THE ANALYSIS OF AN ASSEMBLAGE OF GROUND STONE ARTIFACTS FROM GUANACASTE, COSTA RICA

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CONTENTS

1. Introduction

The primary purpose of this paper is to present the results of the study of an archaeologically recovered collection of ground stone artifacts from Guanacaste, Costa Rica, commonly referred to as celts. Both macromorphological and microscopic attributes of the celts are analyzed, in order that questions of variability in artifact style as well as function may be addressed. Functional hypotheses, generated from the results of the examination of large scale morphological features, are tested through microwear analysis. This two-stage research strategy is felt to provide an efficient means for evaluating the relation between form and function in an assemblage of lithic artifacts. The "form-function" issue is discussed in the context of past Lower Central American lithic studies in order to place this study in an areal perspective, as well as to provide a format for suggesting certain improvements which can be made in this important field of research. The relationship of form and function in the case of the Guanacaste celts is addressed in detail.

In addition to these area-specific considerations, certain problems of method and technique frequently encountered in lithic analysis are treated. The most important of these include the measurement of edge angles, the use of certain metric data in the construction of artifact typologies, and the applicability of the techniques developed for the study of chipped stone artifacts to the analysis of tools made of ground stone.

The artifacts included in this study come from 11 different prehistoric sites in Guanacaste, Costa Rica, and with the exception of one celt, which is on display at the Museo Nacional de Costa Rica, all of the celts recovered during surface collection and excavation at these sites have been analyzed.

II. The Central American Celt: Considerations of Form and Function

For a number of years there has been a heated debate among lithic researchers over what constitutes the most meaningful manner in which to analyze and describe stone tools. S. A. Semenov (1964, 1970), the most vocal member of the so-called "functionalists", holds that the goal of artifact analysis should be the reconstruction of past technologies. To this end, Semenov examines in minute detail the "traces of wear", particularly striations, which occur on the edges of stone tools (1964:2). It is his contention that the observation of these traces and their orientation along an artifact's edge allows the archaeologist to make firm interpretations regarding the uses of a specific tool. Once function has been determined for all, or most, of the lithic artifacts in an assemblage, then one can go on to make statements regarding the technology possessed by a prehistoric group (1964:6).

In contrast to the "functional school", the focus of the "morphologists" has been on constructing typologies based on the macromorphological or formal attributes of lithic artifacts (Bordes 1969). The relative proportions of these morphological types in different assemblages is said to reflect cultural variation over space and/or time, depending on the particular situation under study. The classic application of this approach is Bordes' work with Mousterian artifacts from France (1953, 1961a, 1961b, 1963, 1968). On the basis of morphological attributes, Bordes constructed a number of tool types (side scrapers, handaxes, backed knives, etc.) for the French Mousterian. The frequency of these types in an assemblage serves to place it in one of the Mousterian "industries". For example, Bordes' grouping known as Ferrassie contains a:

> Very high percentage of side scrapers, rather low percentage of transverse scrapes, medium percentage of Quina-type scrapers, absence or rarity of handaxes (when found, of special types) and backed knives.(Bordes and Bordes 1970: 63)

Other groups, such as Quina, Typical Mousterian, etc. contain different frequencies of these same tool types and/or additional types in varying proportions.

What are important to consider, when discussing the "morphological approach", are the terms selected to describe the various classes of artifacts. In the case noted above, for example, Bordes and Bordes mention three different kinds of scrapers, as well as handaxes and backed-knives as being significant for defining the Ferrassie industry, though no attempt is made to prove that these artifacts were actually <u>used</u> for scraping, chopping, or cutting. The terms serve only to describe the way certain artifacts <u>look</u> and how they were made, and not necessarily specific functions. Names with very powerful functional connotations are being employed here to describe groups of artifacts which are held to be alike solely on the basis of appearance or manufacturing technique.

In this report no attempt is made to defend the position of either the "functionalists" or the "morphologists" and, in fact, I have chosen to follow the suggestion of Tringham <u>et al</u>. (1974:173) that a combination of both approaches is necessary to fully understand the amount of variability present in any lithic assemblage.

What I do contend, however, is that one should be very careful when naming classes of artifacts. For example, when a tool is called a side-scraper, it should be explicitly stated whether or not it is felt that the artifact was actually used for scraping, or if it merely shares formal characteristics with other lithics which, as a result of tradition, have come to be called side-scrapers.

This confusion of functional and morphological categories is long-standing in archaeology and I have found it particularly acute for the class of artifacts, celts, with which this report deals. A brief treatment of the basis and history of the problem will help to place in perspective the analysis presented in the following sections and may also serve to suggest a way out of the dilemma.

As is typical for most other terms used to describe lithic artifacts, the imprecision of the word "celt" comes from its being used, in some cases, to designate artifacts which possess certain (usually unstated) gross morphological features, while in other instances it takes on specific functional meanings. To complicate matters further, there is little agreement as to precisely what these functions are, not to mention a paucity of evidence to support any of the supposed uses. Depending on the area and/or time period under consideration, a celt can be seen as a tool used for chopping, cutting, digging, carving, splitting, butchering, chiseling, fighting, breaking ground, or mining. In addition, these artifacts are often felt to be associated with a variety of ceremonial practices (see Coles 1973:118 and Sonnenfeld 1962: 56 for a more detailed discussion of proposed functions).

