefore the axis of the piece cannot be adequately measured) and/or that their caps are not sufficiently flat to use as the side of an angle (for measuring the angle of force), this variable appears to have little utility.

Table 4.26a-c: Variability in Blade Caps

The set of descriptive data about the cap presented in Table 4.26 is relevant for considering variation within the BLADE manufacturing class.

The variable presented in Table 4.26a, PROXEO, is the outline of the proximal element. For comparative purposes, totals for all obsidian flakes other than blades are shown at the bottom.

The outline of the proximal element of a flake is produced by the intersection of the Herzian cone (forming the interface between the parent body and flake) and the surface of the parent body itself. The values coded here for this variable are: ROUN, rounded, resulting in a pointed end to the flake; FLAT, similar to ROUN but having a wider cap, thus appearing to truncate the point; AWRY has an asymmetrical outline, rounded on one side, squared off on the other; ANGU, angular, is a proximal element with straight sides meeting the cap, no rounding; SHLD, shouldered, is similar to ANGU, but reflects the constraint imposed that produces parallel sides to the rest of the flake; and SWOL, swollen bulges out around the bulb. (RETC means the outline was changed by retouch.)

Comparing the PROXEO values for blades and non-blades, one sees a ready contrast. Sizeable percentages of the blades are coded as AWRY and ROUN, whereas most flakes have ANGU outline.

Table 4.26b indicates, via the ventral-dorsal dimension (thickness) of the cap, the distance from the point of applied force to the core's edge. $\overline{CT}$ is the mean cap thickness, "Min" is minimum, "Max" is maximum, "s" is standard deviation, and "N" is number of specimens.

Table 4.26a. Proximal Element Outline of Blades (with Comparative Data on Obsidian Non-Blades).

		ROUN	FLAT	AWRY	SHLD	ANGU	SWOL	RETC	OTHR	Total
E47MCUAU	#	3	3	5	3	1	3	1	1	20
	%	15.0	15.0	25.0	15.0	5.0	15.0	5.0	5.0	
E47UCUAU	#		2	3	1				2	8
	%		25.0	37.5	12.5				25.0	
A37ATOTO	#	2		1	2			1		6
	%	33.3		16.7	33.3			16.7		
A36TOTOL	#			1		1				2
	%			50.0		50.0				
L56MPAST	#	6	2	9	7	1		4	3	32
	%	18.8	6.3	28.1	21.9	3.1		12.5	9.4	
L56UPAST	#			1	2		1			4
	%			25.0	50.0		25.0			
L55ARBOL	#			3	2			1		6
	%			50.0	33.3			16.7		
P143OMBA	#	3	1	4	3		1		2	14
	%	21.4	7.2	28.6	21.4		7.1		14.3	
P13IAYCT	#	1		3	2	1	2		3	11
	%	9.1		27.3	18.2	9.1	18.2		27.3	
P12EAYCT	#	1		1						2
	%	50.0		50.0						
Mixed Totals	#	9	5	14	10	2	3	5	4	52
	%	17.3	9.6	26.9	19.2	3.8	5.8	9.6	7.7	
Unmixed Totals	#	7	3	17	12	2	4	2	7	54
	%	84.2	23.5	73.8	66.7	1.7	58.3	30.4	18.0	
Non-Blade	#	3	26	11	11	229	5	16	50	351
	%	0.9	7.4	3.1	3.1	65.2	1.4	4.6	14.2	

Table 4.26b. Cap Thickness of Blades, in mm (with Comparative Data on Obsidian Non-Blades in Unmixed Assemblages).

	$\overline{CT}$	Min	Max	s	N
E47MCUAU	1.4	0.5	2.3	0.47	19
E47UCUAU	1.4	0.3	2.0	0.68	8
A37ATOTO	0.7	0.4	1.0	0.22	5
A36TOTOL	1.5	0.7	2.2	1.06	2
I56MPAST	1.3	0.2	3.0	0.73	31
I56UPAST	0.5	0.2	0.7	0.35	2
I55ARBOL	1.0	0.6	1.5	0.38	6
P14BOMBA	0.7	0.3	1.1	0.27	13
P13IAYOT	0.4	0.1	0.7	0.21	12
P12EAYOT	0.5	0.4	0.5	0.07	2
Mixed	1.3	0.2	3.0	0.64	50
Unmixed	0.8	0.1	2.2	0.51	50
Non-blades	2.8	0.1	13.2	0.61	258

Table 4.26c. Arris Removal in Relation to Nape Characteristics of Blades in Unmixed Assemblages.

	NONE	CHP	ABR	FLAK	FLAK +CHP	FLAK +ABR	BATT	BATT +CHP	BATT +ABR	Totals
arris removal	1		2		7	5	5	12	7	39
no arris removal	1					2	2	6	4	15
Total	2		2		7	7	7	18	11	54

$\overline{CT}$ is small--only 0.8 mm for obsidian blades in unmixed assemblages. By contrast, $\overline{CT}$ for obsidian non-blades in unmixed assemblages is 2.8 mm. Given "s" is 0.51 and 0.61 mm for blades and non-blades respectively, the means are more than 2 standard deviations apart.

Table 4.26c elaborates on the nape characteristics of blades, since they exhibit some arris (dorsal ridge) removal, wherein lip removal from the blade-core's edge involved detachment of small flakes that removed the proximal portions of the arris, these spalls at times taking off more than 10 mm worth of ridging. 39 of the 54 blades (72%) with caps had arris removal. Thus, in addition to the two levels of core-edge preparation earlier discussed, there could be a third level, involving these arris-removal spalls.

Table 4.27: Cortex on Artifacts

Table 4.27 presents data on cortex surfaces for obsidian artifacts in each unmixed assemblage.

In E47UCUAU, 92% have no cortex. Cortex is found only on P-SMASH and UNCERTN.

In A37ATOTO, 95% have no cortex. The percentage may even be higher if the possible (POSSBL) cortex is not cortex but some interior boundary layer of impurities caught between forming bands of obsidian. Again cortex is found only on crude specimens.

In A30UNKNO, A36TOTOL, L56UPAST, L55ARBOL, the pattern is similar to the above, except there may be slightly more cortex specimens and L56UPAST has 2 simple flakes with cortex facets.

P14BOMBA and P13LAYOT, while generally the same, have a small number of SIMPLE flakes, BLADEs and RIDGED flakes with cortex.

P12EAYOT has the most items with cortex (with P13LAYOT) second). The cortex items are crude or simple flakes.

Table 4.27. Number of Cortex Facets, by Manufacturing Class, on Obsidian Artifacts in Each Unmixed Assemblage.

			P-SMSH	P-MULT	UN-CERT	SIM	RIDG	P-REJV	FINE	BIAD	Total
E47-UCUAU	NO CORTEX	#	26	4	12	4		3		20	69
		%M	83.9	100%	92.3	100%		100%		100%	92.0
	1 CRTX FACET	#	3		1						4
		%M	9.7		7.7						5.3
	2 CRTX FACETS	#	2								2
		%M	6.5								2.7
		M	31	4	13	4		3		20	75
A37-ATOTO	NO CORTEX	#	73	11	32	21	2	3	3	17	162
		%M	93.6	84.6	94.1	100%	100%	100%	100%	100%	94.7
	POSSBL CORTEX	#	1	1							2
		%M	1.3	7.7							1.7
	1 CRTX FACET	#	4	1	2						7
		%M	5.1	7.7	5.9						4.1
		M	78	13	34	21	2	3	3	17	171
A30-UNKNO	NO CORTEX	#	11	1	10	1				2	25
		%M	78.6	100%	100%	100%				100%	89.3
	1 CRTX FACET	#	3								3
		%M	21.4								10.7
	3 CRTX FACETS	#	1								1
		%M	7.1								3.6
		M	14	1	10	1				2	28

Table 4.27 (Cont.)

			P- SMSH	P- MULT	UN- CERT	SIM	RIDG	P- REJV	FINE	BLAD	Total
A36- TOTOL	NO CORTEX	# %M	65 85.5	11 78.6	29 80.6	19 100%	1 100%	4 100%	3 100%	9 100%	141 87.0
	POSSBL CORTEX	# %M	2 2.6		1 2.8						3 1.9
	1 CRTX FACET	# %M	8 10.5	2 14.3	4 11.1						14 8.6
	2 CRTX FACETS	# %M		1 7.1	2 5.6						3 1.9
	3 CRTX FACETS	# %M	1 1.3								1 0.6
		M	76	14	36	19	1	4	3	9	162
L56- UPAST	NO CORTEX	# %M	78 97.5	11 100%	32 84.2	6 75.0	2 100%	2 100%		14 100%	145 87.9
	POSSBL CORTEX	# %M	3 3.8		1 2.6						4 2.4
	1 CRTX FACET	# %M	7 8.8		4 10.5	2 25.0					13 7.9
	2 CRTX FACETS	# %M	2 2.5								2 1.2
	3 CRTX FACETS	# %M			1 2.6						1 0.6
		M	80	11	38	8	2	2		14	165

Table 4.27 (Cont.)

			P-SMSH	P-MULT	UN-CERT	SIM	RIDG	P-REJV	FINE	BLAD	Total
L55-AREOL	NO CORTEX	# %M	49 87.5	6 100%	23 92.0	7 100%		1 100%		14 100%	100 91.7
	POSSBL CORTEX	# %M	2 3.6		1 4.0						3 2.8
	1 CRTX FACET	# %M	5 8.9								5 4.6
	2 CRTX FACETS	# %M			1 4.0						1 0.9
		M	56	6	25	7		1		14	109
P14-BOMBA	NO CORTEX	# %M	171 91.4	67 85.9	110 84.0	26 89.7	10 90.9	4 100%	2 100%	65 98.5	455 89.6
	1 CRTX FACET	# %M	11 5.9	10 12.8	16 12.2	2 6.9				1 1.5	40 7.9
	2 CRTX FACETS	# %M	2 1.1	1 1.3	3 2.3	1 3.4	1 9.1				8 1.6
	3 CRTX FACETS	# %M	3 1.6		1 0.8						4 0.8
	5 CRTX FACETS	# %M			1 0.8						1 0.2
		M	187	78	131	29	11	4	2	66	508

Table 4.27 (Cont.)

			P-SMSH	P-MULT	UN-CERT	SIM	RIDG	P-REJV	FINE	BLAD	Total
P13-LAYOT	NO CORTEX	#	102	32	94	17	3	1		36	285
		%M	86.4	86.4	82.5	85.0	75.0	100%		97.3	86.1
	POSSBL CORTEX	#	1	1	1						3
		%M	0.8	2.7	0.9						0.9
	1 CRTX FACET	#	14	4	15	3	1			1	38
		%M	11.9	10.8	13.2	15.0	25.0			2.7	11.5
	2 CRTX FACETS	#	1		2						3
		%M	0.8		1.8						0.9
	3 CRTX FACETS	#			1						1
		%M			0.9						0.3
	4 CRTX FACETS	#			1						1
		%M			0.9						0.3
		M	118	37	114	20	4	1		37	331
P12-EAYOT	NO CORTEX	#	22	6	23	5				10	66
		%M	73.3	66.7	92.0	71.4				100%	81.5
	POSSBL CORTEX	#		1		1					2
		%M		11.1		14.3					2.5
	1 CRTX FACET	#	7	2		1					10
		%M	23.3	22.2		14.3					12.3
	2 CRTX FACETS	#	1		2						3
		%M	3.3		8.0						3.7
		M	30	9	25	7				10	81

Table 4.28: Distal Elements

Table 4.28 presents data on the obsidian specimens with distal elements. "BOW" refers to a ventralward curving of the distal element; "NBOW" means not bowed, i.e. either flat or backward curving; "INB" means that bowing is not determinable (fragment involved). "HING" refers to a hinge termination of the flake and "OUTP" refers to *outrepassé*, in which the distal element is thicker because it has taken off the bottom of the parent body from which it was flaked. "CVR" refers to a convergent outline; "NCVR" to non-convergent, i.e. a parallel or divergent outline; "INB" means that the outline is indeterminable. "LD" means that the distal element is laterally displaced from the axis of the piece otherwise.

Blades and ridged flakes, generally, are BOW and/or CVR, most being both. Other pieces, on the contrary, generally are neither bowed nor convergent (NBOW +NCVR).

In mixed assemblages, 1 blade has a HING termination and 2 are OUTP. In unmixed assemblages, 1 ridged flake has a HING termination as do 8.4% of OTHER flakes.

Table 4.28. Distal Element of Obsidian Artifacts in Mixed and in Unmixed Assemblages.

			BOW + CVR	BOW + INC	NBOW + CVR	INB + CVR	BOW + LD	BOW + NCVR	NBOW + NCVR	HING	OUTP	Totals
Mixed	BLADES	#	22	7	7	1	1		6	1	2	47
		%	46.8	14.9	14.9	2.1	2.1		12.8	2.1	4.3	
	RIDGED FLAKES	#	5	1	2				2			10
		%	50.0	10.0	20.0				20.0			
	OTHER	#	4		1			7	18			30
		%	13.3		3.3			23.3	60.0			
Unmixed	BLADES	#	37	4	3		2	1	11			58
		%	60.3	6.9	5.2		3.4	1.7	19.0			
	RIDGED FLAKES	#	1		3	1			1	1		7
		%	14.3		42.9	14.3			14.3	14.3		
	OTHER	#	14	1	6			14	96	12		143
		%	9.8	0.7	4.2			9.8	67.1	8.4		

Chapter 5

LITHIC SYSTEMS

I. Input System

The debitage types that, according to several theoretical models, may be used as records of what has happened to stone as it is changed into cultural items was presented in Chapter 3. How do the observations, the data presented in Chapter 4, compare?

A. Blade-core subsystem

There is little evidence in any of these assemblages for early steps in the blade-core reduction strategy. Indeed, if manufacturing loci had indeed been found, one would have expected a much higher relative representation of waste by-products in the debris than are produced by the manufacturing process itself, for the usable items, the blades, would have been moved to their use contexts.

We find no residue associable with "Step 1--Producing a platform" (51). There are no split nodules or nodules of any kind, for that matter, no large flakes nor any large tabular pieces of obsidian.

There is virtually no evidence of "Step 2--Establishing the fluted, polyhedral core" (54). There are no large flakes that might represent fluting or ridge straightening efforts. There are a few small flakes with ridged or facetted cap surfaces (Table 4.25a) but no "crested flakes" nor any comparable ridge-straightening flakes.

Since small flakes with ridged or facetted cap surfaces could be produced in many ways and since no other evidence of Step 2 is present, it seems unlikely that these are to be attributed to blade-core processing.

There is some evidence for "Step 3--Producing a large, irregular blades" (56)--two blades, to be exact. One is a possibly regular blade-like fragment of relatively large size (width of 38.7 mm--see Table 4.23) from P14BOMBA. The second is a moderately large (width of 21.1 mm) blade with somewhat irregular outline from A37ATOTO.