In the New World, celts are quite often seen as ungrooved axes and for descriptive purposes are frequently considered apart from ground stone tools of similar general form and size, but which have grooves, presumably to aid in hafting (Ford 1969: 49-53; Fowler 1963). This view of celts as axes is based purely on observation of form; that is, they look similar to tools used by either industrial or technologically primitive peoples to chop down trees or to perform other heavy woodworking tasks.

In Mesoamerica proper, where celts date back as least as far as the Early Formative (W. R. Coe 1959: 40-42; Griffin 1966: 25), this association of celts with wood chopping is especially prevalent (Tolstoy 1971: 287; Woodbury and Trik 1954: 216; Woodbury 1965: 164). Other Mesoamericanists have rejected the heavy woodworking interpretation and have instead postulated that the celts from the sites they studied functioned as intermediate tools, such as chisels (W. R. Coe 1959: 40-42, 1965: 600). Stone quarrying, cutting, and carving have also been suggested (Pollock 1965: 397; Willey 1972: 132). Finally, Coe, Shook, and Satherwhaite (1961: 43) feel they may have been used to carve wooden lintels.

It is essential to note here that <u>none</u> of the interpretations mentioned above is based on any type of systematic study. Analysis of lithics (particularly ground stone) has, up until very recently, not been a popular field of inquiry, and has been seen as ancillary, at best, to other types of study (see Sheets 1977 for a discussion of the current state of lithic analysis in Mesoamerica). Functional interpretations for ground stone tools, it would seem, result from very cursory considerations of artifact form and <u>unstated</u> analogies with either contemporary or historically known peoples.

In Lower Central America, where the analysis of ground stone tools is no more advanced than in Mesoamerica proper (Ranere 1975 being a notable exception), there is somewhat more of a consensus on the function of ground stone celts and <u>heavy</u> lithic cutting tools in general. Here, they are most often associated with agricultural activities, primarily clearing land for slash-and-burn cultivation. Snarskis, for example, feels that his andesite and shale "waisted axes" from the El Bosque component at the eastern Costa Rican site of Turrialba served this purpose.

> It is probable that the axes were used in agricultural activities such as cultivation and clearing scrub vegetation. Their lack of sharpness or hardness would seem to preclude their use in most other endeavors. Almost all show some breakage or wear. Lynch has commented on the use of similar tools in the preparation of agricultural fields in Peru (Thomas Lynch, personal communication). Such axes are found in great quantities throughout the Turrialba Valley in association with ceramics from the period A.D. 1-800. (Snarskis 1977: 7)

Linares, who has worked extensively on both the Atlantic and Pacific coasts of Panama, is quite adamant in her assertion that celts are clearly associated with agricultural pursuits (1968: 72, 1977: 309). The presence of celts, in one instance, is taken as <u>proof</u> of the existence, at the site of La Pitahaya on the Panamanian Pacific coast, of extensive plant domestication.

> The large quantity of celts and adzes that came out of the nearly 100 cubic meters excavated at IS-3 leave little doubt that this was a predominantly agricultural society. (Linares 1968: 72)

The same association is posited for the site of Bocas del Toro on the Caribbean coast where "adzes and celts" are seen as having been used for "deforestation", presumably in the preparation of agricultural plots (Linares 1977: 309). Finally, when discussing the prehistoric subsistence strategy of the inhabitants of Chiriqui, it is asserted that:

> For farming they used celts; these may have served the dual purpose of felling trees and breaking the ground. (Linares 1968: 72)

In the Greater Nicoya Archaeological Subarea, from which the artifacts examined in this study originate, celts are again commonly associated with agriculture, though here functional interpretations are usually couched in more cautious terms than in other portions of Lower Central America. Sweeney, when discussing the subsistence patterns at the three coastal Guanacaste sites she studied states that: "There were the celts and axes to cut trees for swidden . . ." (1975: 55). More recently, she has reiterated her interpretation of the economic role played by these artifacts and has also suggested that celts, along with a number of other shell and stone artifacts, may have been important in the construction of dugout canoes (1977: 8).

Baudez (1967: 183-5), who describes "polished axes" from his Tempisque River sites, feels that they, along with the other lithic artifacts he recovered, were probably important in agricultural activities. Similarly, Lange (1971a: 265, 1971b: 53), when discussing the lithics found at his Sapoa River excavations states: "A small quantity of ground stone axes possibly represent the meager evidence for shifting cultivation."

Healy (1974: 453), like Lange and Baudez, is quite circumspect when making functional interpretations. He summarizes the celt assemblage from Rivas, Nicaragua as follows:

> More than likely the larger celts were for forest clearing, wood, or even stone cutting. Smaller celts, like our very small variety, may have been utilized for fine wood cutting jobs, or as Willey (1972: 132) has cautioned, they may have been used for quite different functions from the larger specimens (Healy 1974: 453).