Evidence of "Step 4--Producing prismatic blades" (57) consists almost exclusively of the final products. These conform to expectations regarding fine, parallel-sided, straight-edged prismatic blades.

B. Nodule-smashing

It would appear that the bulk of the obsidian debitage is due to nodule-smashing. While the clearest evidence of nodule-smashing is provided by the smash flakes, the less certain evidence provided by multiple and/or split flakes, by the possible smash flakes, and by the chunks and shatter of the dregs class, also points to nodule-smashing, for, as will be discussed, other lines of evidence provide support for this interpretation and alternative interpretations can be eliminated.

Why are no nodules found? But some nodules may indeed have been found. Namely, the "chunks" included in the dregs class may indeed be all that remain of nodules after smashing. The nodules need not have been very large to begin with and smashing could have merely left such chunky rubble.

Rival interpretations center on the theme that these various classes are the waste by-products of this or that more sophisticated technology. But what might such technology be? The flakes are too small to be associated with the initial stages of either blade-core shaping or the initial trimming of nodules to make more refined core tools. They do not seem referable to the blade-core reduction strategy, as discussed above. They are too crude (thick and irregular) to be the finer trimming flakes associated with the shaping of blanks or preforms, let alone of finished tools. Indeed, there is little evidence to indicate any other more sophisticated technology whose production activities would have resulted in waste by-products. There are no "eccentrics," no obsidian ear-spools, no obsidian mirrors--only a small number of bifacially-shaped pieces, and even smaller numbers of facial retouching and rejuvenation flakes.

As to flake production from "casual" cores, the only evidence is provided by the relatively small number of "simple" flakes. There are no obsidian flake cores. Thus, if anything, the suspicion is that many, if not all, simple flakes are the result of nodule-smashing but have no anomalies to indicate their origins.

If attention is switched to non-obsidian debitage. we find additional support for a nodule-smashing model, for virtually all non-obsidian is of a crude or simple nature. The working of non-obsidian gives virtually no indication (only the one ridged flake and the one doubtful crested flake of non-obsidian, both from A36TOTOL--see Table 4.3) of the blade-core reduction strategy. Bifacially-worked non-obsidian items are extremely rare. Thus the bulk of the obsidian and virtually all non-obsidian indicates the same crude technology.

C. Shaping subsystem

The evidence of shaping is extremely limited. Three manufacturing classes serve as evidence: the bifacially-worked pieces themselves; fine "facial retouch" flakes; and rejuvenation flakes.

The bifacially-worked items tend to be made of unusually large percentages of otherwise rare obsidians, GREEN and ANOM2, in addition to the more prevalent GRAY (Table 4.6b). Points do not appear, from their dimensions, to be made from blades (Tables 4.23 and 4.24), at least from the range of blade sizes at these sites. Further, of the eight bifacially-worked obsidian points in unmixed assemblages which still exhibit traces of their manufacturing origins, seven were made from non-blade flakes and one was made from a smash flake. Hence the shaping subsystem seems to be a further elaboration of non-blade production--possibly of nodule-smashing.

It is difficult to determine the location of shaping activities. Most of the bifacial flaking would have resulted in flakes too small to have been recovered. Only eight fine retouch flakes (morphologically defined) have been found: six roughly parallel-sided ones from Loma de Atoto assemblages and two with expanding outline from P14BOMBA (Table 4.3). The three A37ATOTO and the two P14BOMBA flakes are of GRAY obsidian, whereas A36TOTOL's three appear to be all different--one GRAY, one CLEAR, one ANOM1 (Table 4.5).

Regarding rejuvenation of shaped items (non-points or points), again evidence is extremely rare, Again Loma de Atoto assemblages have several such items. They have six of the ten rejuvenation flakes and one of the eight possibles (Table 4.3--E47UCUAU has relatively more, but the number involved is extremely small). Almost all of these are of GRAY obsidian--the exceptions are: one CLEAR from E47UCUAU, one of FUZZY obsidian from A36TOTOL, one of GREEN obsidian from L55ARBOL, and one of non-obsidian CRPTO from P13LAYOT.

II. Cultural System

The "input system" discussion focussed on what was happening to the stone as it was being reduced and thereby transformed into cultural items. But what of the cultural apparatus that was changing lumps of stone into tools and weapons and, secondly, what of the cultural activities which used such end-products of lithic processing?

A. Production and Distribution of Chipped Stone Artifacts

In this section I will be discussing the cultural manufacturing apparatus that was processing chipped stone, first re-considering each of the chipped stone subsystems from this perspective, and then considering the locations of the manufacturing steps and the movement of items between these locations.

1. Blade-core subsystem

Since no evidence for early steps in the blade reduction strategy are found at these sites, an obvious and strong possibility is that these steps were carried out elsewhere. But perhaps cores were produced elsewhere, imported, and blades produced locally from them. Since evidence consists, almost exclusively, of prismatic blades, it is difficult to support any assertion that blades were produced locally. There is no evidence of blade-cores except for three smash flakes which appear to have come from exhausted cores (two from L56UPAST, one from A37ATOTO--see Table 4.3) and the possible blade-core smashings from L56UPAST are weakened as evidence of local blade production by the small amount of size variation among the blades there (L56UPAST has virtually the smallest variation in blade width among unmixed assemblages, with a standard deviation of 1.88 mm--see Table 4.23). It is quite possible that exhausted cores were imported as would any other smallish nodules of obsidian for non-blade production. There are no core tablets or other indications of core rejuvenation. There are no "errors" or "error-corrections" in blade production (except for three blades in mixed assemblages--one terminates in a hinge-out and two with outrepassé--see Table 4.28).

Some evidence of local manufacture is provided by the variability in blade width found in A37ATOTO, A36TOTOL, P14BOMBA (P14BOMBA is not quite so variable in its blade thicknesses). This evidence is not contradicted by consideration of the sources of blade obsidian (in all three of these assemblages, most blades and most other debitage is of GRAY obsidian, suggesting that similar distribution channels were involved).

Of the little evidence available for local blade production, A37ATOTO has the most; size variability, blade-core smashing, largish blade with irregular outline, blade and non-blade obsidian of relatively the same obsidian sources.

On the contrary, the most evidence of non-local origins of blades is provided by P13LAYOT. First, it has very little variation in blade width (among the lowest in unmixed assemblages). Secondly, a large proportion of blades (almost half) are either of ANOM2 or FUZZY obsidian, while small proportions of non-blade debitage are of these types (see Table 4.5 and 4.6).

On the basis of this evidence, there does not seem to have been local blade production. The corollaries of this are that finished blades were imported (either from blade-making workshops at/near the quarries themselves or, more indirectly from local "middle-men" communities which specialized in blade-making) and that local villagers were not skilled or practiced in blade-making. However, what of the alternative explanation that there was community blade production, but in special work areas and those specialized locations have not been sampled by the excavations? Succeeding arguments tend to diminish the likelihood of such possibility. For example, consider the following.

The relatively small proportion of blades to total obsidian in unmixed assemblages (between 5 and 13%, except for E47UCUAU's 25%--see Table 4.3) and the high proportion of non-blade related obsidian debitage suggests that blade-making was either a minor local activity or that blades were relatively inaccessible as an import as compared with local manufactures. Since blade-making is such an efficient way of producing sharp-edged flakes with so little waste and since obsidian is not immediately available but has "costs" related to its being brought in, it seems unlikely that had local people a blade-production capability, they would not have considered blade production a preferred way of making obsidian into culturally-serviceable items. Thus importation of finished blades is suggested. Following this line of reasoning, the proportion of blades to total obsidian might be used as a measure of the productivity and/or distribution capabilities of the blade-core subsystem (industry) within Preclassic interactions spheres. Compared to the mixed assemblages, unmixed assemblages indicate low-level productivity and/or limited distribution capability.

2. Nodule-smashing

That so much of the debitage is of a crude manufacturing character, that the bulk of it shows little evidence of use, and that fragments are so small, suggests that nodule-smashing was carried out locally. Such is obviously consistent with the evaluation of nodule-smashing as requiring little skill or knowledge. It is of no surprise that nodule-smashing does not appear to have been a specialized activity.

The picture that emerges, for both obsidian and non-obsidian working, is that local villagers had little stone-working skill and were, for the most part--perhaps completely--limited to the smashing of nodules to get serviceable flakes. Otherwise they "imported" finished products, especially blades.

3. Shaping subsystem

Where were shaped items made? There is little evidence of either facial retouch or rejuvenation flakes. Indeed, given the small numbers involved, that some flakes have been interpreted as retouch or rejuvenation flakes must be viewed cautiously since they may merely by chance have the morphology of retouch or rejuvenation flakes. But, even if they have been interpreted accurately, we can assert that there is little evidence to indicate the manufacture of bifacially worked items at these sites. The strongest evidence, weak as it is, is provided by the Loma de Atoto assemblages, which have both retouch and rejuvenation flakes.

Several alternative models explain the data: excavations at these sites did not sample the loci of bifacial working that are present there; bifacially worked pieces were "imported" from nearby "middle-man" manufacturers (perhaps at Loma de Atoto?); importation came from distant communities. The first alternative seems to be the weakest if we consider variability in the materials used, as follows.

How is one to interpret the unusual percentages of material types used for bifacially worked pieces (assuming they are not merely the product of sampling error)? Does it represent: (a) choices made by manufacturers based on the quality of the material; (b) differences in the distribution of the raw materials (prior to manufacture); (c) differences in the locations and/or distribution capabilities of the manufacturers? Since non-obsidian is used for such items, quality of the material, in general, and of each obsidian type, in particular, does not appear to be at issue. If quality is not at issue, there would appear to be no technological reason for using one obsidian rather than another in making bifacially worked pieces. And if any obsidian coming into a community might be made into a bifacially worked piece, then differences in the distribution of the different obsidians in their unshaped state could not account for the differential percentages for the obsidians of the different manufacturing classes (for shaped pieces vs. unshaped pieces, in particular). It follows that shaping was not carried out at the local communities. This notion is further supported if one considers stylistic variation. Although too small a sample to be more than suggestive, that there are a number of different and approximately contemporaneous point types in such a small sample suggests that there were a number of different communities manufacturing such items, each perhaps located near a particular obsidian source (e.g. that more GREEN points were made in communities near the source of GREEN obsidian), and that subsequently, because of differential productivity and/or differential distribution capability, their products entered the communities under consideration in different relative quantities than did other chipped stone items.

The hypothesis generated is that bifacially-shaped pieces were not made locally, but imported from several different manufacturing loci (whether through a "trickle-trade" network or through "middlemen" traders).

4. Interaction Spheres

In considering the movement of materials between sites, we are broaching the notion of regional interaction. Supra-community interactional approaches have gone under various names: regional division of labor (Engels 1942), economic symbiosis (Sanders 1956), social fields (Lesser 1961), interaction spheres (Caldwell 1964, Binford 1965), interaction sphere hierarchy (Struever and Houart 1972), total social systems (Wallerstein 1974), central place systems (Smith 1974). The basic organization of interaction spheres involves the complementary relationship between specialization (or "differentiation" [Hole and Heizer 1973]), on the one hand, and exchange between the specialized segments, on the other:

> . . . I have divided Meso-America into component geographical regions which are based upon an internal economic symbiosis. These 'symbiotic regions' consist of several parallel subdivisions of differing climates and productions, which, because of these differences, formed mutual trading units (Sanders 1956: 115)

> We take the defining characteristics of a social system to be the existence within it of a division of labor, such that the various sectors or areas within are dependent upon economic exchange with others for the smooth and continuous provisioning of the needs of the area. (Wallerstein 1974:390)

There may be a hierarchy of interaction spheres with horizontal and vertical connections. The highest level in the hierarchy would have the largest areal extent for its interactional network. Horizontal exchanges are between relatively equal communities; vertical exchanges between lesser communities and an economically central community. One example of such an hierarchy is provided by Harding's work in northeast New Guinea (1967). The configuration there is rather simple. The horizontal exchange is the long distance trade in which "middlemen" societies serve as traders connecting local regions. The vertical exchange is the local exchange within each region, usually with coastal settlements serving as exchange centers for local inland villages.

In applying such models to the Basin of Mexico sites, several measures involving chipped stone utilization appear to be relevant indicators of social interaction: (1) the relative amount of (each type of) obsidian to the chipped stone in total and within each manufacturing subsystem; (2) the size of the items; (3) the proportion of items with cortex; (4) which activities in the manufacturing sequence are thought to have taken place at the sites; (5) characterization of the sites using the clusters of artifacts which co-occur in lots.

First, as we have already seen (Tables 4.1, 4.3, 4.5, and 4.6) the assemblages vary in their relative utilization of obsidian (and their sub-groups). Using the proportion of obsidian to total chipped stone as a measure, we find that the community highest in the obsidian hierarchy of its time was P14BOMBA at Tlapacoya during FI-1, next was A36TOTOL at Loma de Atoto during late FI-3 (the small sample of A30UNKNO, not considered here, could only serve to increase the ranking of A36TOTOL, since A30UNKNO is referable to Totolica and/or Atoto phases), then P13LAYOT at Tlapacoya during EH-4, A37ATOTO at Loma de Atoto during early FI-4, P12EAYOT at Tlapacoya during EH-3, L55ARBOL at El Arbolillo East during FI-2, E47UCUAU at El Arbolillo West during FI-4, and L56UPAST at El Arbolillo East during FI-3 (see Table 5.1).

Let us consider the (possible) source types of obsidian from the interaction sphere standpoint. If we rank each obsidian subgroup based on its percentage within the total obsidian of each assemblage, we find that, for the most part, the assemblages ranked high (5th to 8th) in obsidian acquisition are also ranked high on GRAY (presumably TA-79, the nearest source) acquisition, but low on the more exotic varieties, whereas the assemblages ranked low (1st to 4th) in obsidian acquisition are low on GRAY acquisition, but high for exotics. The two exceptions are P13LAYOT, which is high on obsidian acquisition and also high on most of the exotics, and L56UPAST, which is low on obsidian acquisition but high on GRAY acquisition.

The general interpretation would be that the communities with higher acquisition rankings are better tied into the distribution

Table 5.1. Ranking Assemblages according to percentages of obsidian within total chipped stone in the assemblage and according to percentages of obsidian subgroups within each obsidian sub-assemblage.

	Acquisition Rankings (and percentages)					
	Obsidian	GRAY	ANOM2	GREEN	CLEAR	FUZZY
P14BOMBA	8 (82.1)	7 (93.4)	3 (2.3)	2 (1.6)	1 (1.4)	3 (0.8)
A36TOTOL	7 (74.2)	8 (93.9)	1 (0.0)	1 (1.2)	4 (2.4)	5 (1.2)
P13LAYOT	6 (72.2)	4 (81.7)	7 (7.5)	3 (3.0)	7 (4.2)	8 (2.4)
A37ATOTO	5 (68.2)	6 (89.4)	2 (2.2)	6 (4.4)	2 (2.2)	4 (1.1)
P12EAYOT	4 (66.9)	1 (69.9)	6 (7.1)	4 (3.5)	6 (3.5)	5 (1.2)
L55ARBOL	3 (55.3)	3 (77.3)	8 (9.1)	7 (10.9)	5 (2.7)	1 (0.0)
E47UCUAU	2 (54.7)	2 (72.8)	5 (4.9)	8 (17.3)	8 (4.9)	1 (0.0)
L56UPAST	1 (44.8)	5 (87.9)	4 (4.8)	5 (3.6)	3 (2.4)	5 (1.2)

network for the nearest obsidian source and this network tends to monopolize obsidian distribution, whereas the communities with the lower obsidian acquisition ranking are less well tied into the distribution network for the nearest obsidian source and competitor distribution networks have more of a foothold.