The preceding discussion should serve to point out the somewhat confused picture archaeologists working in Central America have of a class of artifacts which is found in almost all areas of the region. I would suggest that this confusion results from two factors. First, as stated throughout this report, lithic studies in this part of the world have traditionally ignored techniques of analysis which would allow functional interpretations to be firmly rooted in some type of data base. Here, I am speaking of wear analysis or the careful, systematic use of ethnographic analogy. In precious few of the instances cited above have any attributes of the celts, other than the most obvious morphological characteristics, been considered. The second factor contributing to our lack of understanding is by no means limited to this area. This is the inability to distinguish between descriptive categories based on general tool morphology and those derived from considerations of function. As in the Mousterian example discussed earlier in this section, as a result of tradition there is often a tendency in lithic studies for terms to be used in both contexts. Foss and Elnitsky provide a good synthesis of the problem:

> Such a variety of opinion about the function of this tool [pick-shaped artifact] has arisen because the older methods of formal classification made evaluation of the remains more difficult. They gave rise to the conventional terminology which still has not gone out of use. 'Hoe' for example is the name given to certain tools

> regardless of whether they could have been used for agriculture. Even if the student denied the existence of agriculture in the period or area under discussion all tools of a certain form had to be called hoes for the sake of typology (Foss and Elnitsky 1941:184 quoted in Semenov 1964: 127).

Bordes has also dealt with the issue:

> Unfortunately, at the beginning of Prehistory [i.e., the discipline], objects were named a little too quickly and their utilizations inferred from their forms without precautions. It is due to this fact that there exist the terms for end scrapers, burins, etc., which are functional terms for morphological types (Bordes 1969: 2).

I would suggest that the time has come to break with tradition and that an attempt should be made to begin keeping functional and morphological categories <u>explicitly</u> distinct. To this end, I propose that the term "celt" be retained as a way of describing a class of artifacts with a certain characteristic appearance and that all functional connotations be rejected until their applicability can be demonstrated. John Evans, over a hundred years ago, provided a morphological definition of celts which can still serve as a standardized way of defining this artifact class on the basis of form:

> . . . more or less flat blades, approaching an oval in section, with the sides more or less straight, and one end broader and also sharper than the other (Evans 1872: 51).

It is also necessary to state whether the artifacts under consideration are of chipped or ground stone. Defining celts in this manner, using only morphological criteria, allows functional analysis to procede without preconceived ideas influencing the obtained results. It is the major purpose of this paper to examine just how much congruence there is between form and function in the specific case of one celt assemblage.

III. Cultural Historical Background and History of Research in Guanacaste, Costa Rica

This section provides a brief description of what is currently known of the prehistory of northwestern Costa Rica traces the development of research in the area. Special attention is paid to past studies of lithic materials, particularly ground stone artifacts. It should be stated at the outset that archaeological research in Guannacaste is still in its infancy. With a few early exceptions, scientific investigation has been going on for only about twenty years, and data from many recent projects are still not available either in published or unpublished form. The problem is particularly acute for those excavations which have been sponsored by the Museo Nacional de Costa Rica, as the majority of their efforts over the last few years have been devoted to mitigating the effects of industrial development and the growth of tourism on archaeological resources. Employees of the Museo Nacional, myself included, often find themselves darting from one "brush fire" to another in the attempt to salvage whatever they can at sites doomed for immediate destruction. This necessary emphasis on salvage excavation has created a situation where data analysis and the publication of reports has not been as up to date as would be desirable.

Northwestern Costa Rica, of which Guanacaste Province is a part, and coastal, southwest Nicaragua (Figure 1) are commonly referred to as the "Greater Nicoya Archaeological Subarea" (Norweb 1964: 561). This designation, and its assumption of cultural continuity, is based on the appearance of similar ceramic styles throughout the area (Lange 1978: 101). The basic framework for a cultural chronology, again based on ceramics, has been developed over the years, though many of the details still remain to be worked out (Figure 2). For the sake of simplicity and convention, I have chosen to utilize the four periods outlined by Lange (1971a) which are detailed in Figure 2.

Formal archaeological investigation in Guanacaste began in the late 19th and early 20th centuries with the pioneering expeditions of J. F. Bransford (1881, 1882) and C. V. Hartman (1901, 1907). Bransford, working under the auspices of the Smithsonian Institution, made an archaeological reconnaissance in the area and collected a number of "valuable archaeological specimens" from Minor C. Keith, one of the builders of the Costa Rican railway (Bransford 1881: 20). The importance of the extensive archaeological collection of Minor C. Keith is discussed more fully below. Carl Hartman spent a number of seasons in Costa Rica, working in the highlands, as well as in Guanacaste. The primary focus of Hartman's labors was on the excavation of prehistoric graves, and his meticulous mapping and note-taking procedures have caused him to be hailed as one of the earliest champions of scientific archaeological method (see Rowe 1959 for a discussion of Hartman's contributions). Hartman's published burial records preserve the original context of all associated artifacts and features in a manner detailed enough to allow his findings to serve as a valuable source of comparative data, even though his work was carried out during a period when less rigorous field method was the rule.