Three of the four assemblages with high obsidian acquisition ranks not only are high ranked on GRAY acquisition, but also are the assemblages with some slight evidence for local manufacture of blades (A37ATOTO, A36TOTOL, P14BOMBA). The fourth of the high ranked assemblages, P13LAYOT, is high on three of the exotics (ANOM2, CLEAR, FUZZY) and has the most evidence for non-local origins of blades. These two somewhat divergent patterns can be explained by a single principle (discussed earlier in dealing with the blade subsystem)--blades are imported. Sites using close sources of blade obsidian have more blade variability because there are more channels of contact, whereas the sites using more distant sources of blade obsidian have less blade variability because there are fewer channels of contact. Thus differences between communities is to be attributed to changes in the obsidian distribution networks, not to changes or specialization differences in the communities themselves. While the neatest explanation of the data is thus importation of blades, it is still possible that there are internal differences between communities, some of them having blade-producing specialists, others not.

The other exception to the rankings discussed above, L56UPAST, while getting the least amount of obsidian, is fairly well tied into the GRAY interaction sphere. It may be that the relative strength of all obsidian distribution networks into the Basin of Mexico was low at the time, since its period of occupation occurred just prior to an apparent population drop in the Basin (Tolstoy, Smith, Fish, Boksenbaum, and Vaughn 1977).

The size of specimens has been suggested as a rough index of the number of transactional links between the community and the source, the smaller the pieces, the greater the number of transactions (and the greater the value of obsidian). However, in considering the data on weight (Table 4.22) we get no consistent picture. The rank order of assemblages according to mean weight changes from one manufacturing class to the next and from whole to fragmentary specimens.

Paradoxically, one of the most consistently weight ranked assemblages is the anomalous L56UPAST (see above discussion regarding obsidian acquisition ranking). Its consistently high weight ranking does not make sense, for that suggests ease of access to obsidian, on the one hand, while, on the other hand, it has the lowest ranking for obsidian acquisition (although moderately high for GRAY acquisition), suggesting lack of access. This contradiction appears resolvable if obsidian distribution networks were weak at this time (see above discussion regarding population drop).

However, given the lack of coherence of weight ranking as a measure of the number of transactional links, it may be that post-depositional processes have been skewing the results (differential breakage) or, more significantly, the interpretation of the measure is incorrect. Two alternative interpretations of the measure seem plausible. First, it may be that the size of specimens is, at least partially, a measure of the efficiency of utilization and thus of the productive efficiency of the community. In which case, the Loma de Atoto communities would be the most efficient and L56UPAST the most inefficient (using the average weight of whole and fragmentary, crude and simple obsidian specimens). A second possibility is that the differences between communities is negligible and cannot be used to interpret real differences in their places within the distribution hierarchy and that all communities here studied are at the tail end of obsidian distribution networks. Some support for this view is provided by comparing obsidian specimens in each assemblage with the probably locally obtained and considerably larger non-obsidian specimens.

The relative number of specimens with cortex (see Table 4.27) has also been suggested as a measure of the number of reduction steps between the quarry and the site--the greater the number of reductions prior to acquisition by a community (assuming the initial "quarry" acquisitions were of comparable nodules with comparable extent of cortex cover) the smaller the number of flakes with cortex in the debitage. Almost all assemblages have little evidence of cortex on debitage items. This again suggests that there were many intervening steps between the obsidian sources and these communities.

The one possible exception is P12EAYOT, which has the most cortex flakes. This may indicate that it had more direct access to obsidian sources than did later communities. That P12EAYOT has somewhat larger specimen sizes than other assemblages gives some support to this direct access possibility. Further support is provided by historical considerations. P12EAYOT is one of the earliest agricultural communities in the Basin of Mexico; there appears to be a time gradient in percentages of cortex items at Tlapacoya, perhaps indicating increasing dependence on external suppliers of obsidian and that utilization of Basin of Mexico resources is coming under a regional division of labor.

Regarding the smashing of nodules, the picture gotten by putting together the manufacturing class data (discussed earlier in dealing with the various subsystems), size data and cortex data, suggests that relatively small pieces of already reduced nodules (in addition to finished blades and points) were brought into the communities and smashed by local villagers in order to produce usable flakes.

Finally, what of the characterization of the sites using the clusters of artifacts which co-occur in lots (Tables 4.18-4.22)? We have found no evidence of manufacturing loci in these assemblages. For the most part, all manufacturing classes seem to be randomly scattered, with blades being rather ubiquitous (given that blades constitute so small a percentage of the chipped stone). The impression, therefore, is that all sites are similar in having an unspecialized character, suggesting that if they are part of any lithic interaction sphere, they are at the receiving, consuming terminals of the networks. This model seems to account for all of the data presented in this section: the rankings based on obsidian and obsidian subgroup acquisition; the small size of debitage; the lack of cortex; the limited nature of local manufacturing; and the characterization of sites as unspecialized vis-a-vis lithic processing.

B. Uses of Chipped Stone Artifacts

The bulk of data bearing on the interpretation of use of chipped stone artifacts (Tables 4.8-4.13, 4.20) suggests rather casual use of items, whether of obsidian or non-obsidian, whether derived from the blade or nodule-smashing subsystems. Some items were used in more concentrated or regular fashion. What can be said about the kinds of uses to which artifacts were put, the manner in which they were wielded, and the context--the cultural apparatus--in which they were used (see Chapters 2 and 3 for the models used as theoretical underpinnings for the following synthesis)?

1. Kinds of use

More blades have slight to heavy edge modification than do other manufacturing classes, which suggests more concentrated use of blades than of other items. However, most items have little evidence of modification from or for use, all manufacturing classes having comparably large proportions of items with either no scarring or only nibbling. The kind of casual use to which such sharp edged pieces would have been put is likely to have been the cutting of very soft materials.

Two major edge types are in evidence, both on blades and on non-blades, that involve some modification. One type is an edge-on wearing-down of the edge, reaching an abraded appearance in some specimens. That retouch scars do not extend onto the faces of the artifacts, suggests a sawing, back-and-forth action. Most blades with slight modification have such edge-on retouch, the bulk having it on both lateral edges. The suggested sawing action is supported by the edge outline, most lamellar flakes with edge-on retouch having craggy or straight outlines.

The other major type has uni-directional edge scarring (on one or more edges). Most such scarring consists of a series of small overlapping scars, suggestive of "use-retouch." Since the scars are so small, it would appear that the artifacts were used against relatively soft materials. Given the above scarring, one can conclude that the greater the angle of the working edge the more likely one is dealing with a scraping action, while the smaller the angle the more likely one is dealing with a peeling action. Uni-directionally use-retouched blades seem to be "peelers" since they tend to have sharp angles, the slight modification on most items not changing the edge angle from the 26 to 44 degree range found on the majority of unmodified blades, while uni-directionally use-retouched non-blades tend to be scrapers for they have somewhat steeper angles, a majority of them measuring in the 45 to 75 degree range.

The small number of pieces with a greater degree of modification appear to indicate a variety of uses, either involving their points--projectile points (see Tolstoy 1971 for their possible interpretation as arrow points), drills, piercing tools--or their edges (usually unidirectional "scrapers," some bidirectional "knives").

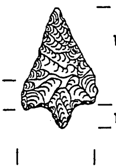
2. Manner in which wielded

The most clear-cut evidence of the manner in which an artifact was wielded is provided by shaped pieces with a clearly demarcated half element: point-like pieces with stems, barbs, tangs, abraded edges separating "blades" from "bases"; drills with stems. These were clearly hafted. whatever the nature of the handle/shaft.

Given the variety of haft elements on these shaped items, they could have been inserted into different types of handles/shafts. The tear drop shaped points and the drills presumably had been hafted to shafts as thick as the stone head's greatest width. Tanged points could have been attached to narrower shafts, their "barbs" protruding laterally. The truncated variant of the tanged point may have been made the same width as the handle/shaft to which the item was attached (Fig. 5.1). The truncated variant has had the basal corners of its blade element "clipped," so to speak, making the sides of the point at its widest into two straight, parallel, retouched segments. This kind of transitional element (the element between the blade and the base) also appears on two tear-drop shaped points and two drills. In each instance, the transitional element is the widest part, the edges have been straightened via retouch (and sometimes abraded), and are roughly parallel. This pattern suggests alignment of the edges with the outer margins of the shaft into which the points were fitted. If this was indeed the case, the truncated variant of the tanged point would have been fitted to shafts rather thick for arrows (widths: truncated tanged point 22 mm; tear-drop points with such transitional element 14 and 19 mm).

Shaped pieces are relatively rare. What of the other items? Let's consider blades. First, how much of the breakage of blades is intentional snapping and how much post-use accident? Some blades were clearly snapped intentionally. Two shaped pieces in unmixed as-blages, both non-points, were presumably made by first snapping a blade and then retouching the fragment to produce the resulting drills. Some

Figure 5.1. Truncated Variant of the Tanged Point (L86#4 from El Arbolillo East, actual size).



edge modified pieces also are apparently made on snapped blades (see Table 4.11 and Figure 4.11)--some are medial element segments and some are proximo-medial, their caps clearly present. The proximal part of a blade, thus, was not necessarily discarded as waste.

However, when we consider blades with modifications ranging from slight to none, it is not possible to use retouch to judge intentionality of breakage. Tables 4.14 to 4.17 present additional information. The breakage class data for blades in unmixed assemblages does not suggest the bias toward medial element fragments found in mixed assemblages. In unmixed assemblages there are relatively high proportions of blade fragments consisting of proximo-medial or medio-distal elements, thus containing some "irregularities." But proximal elements and distal element fragments are rare. This suggests that large portions of a blade could be used, regardless of irregularity, but that the smallish proximal element and tip fragments were of little utility. But still unresolved is the question of whether the ends were broken off intentionally or accidentally. If they were broken off intentionally, it would mean that, for some purposes, the ends were in the way and were removed. If they were broken off accidentally, it would simply mean that the relative long proximo-medial or medio-distal pieces that were utilized, broke into proximal and medial or distal and medial element fragments.

There are a number of indicators of accidental breakage. Table 4.15 compares breakage for blades and thin obsidian non-blades, including points. It would appear that a significant amount of breakage is occurring accidentally. Table 4.16 suggests, from the very limited data on artifacts found in two or more pieces, that blades were breaking accidentally. Finally, variability in the lengths of the different blade fragment types (Table 4.17) supports the idea that accidental breakage was a frequent occurrence.

The above discussion leads to the following conclusions: it does not appear that medial elements were being selected, via snapping, for use and it appears that accidental breakage was a major factor in producing the breakage classes. A further implication of this interpretation of breakage is that blades were not hafted. If blades were to be hafted the way blades were in later times, inserting one edge in a slot in a handle of a hard material such as wood, one would expect selection for regular blade segments, both to fit into the slot and to provide a continuous straight edge made of up several aligned segments. Further support for this hypothesis is provided by considering left and right edges of blades (Table 4.13f). If blades were edge-hafted, one would expect one edge to either have no retouch or to have simple crushing because of its insertion into a slot. However, for a majority of lamellar flakes (52%), the two edges cannot be distinguished on the basis of direction of retouch. Further, if the blades with heavy edge modification are considered (Table 4.11), some of these blades were almost certainly hand-held while the others probably were, since there is no single "retouch" pattern which can be attributed to the effects of being inserted in a slot.

If this line of reasoning is a valid interpretation of blade use in the communities represented by these assemblages, composite implements involving edge-hafted blades were not in use.

Most, if not all, non-blades with slight modification also appear to have been hand-held (Table 4.10b). The "backed" items and the pieces with several "retouched" segments are fairly certain hand-held artifacts. In addition, the very irregularity of the outlines of non-blade flakes makes extremely unlikely the possibility that they were hafted.

Thus most items which have some likelihood of having been used appear to have been hand-held (with or without a leather handle or similar padding).

3. Archeological Analogy

The context of these assemblages is not well defined, but using the "archeological analogy" approach discussed in Chapter 3 (pages 90 -109), some interpretations can be presented.

First, comparison with the other sites (and their various activities) discussed in Chapter 3 suggests that we are dealing with the unspecialized residue of domestic activity (either within or between houses). We have a limited array of artifacts such as is found in houses in San José Mogote, while lacking the concentration of items associated with specialized tasks, such as is found in limited parts of Oaxacan sites or, in later times, in metropolitan Teotihuacán.

Secondly, comparing the Basin of Mexico assemblages with the roughly contemporaneous Oaxacan villages, we find that, on the one hand, the proportion of obsidian to non-obsidian is greatly higher in the Basin of Mexico communities, whereas, on the other hand, the proportion of blade to non-blade obsidian is greatly lower in the Basin of Mexico. This pattern suggests that the Oaxacan sites, relatively far from the sources of obsidian, were importing blades as the major obsidian item, obsidian modules for smashing not being competitive with local non-obsidian distribution, while the Basin of Mexico sites, very much closer to sources of obsidian, were able to acquire obsidian nodules rather cheaply.

As with Oaxacan sites, points and other shaped pieces are exceedingly rare, suggesting that they were not an important part of domestic life.

Finally, in the limited collections from the Basin of Mexico sites, there is no evidence of stratification, such as is suggested by the differential distribution of blades at San José Mogote.

Chapter 6

SUMMATION

I. Obsidian and Cultural Evolution

> The first step towards escape from the rigid limits of . . . barbarism was the establishment of a metallurgical industry . . . that not only provided farmers with superior tools and weapons, but . . . overturned the barbarian social order, based on kinship, and evoked a new population of full-time specialists. The latter is my excuse for calling it the Urban Revolution. (Childe 1958: 78)

> What is important is that this seems an auspicious time to seek cultural universals, though not to assume them . . . And what universals there turn out to be will--most interestingly, at least--be universals of process, of logic, of structure, of organizational principles, rather than of substances . . . (Keesing 1974: 86-87)

An explanatory issue which originally motivated this study was a contradiction between theoretical expectation and empirical observation: on the one hand, the V. Gordon Childe model for the rise of civilization which emphasized metallurgy as a causal factor; on the other hand, as was well known, the evidence that Mesoamerican civilization had evolved without metallurgy. I hypothesized that the cultural processes considered by Childe were essentially valid, but that the material markers of these processes differed cross-culturally. That is, metallurgy was merely a specific manifestation of general processes --other materials could have served as functional equivalents in, for example, cultural systems based upon craft specialization and long distance trade.