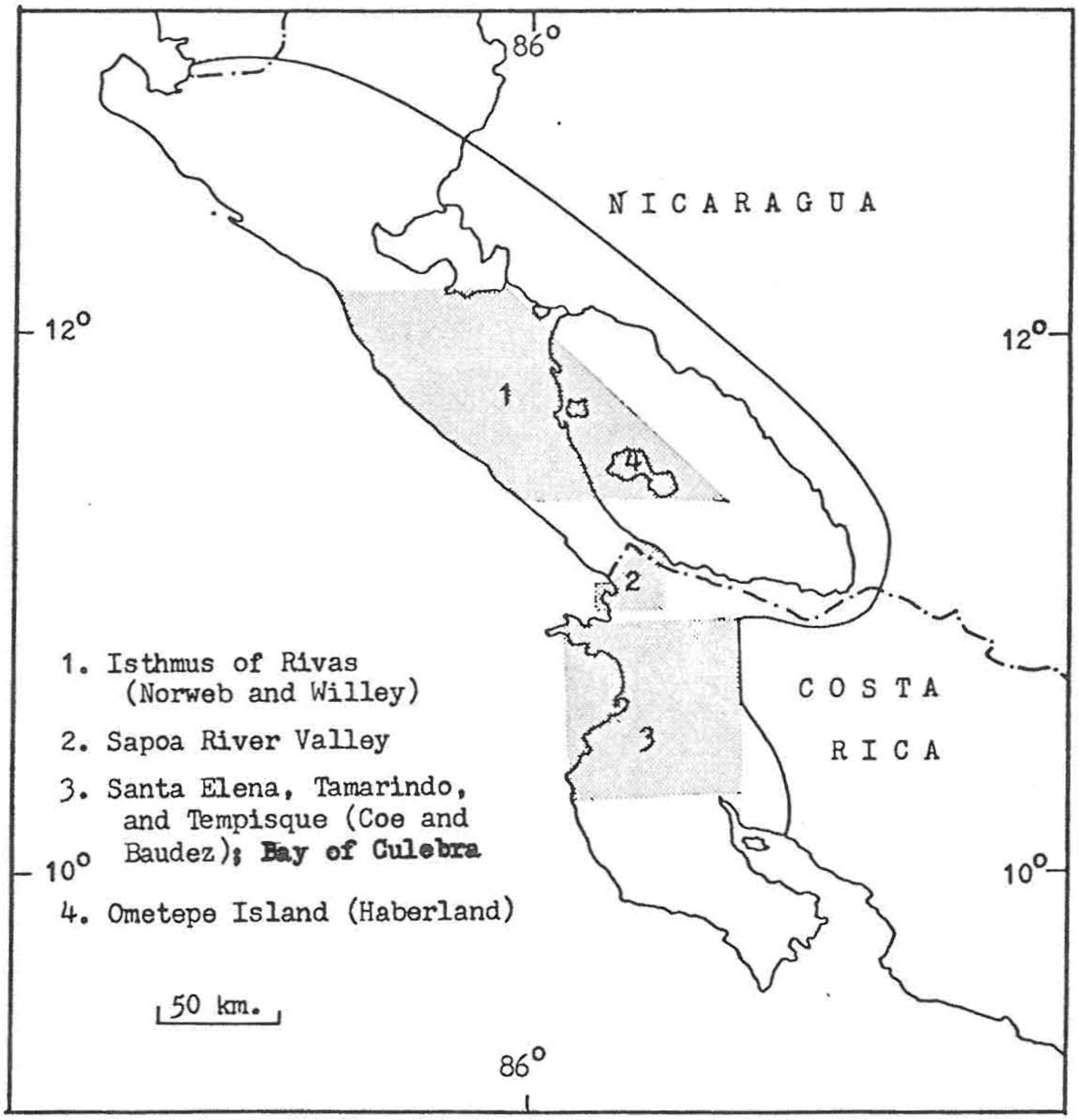


Fig. 1 Greater Nicoya Archaeological Subarea, showing major centers of research (1959-1970). **Dates of research are provided in the text. (Lange 1971a: 5).**

Figure 2
Comparative Chronlogy of Central America (Sweeney 1975: 31)