I focussed on Mesoamerica since it was the primary anomaly. What could have been a functional equivalent of metallurgy in Mesoamerica? A 1967 Millon article on Teotihuacán made a clear suggestion--obsidian. Tolstoy's collections from several Early and Middle Preclassic sites in the Basin of Mexico seemed an eminently suitable source of data to examine the obsidian alternative since these sites constituted evidence of the indigenous background for the evolution of civilization in the Basin of Mexico.

Since then, my studies of obsidian became more focussed on descriptive detail, it becoming apparent that the data I was dealing with would be insufficient in providing an answer to so global a question as I had originally envisioned answering. However, my sense of legitimacy gained support from additional statements regarding the importance of obsidian in Mesoamerica. For example, it was suggested that "the importance of obsidian for the economy of ancient Mesoamerican people was probably similar in magnitude to that of steel for the economies of modern industrial nations" (Cobean et al. 1971: 666). Work by Crabtree, Sheets and Muto, and others, suggested that the hypothesized reliance on obsidian was at least plausible, considering the cutting quality of obsidian, the efficiency of blade-core techniques, the relative abundance or "cheapness" of obsidian, its localized source distribution, its value in weaponry, and its craft specialization implications (Crabtree 1968, Bordaz 1970, Rathje 1971, Spence 1967, Sheets and Muto 1972). Spence (1973) commented that he was not an "obsidian chauvinist," apparently to make clear that he was not making obsidian into the causal factor in the rise of Mesoamerican civilization.

But might not the particular nature of obsidian utilization in Mesoamerica have been one of the elements of a "revolutionary" process, i.e. a "deviation amplifying" element and/or an index or marker of such processes?

Here, in the summation of this dissertation, I would like to consider the original question, first from the theoretical standpoint and then from the perspective of the data and synthesis presented in Chapters 4 and 5.

A. Theoretical issues

Childe's model, derived from Old World archeological evidence, was within an early paradigm for the study of cultural evolution, whereby archeological cultures were classified according to "stage" criteria and differences in technology between stages were used as bases for the "revolutions" from one stage to the next. As archeological work proceeded, however, anomalies appeared which contradicted the expectations of this metallurgical model. Indeed, Childe himself recognized these anomalies. He noted that Old World Bronze Age societies differed "enormously among themselves in their political and social organization, in their economic structure, and even in their level of technological achievement," thus straddling two sociological stages ("Barbarism" and "Civilization"), and that, in Mesoamerica, civilization was achieved without metallurgy, thus "it cannot even be contended that the use of metal--for instance, in imposing industrial specialization and trade or by making advanced transport available--was an essential precondition for Civilization" (1951: 36). Childe did not adequately deal with the problem--he concluded that "a comparison of the [culture] sequences summarized discloses not only divergence and differentiation, but also convergence and assimilation" (ibid: 163). But in what aspects is there "divergence" and in what aspects "convergence," and why?

A number of logical alternatives can be posited as models for resolving this problem.

1. Multilinear evolution

One way of resolving the contradiction is to assert that we are dealing with "multilinear" evolution, i.e. there are different pathways in cultural evolution--processes involved in the Near Eastern cultural trajectory simply are different from processes elsewhere. Thus, what happened in the Near East is no guide for what happened in Mesoamerica. However, "nuclear areas" are thought to have had parallel developments; divergences would occur rather between nuclear and non-nuclear areas (Steward 1955). Otherwise we would not be able to refer to general stages in cultural evolution and would be left with an historical particularist position. Some differences have been noted between the developments in the Near East and Mesoamerica. For example, there are differences in the temporal priority of sedentism or of domestication--but this is seen as related to differences in "triggering" mechanisms rather than differences in systemic processes themselves (Flannery 1972). There would seem to be agreement that what happened in the Near East and Mesoamerica bear on the same general processes.

2. Mistaken interpretation of Near Eastern data.

Another resolution might be that Childe's interpretation of the Near Eastern data itself was wrong. The stages discussed for Near Eastern cultural evolution and the importance of metallurgy in trade and manufacture might have been incorrectly assessed. However, while authors may criticize Childe's interpretation of the diffusion of Near Eastern civilization to Europe or may argue that Childe's interpretation is incomplete either in data or in the complexity of the historical factors, there does not appear to be any basic disagreement with the broad outline of his interpretations of Near Eastern cultural evolution--provided, that is, that his research strategy ("paradism"--Kuhn 1970) is accepted.

3. Wrong paradigm

But perhaps his research strategy is not to be accepted, for the contradiction might be an artifact of Childe's paradigm. The "new archeology" has ideological weapons in its arsenal which might serve to demolish the model which spawned the contradiction. Although there are different forms to the arguments they are based essentially on the replacement of the old "classificatory" approach by the new "processual" approach.

One line of argument asserts that it is false to assume that technology and other aspects of culture will be closely correlated. Cultural processes operate within subsystems that are more or less isolated from other subsystems. The culture is not a tightly articulated functionalist "whole"; the subsystems interact through "feedback" rather than through overall design (e.g. in archeology, Flannery 1968--but such has also been argued by Barth 1967 in discussing social change in ethnographically known societies and by Washburn 1951 in discussing biological "functional complexes"). Thus some parts of the system can evolve at different rates than other parts of the system. A "Neolithic" technology could be associated with urbanized "Civilizations" because there is no tight articulation between the various subsystems.

Yet, however significant are analytical procedures which can define subsystems, they do not account for the common basis underlying the holistic manifestation labeled as a "civilization" or as a "state." There does seem to be, empirically, some kind of correlation between subsystems, some clustering of values of the variables, that enables anthropologists to classify cultures into types. As Webb (1974: 365) notes: "The ethnographic record indeed indicates that the variety of possible economic systems open to societies in particular ecological situations at given levels of social complexity is certainly not limitless, at least in broad outline. There is, rather, a definite restriction of possibilities, and patterns do emerge."

Another line of argument is to assert that stage classifications are not equipped to demonstrate change. A temporal sequence of types of cultures does not indicate the processes of change undergone. This would seem to be more appropriately directed at Steward's 1955 theory of culture change than at Childe who has discussed Neolithic and Urban "revolutions" at great length. However, a corollary of this criticism is that "stages" are arbitrary points along a continuum and that "revolutions" are artifacts of gaps in our knowledge about the intervening gradual changes from one known point in time to the next. Such criticisms can be applied to Childe (and any other model of "non-proportional change" or "quantity-quality transformation"). Compare several Mesoamericanists. Coe and Flannery (1964: 650) state:

> Much has been written about food-producing "revolutions" in both hemispheres. There is now good evidence both in the Near East and in Mesoamerica that food production was part of a relatively slow evolution . . .

And MacNeish (1964: 536) similarly notes:

> If this phase [Abejas Phase, Tehuacán Valley] provides evidence of a Marxian "Neolithic revolution," the revolution came long after the first plant domestications; the population showed no sudden increase in size, and the artifacts were little better than those of the preceding phase (footnote 11: V. G. Childe, Social Evolution . . .).

The problem with this line of argument is that, rather than destroying the old classificatory model, it ends up supporting it--the new approach eventually arrives at a conclusion parallel to that of Childe's. For example, while Flannery (1968: 68) maintains that the "period of transition from food-collecting to sedentary agriculture . . . can best be characterized as one of gradual change in a series of procurement systems . . . none of which arose de novo, but were the . . . expansion or contraction of previously-existing systems," he also indicates that "positive feedback" can "cause systems to expand and eventually reach stability at higher levels," i.e. at a new stage of sociocultural integration. And isn't the argument then simply that there are cross-cultural similarities in the stabilized higher level systems?