Mesoamerica	Middle Preclassic — Late Preclassic — Proto Cl. — Early Classic — Late Classic — Early Postclassic — Late Postclassic
Baudez's Periods	II — III — IV — V — VI
Lange	Zoned Bichrome — Early Polychrome — Middle Polychrome — Late Polychrome
Haberland	Zoned Bichrome — Early Polychrome — Middle Polychrome — Late Polychrome
Sweeney	Zoned Bichrome — Linear Dec. — Early Polychrome — Middle Polychrome — Late Polychrome
Healy	Zoned Bichrome — Early Polychrome — Middle Polychrome — Late Polychrome
Time Periods	900 800 700 600 500 400 300 200 100 AD/BC 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
Period Names	Zoned Bichrome — Lin. Dec. — Early Polychrome — Middle Polychrome — Late Polychrome
RIVAS	San Jorge — Aviles — San R+ — Palos Negros — Apompua** — Las Lajas *
OMETEPE ISLAND	Dinarte — Angeles — Aviles — Early Polychrome — Middle Polychrome — Late Polychrome
SANTA ELENA AREA	Chombo — Murcielagos — Sta. Elena — Doscientos — La Cruz A — La Cruz B
LAS MARIAS (Sapoa R.)	Early Zoned Bichrome — Late Zoned Bichrome — Early Polychrome — Doscientos — La Cruz A — La Cruz B
TAMARINDO AREA	Monte Fresco — Las Minas — Matapalo — Tamarindo
TEMPISQUE AREA	Catalina — Ciruelas — San Bosco — Palo Blanco — Bebedero
HIGHLAND COSTA RICA	Curridabat — Cartago Graves — Orosí
ATLANTIC COSTA RICA	Early Period — Middle Period A — Middle Period B — Late Per.
DIQUÍS AREA	Early Diquís — Middle Diquís — Late Diquís
CHIRIQUÍ (panama)	Concepción — Aguas Buenas — Burica — San Lorenzo — Chiriquí
PACIFIC PANAMA	Santa Maria Guacamayo — Early Coclé — Late Coclé — El Hatillo
Time Periods	900 800 700 600 500 400 300 200 100 AD/BC 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500

* Las Lajas and Alta Gracia phases.
** Apompua and La Virgen phases.
\+ San Roque phase.

S. K. Lothrop's (1926) elaborate study of Costa Rican and Nicaraguan ceramics was the first attempt to deal with the enormous quantity of archaeological materials which had made their way into private and museum collections throughout the world. Aside from his marvelous pottery descriptions, the main contributions made by Lothrop were his delineation of "archaeological areas" and his synthesis of the extant ethnohistorical materials. He defined the Pacific Area, which includes Guanacaste, as the region "embraced by the Pacific Coast of Nicaragua, including the lake shores and the western slopes of the Cordilleras, together with the northwestern portion of the Gulf of Nicoya" (Lothrop 1926: XXXV). With some slight modification, this is what is now referred to as the Greater Nicoya Archaeological Subarea (Norweb 1964: 561). In addition to ceramics, Lothrop also described a large number of stone artifacts, primarily statuary and jade offerings, but he did not mention utilitarian lithics.

The work of J. Alden Mason (1945), although he did not analyze any artifacts from the northwestern sections of Costa Rica, is important for a number of reasons. Mason, like Lothrop, did not excavate, but examined artifacts which were held in a museum collection (the American Museum of Natural History). The materials have since been sold to the Brooklyn Museum and a number of private collectors. Mason studied a wide range of lithic artifacts with an eye not merely towards description, but also to making some interpretations from the materials at hand. Based on morphology, he set up a classification system for the lithic artifacts in the Keith collection and then went on to postulate a number of functions. While by today's standards his functional interpretations and typological analysis cannot be considered rigorous, his attempt was commendable in that he listed, in detail, all of the characteristics he felt defined each artifact class. Mason also was very attentive to the intricacies of manufacturing technique and in addition was able to isolate certain features on lithics thought to have been produced as a result of use.

The first modern archaeologists to undertake stratigraphic excavations in Guanacaste were Michael Coe (1962a, 1962b) and Claude Baudez (1962, 1967) (Figure 3). The results of Coe's work are presented more fully in Jean Sweeney's doctoral dissertation (1975). Coe, who worked under the auspices of the Institute of Andean Research, had two goals when he began his Guanacaste project:

> 1. to establish a sound chronological sequence for coastal Guanacaste and
>
> 2. to search for archaeological complexes which would be Formative in the chronological sense, that is, which would lie within the 1500 B.C. to 300 A.D. time span. (Coe 1962b: 358)

Coe was quick to realize, as was Baudez, that little advancement could be made in the study of Guanacaste prehistory until a basic chronology for the area had been constructed. To this end, they delineated "four major archaeological periods", in some cases divided into subperiods, based on the distribution of ceramic types (Baudez and Coe 1962: 366). These periods were then correlated with the sequence from Mesoamerica proper (Baudez and Coe 1962: 369). Lithics were not used to help in the formation of a regional chronology, though at many sites, particularly those excavated by Coe (Matapalo, Huerta del Aguacate, and Chahuite Escondido), they were found in abundance. Baudez included a fairly substantial section on lithics in his report on the Tempisque Valley, but he also seems to have felt that lithics are of little importance in building a time sequence (1967: 179-185).

Albert Norweb (1964) applied Coe's (1962a, 1962b) sequence to the ceramic materials he and Gordon Willey found in southwestern Nicaragua and concluded that the two areas can be considered essentially unified for purposes of archaeological analysis. Healy (1974), who studied in detail the materials recovered by Norweb and Willey, devoted most of his attention to ceramic classification, but he did include descriptions of both chipped and ground stone tools. Based on morphology, Healy worked out a general classificatory scheme for ground stone artifacts and made some modest functional interpretations. Healy's analysis is discussed in greater detail in later sections of this report.

During the last ten years, nearly all of the archaeological projects in Guanacaste have been directed by Frederick W. Lange and his students. Lange has challenged the deeply-entrenched assumptions of strong Mesoamerican influence in prehistoric Guanacaste and has pointed out the South American flavor of the archaeological materials from this area (1971a: 267-82). In addition, he has instituted the first studies which have addressed problems other than those presented by ceramic analysis and chronology (Lange 1971a, 1971b, 1976b, 1978).