There is much to be gained from the "process" view (as from any expression of dialectics). However, it is not necessary that its acceptance means rejection of the "classificatory" view. Indeed the two views are complementary. The complementarity of "whole entities" and "open systems" has appeared in a number of forms: type vs. process in archeology; culture vs. field (Lesser 1961); group vs. network (Dirks 1972); "emic unit" vs. ongoing reality (Pike 1964); the requirements of being an individual organism vs. organic homeostasis based on open system requirements (Campbell 1966); the "ongoing culture stream" and the "crystallizations" (Wolf 1967: 449); and even particle vs. wave in physics (Heisenberg 1953). One philosophical model which embraces both particle and wave as different aspects of the same reality is that of dialectics: "Motion is the mode of existence of matter" (Engels 1959: 86). I take the position that both classificatory (stages, types, "revolutions") and processual (systems, isolatable subsystems, transformations) views are dealing with different aspects of the same reality. Hence, processual models do not refute classificatory models. Indeed, a processual solution to the problem of the contradiction between Childe's model and the Mesoamerican data is that the processes are the same but the materials are different.

4. Functional equivalence

If it is indeed the process, rather than particular substances, which are parallel and that involve analogous (rather than homologous) structures, then we might compare Near Eastern and Mesoamerican data by: (a) demonstrating the comparable stages or levels of cultural evolution; (b) defining the analogous processes (organizational principles, structures); and (c) demonstrating that the two cultural systems process alternative materials similarly (there is a comparable structure to their economic maintenance systems) and the processed items are incorporated into similar organizational structures (the uses of artifacts indicate other similarities in their cultural systems).

How does the information generated by this dissertation bear on such issues?

B. Lithic and Metallurgical Processing

The first step proposed is to compare cultures of the same type. As Childe (1951: 27) invited: "Let us compare homotaxial cultures--that is, cultures occupying the same relative positions in the several observed [cultural] sequences--to ascertain whether the agreements between them can be generalized as stages in cultural evolution . . ." However, it is not an easy matter to identify homotaxial cultures. While it is agreed that Mesoamerica and the Near East are nuclear or primary areas in the evolution of civilization, transitional steps in the evolutionary progression are more controversial. And it is the transition which is of interest here. It may suffice to consider the cultures prior to the emergence of full-blown civilization as being homotaxial.

The cultures in the Basin of Mexico during the Early and Middle Preclassic seem to satisfy this requirement. Firstly, subsequent cultural development in the Basin of Mexico produced Teotihuacán civilization. That Teotihuacán was a civilization can be demonstrated using the organizational criteria given by Lanning as being common to "all civilizations, both ancient and modern, in the New World or Old" (1967: 3). Secondly, the cultures of the Basin of Mexico were apparently part of an interaction sphere involving the "Olmec," which seems to have been in the process of acquiring the organizational basis common to civilizations.

As to functional equivalence, Childe discusses three major functions served by metallurgy in the re-structuring of Near Eastern culture (i.e., Near Eastern "cultural systems"): it led to specialization of labor; it required organized trade; and it provided an adaptive advantage through greater technological power (1951).

While the pyro-technic nature of the metallurgical input system (the changes wrought from ore to finished product) cannot be matched by the reduction strategies of the obsidian input system, there appear to be a number of similarities in the related cultural system. Indeed, Childe himself proposed obsidian as a functional equivalent of metallurgy in the rise of civilization in Mesoamerica (1974: 12, originally 1950):

> While the objects of international trade were at first mainly 'luxuries,' they already included industrial materials, in the Old World, notably metal, the place of which in the New was perhaps taken by obsidian.

First, there does appear to have been specialization of labor. Evidence from the Basin of Mexico suggests that the blade-core maintenance system involved specialists, local-villagers basically using a nodule-smashing approach. However, it may be that, at this time, blade making was a part-time specialization, comparable to that of the blade-making peasants in modern Turkey (Bordaz 1969), and that it was not until later times that it became a full time occupation (witness the higher proportions of blades in assemblages at Chalchuapa, discussed on page 84, and the specialist "tool-kits" as in Ticoman burials, discussed on page 111ff).

Secondly, it does seem to have required organized trade. That obsidian sources are localized and require some form of distribution to move obsidian to archeological sites has been recognized by all researchers dealing with trace analysis identification of obsidian sources. However, that blade manufacturers seem not to have resided in the communities considered here suggests the additional matter of moving items between manufacturing and consuming loci. Perhaps specialist traders (middlemen) were involved.

That there is some standardization of blade sizes (widths) does suggest the possibility of organized production and/or specific "consumer" demands. However, during this time period in the Basin of Mexico, the blade distribution system was relatively weak, blades constituting only some 10 to 12% of the obsidian debitage, suggesting that trade was not as well organized as it was in later times. Also, since the size of items being "traded" was relatively small, the amount carried in any individual "shipment" could have been rather small. The absolute quantity of items also may have been rather small, if usage was limited to domestic functions.

This brings us to the "use" realm and the third issue. We find little evidence here for the adaptive advantage of obsidian. Its main context at these sites is a domestic one, with small pieces of obsidian being used for cutting, scraping, and sawing tasts, the artifacts, for the most part, being simply hand-held. There is no evidence for a "superior" agricultural technology (e.g. no evidence of blades inserted into handles to serve as sickles) or for a "superior" military technology (little evidence of weaponry other than a small number of points). It may be that obsidian was involved in providing such advantages, but that domestic refuse does not provide any evidence of it.

In short, this study provides some support for the Childean's model's applicability for Mesoamerican cultural evolution, but leaves open questions of magnitude and of advantage. Additional studies are needed to confirm the hypotheses generated and to some extent supported by the patterning of the data, while unanswered questions require more information than can be generated by the study of small samples for a small number of sites.

II. Methodology

I am pleased that I was able to convert several thousand pieces of artifactual stone, derived from vertical excavations in 4 sites comprising at least 8 assemblages, into useful information about the technology and cultural systems of the Preclassic in Mesoamerica. The interpretations do account for the data. Further, the hypotheses generated can be tested by other investigators.

The approach I used in processing the information involved several major steps. In the first step, the lengthiest one, I transformed the stone artifacts into raw measurement data. What variability would enable me to measure manufacture and use systems? In executing this step, I sought to devise, as Washburn had done in a different context, functional units that could be isolated by using the data of comparative and evolutionary studies, experimentation, developmental studies, and internal assemblage variability. I also used a systems framework that enabled me to discriminate between steps in the manufacturing cycle, on the one hand, and, on the other, the organization of production, distribution, and use.

The second step was the transformation of raw measurement data into operationalized measures of manufacturing and use variables. This step involved the interpretation of variability: the recoding of variables, the lumping and partitioning of values, the carrying out of new measurement tasks. It involved poring over computer print-outs as well as re-examining specimens.

Finally, the operational measures of manufacturing and use were used to consider "structural" questions. Was there a coherent, overall picture of manufacturing and use which could explain the data? The synthesis presented, which had several unexpected results from the standpoint of my original expectations (the nodule-smashing subsystem being the major one), does seem to make sense of several thousand pieces of stone.

Data-gathering seems to be a mis-nomer. One does not gather or collect data. The stone artifacts are not the data--they are not information. The symbolic transformations carried out, from the ones that produce the raw measurement data (initial operational measures) to final operationalized variables, from analysis to synthesis, actually involve data-creation and model-building. What I have done is a basic form of dialectics. I have carried out the basic symbolic alchemy. Namely, I have turned things into information.

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