When discussing the history of archaeology in Guanacaste, it is important to mention the enormous impact which grave robbing or huaquerismo has had on the region's archaeological resources. Museums and private collections the world over are stocked with the renowned jades and ceramics from Guanacaste. I have spent five field seasons working in Guanacaste and have never once observed an archaeological site which did not show at least some evidence of huaquero activity. Many sites have been completely destroyed and those which still remain relatively intact are in constant danger. Heath (1973a, 1973b) and Lange (1976a) have discussed Costa Rica's long tradition of huaquerismo and its place in the international antiquities market.

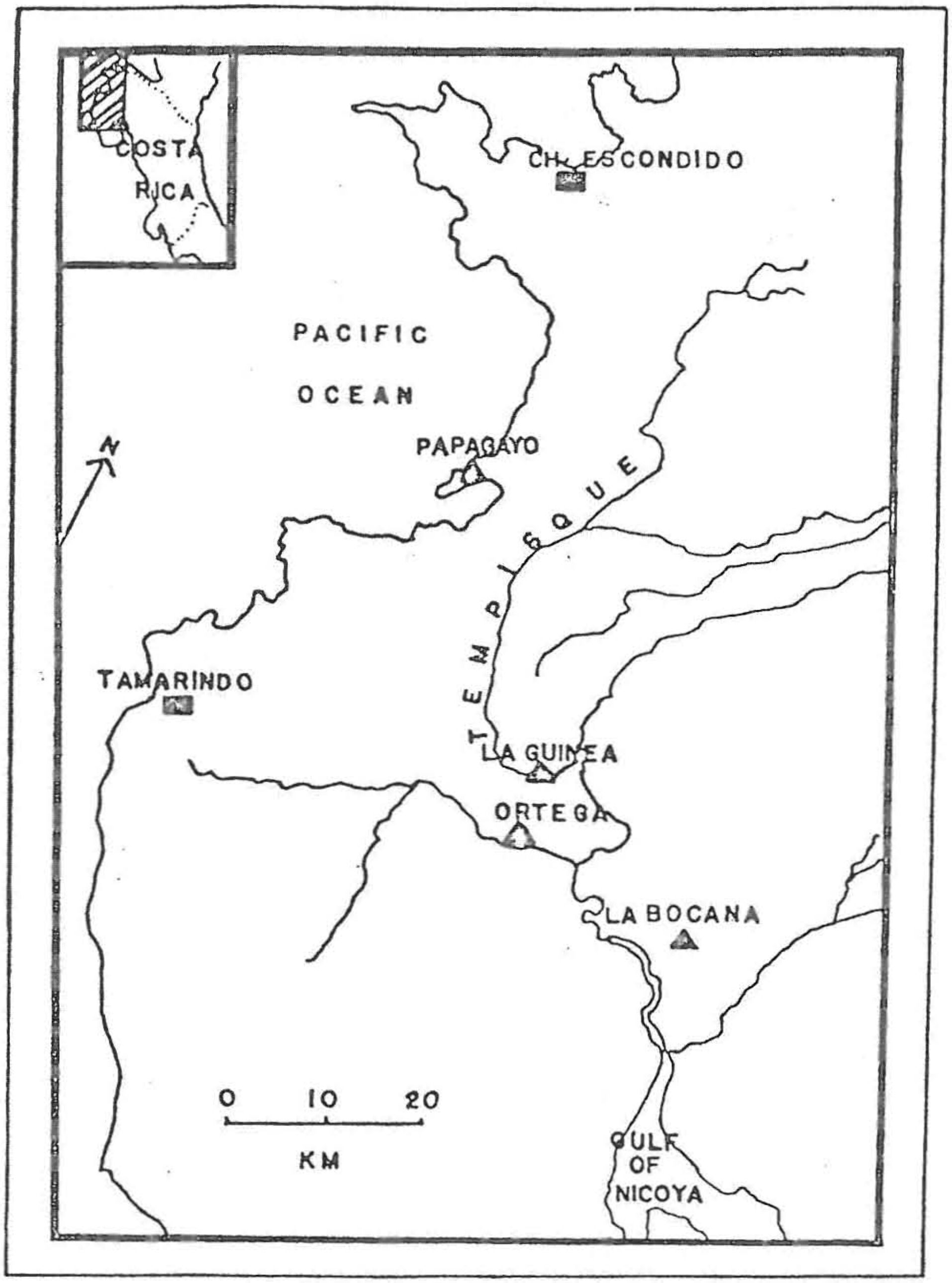


Fig. 3 Sites in the Greater Nicoya area excavated by Coe (squares) and Baudez (triangles). From Baudez and Coe (1962: 367).

IV. Site Descriptions

The celts discussed in this report were found at 11 different sites in Guanacaste, Costa Rica. Each of these sites is briefly described below and whenever possible each is placed in the Guanacaste chronological sequence. Reports have yet to be written for quite a number of the sites and much of the raw data from some has not been analyzed in even a preliminary fashion. When available, references are provided which contain information pertinent to the particular site in question. Field notes and personal observations have been used in those cases where no published material is available. Due to a clerical mishap, there is some question as to the provenience of two of the celts. Although it is almost certain that they were surface collected at the Vidor site, they have not been included in the artifact count from that site. A chronological summary of the finds is presented in Table 1. Provenience data for each celt is provided in Appendix 1.

<u>Rio Sapoa Sites</u> (eight celts)

In 1969 and 1970 Lange, along with a group of students participating in the Associated Colleges of the Midwest (A.C.M.) field program, surveyed the Rio Sapoa Valley and excavated at a number of sites in the region (Figure 1). During the survey, 113 sites were found, of which 24 were eventually tested. All four ceramic time periods were represented in the survey region and a number of aceramic sites were also located. Lange (1971a: 44-45) set up a system of site classification based on "ecological zones" and these are listed below for each of the sites at which celts were found. In addition to those reports cited in the following discussion, a number of student research papers, currently on file at the Museo Nacional in San Jose, Costa Rica, discuss the findings of the Rio Sapoa Valley Project.

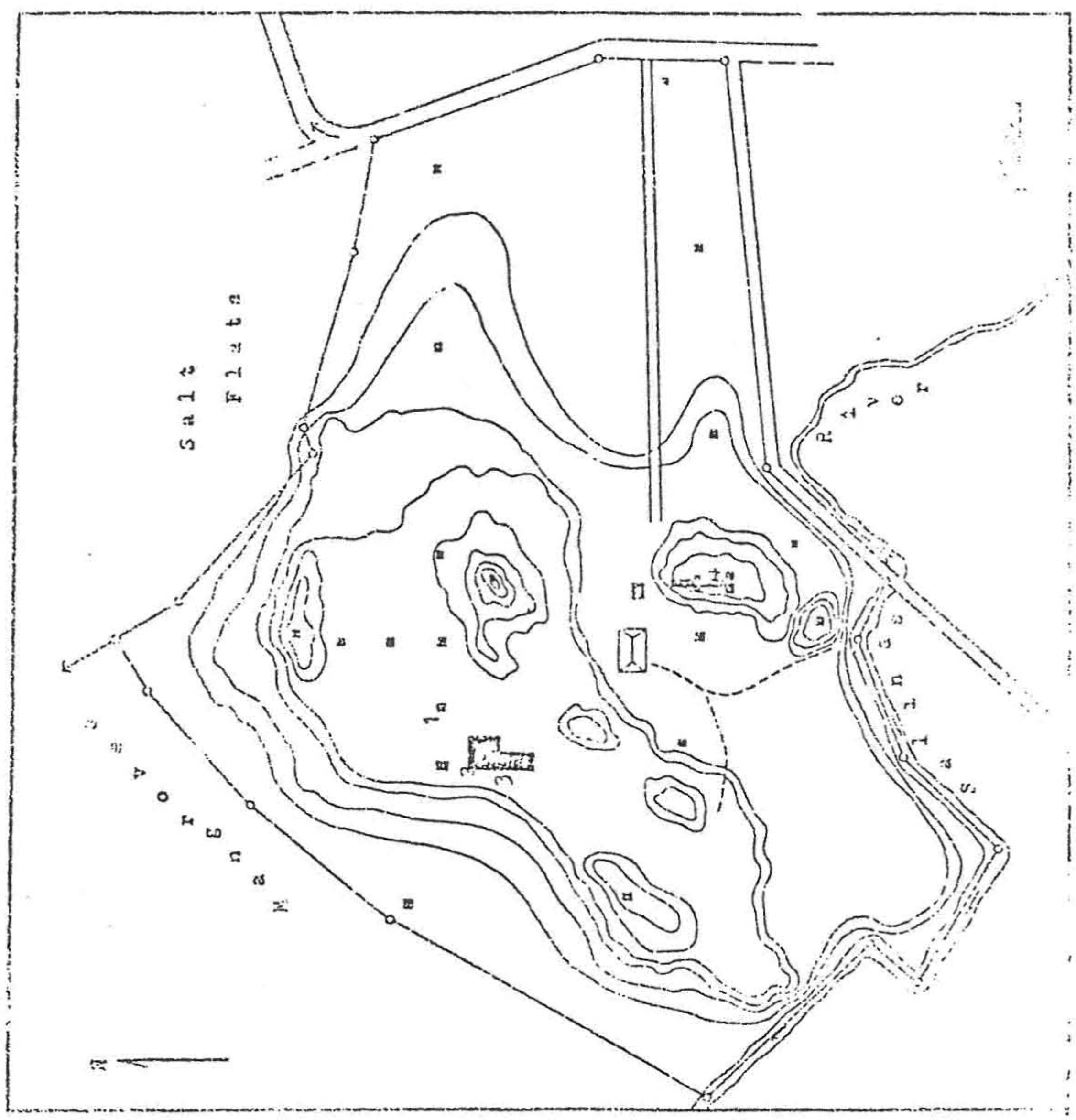
Las Marias (RSVP-69-V11-26). Discussed in Lange (1971a),
Little (1969), and Taschek (1971). 6 celts.

Las Marias, the most extensively excavated site of Lange's Rio Sapoa Valley Project, is located a little less than one kilometer from the Bay of Salinas (Figure 4). In the site classification system used by Lange it falls under the heading of "shell mounds/middens on estuaries and creeks" (Lange 1971a: 91). Las Marias is thought to be the largest site in the Bay of Salinas area. It is comprised of a number of mounds containing shell deposits of varying density which reach a maximum depth of five meters. Zoned Bichrome (300 B.C.-A.D. 300) is the only ceramic period not represented and this component was found at only one site along the Bay of Salinas (Lange 1971a: 211). The Early, Middle, and Late Polychrome deposits are not distributed evenly over the site. Lange describes this phenomenon as follows:

> What we found was that the site had horizontal temporal distribution as well as vertical, with the Early Polychrome and Middle Polychrome components occurring on the western and northern edges, with a shallow overlying Late Polychrome component in some places. As we moved to the southern and eastern sectors, the lone component was purely Late Polychrome, with some Mora, Papgayo, and Castillo Engraved from the preceding period. (1971a: 235)

Lange feels the inhabitants of Las Marias had a "sedentary gatherer pattern of organization" (1971a: 237). Marine mollusca probably

Figure 4 Las Marias (Lange 1971a: 92)



Site	Time Period							
	ZB or EP	EP	EP or MP	MP	MP or LP	LP	Undetermined	Total
Sapoa-26(E)			1			5		6
Sapoa-26(S)								0
total								6
Sapoa 62(E)								0
Sapoa 62(s)						1		1
total								1
Sapoa-65(E)								0
Sapoa-65(s)					1			1
total								1
3047I-1(E)		6	4	12	8	5	19	54
3047I-1(S)							9	9
total								63
3047I-2(E)								0
3047I-2(S)				1				1
total								1
3047I-3(E)						1		1
3047I-3(s)								0
total								1
3047I-6(E)								0
3047I-6(S)					1			1
total								1
3047I-7(E)	1							1
3047I-7(S)								0
total								1
3047I-28(E)								0
3047I-28(S)					7			7
total								7
44018(E)								0
44018					1			1
total								1
44020(E)								0
44020(S)							1	1
total								1
Total	1	6	5	13	18	12	29	84

Table 1. Chronological summary of celts of known provenience.
abbreviations: ZB-Zoned Bichrome, EP-Early Polychrome
MP-Middle Polychrome, LP-Late Polychrome
(E)-excavation, (S)-surface find

provided the majority of the meat portion of the diet and the analysis of shellfish remains performed by Taschek (1971) suggests a "year round occupation of the site and seasonal exploitation of shellfish from the bay" (Lange 1971a: 244). Both inter-tidal and rocky shore areas appear to have been exploited on a seasonal basis. Based on the scarcity of terrestial faunal remains found during excavation, hunting is assumed to have been of little importance at Las Marias.

No actual housing remains were located, but based on the recovery of approximately 50 impressed adobe fragments, Lange feels that it is possible that the Las Maria inhabitants had "semi-permanent" housing made of wattle and daub (1971a: 104).

El Jobo (RSVP-69-V11-62). Discussed in Lange (1969, 1971a). One celt.

El Jobo, located on Punta Descartes, overlooks the Bay of Salinas and has been placed in Lange's (1971a: 116) category of "sites located on promontories around the bay". The site is located approximately one kilometer from the bay. Two distinct areas of cultural activity were located at El Jobo (Lange 1971a: 116). Eroding out of the base of the hill on which the site is situated were found a number of fragments of shell, lithics, and ceramics. On the crest of the hill, where a shell midden was located, cultural material was much denser. To the southwest of the site "is a large salt flat that may have been one of the original reasons for the occupation of this area" (Lange 1971a: 116). El Jobo is a single component, Late Polychrome site.

RSVP-69-65. Discussed in Lange (1969), 1971a). One celt.

RSVP-69-65 is not located in the Rio Sapoa Valley proper, but rather, lies within the confines of the Salinas River drainage system.

It is approximately seven kilometers from the Bay of Salinas. This region was not in Lange's original survey area, but a quick reconnaissance was made of a number of sites, as the Salinas River is "a relatively major source into the bay [Salinas] and a region where sites were known by a local informant (Lange 1971a: 120). Site RSVP-69-65 is located along the banks of a quebrada and cultural material, including "sherds, lithic fragments, and shell and bone debris" were observed over an area extending for approximately 200 meters (Lange 1969: 226). Because of this diversity in materials, Lange (1969: 239) concluded that the inhabitants of the site had a "very mixed economic base". Both Late Polychrome and Middle Polychrome ceramics were found, with the earlier component being more strongly represented.

Sites on or Near the Bay of Culebra (74 celts)

Celts were found at four sites located within one kilometer of the Bay of Culebra (Figure 5). At two other locations (Hunter-Robinson and Ruiz), each within a few hours' walk of the bay, celts were also recovered. The Bay of Culebra is an extremely rich archaeological region. As of this writing, at least 60 sites have been found in the immediate area, many of these covering over five hectares.

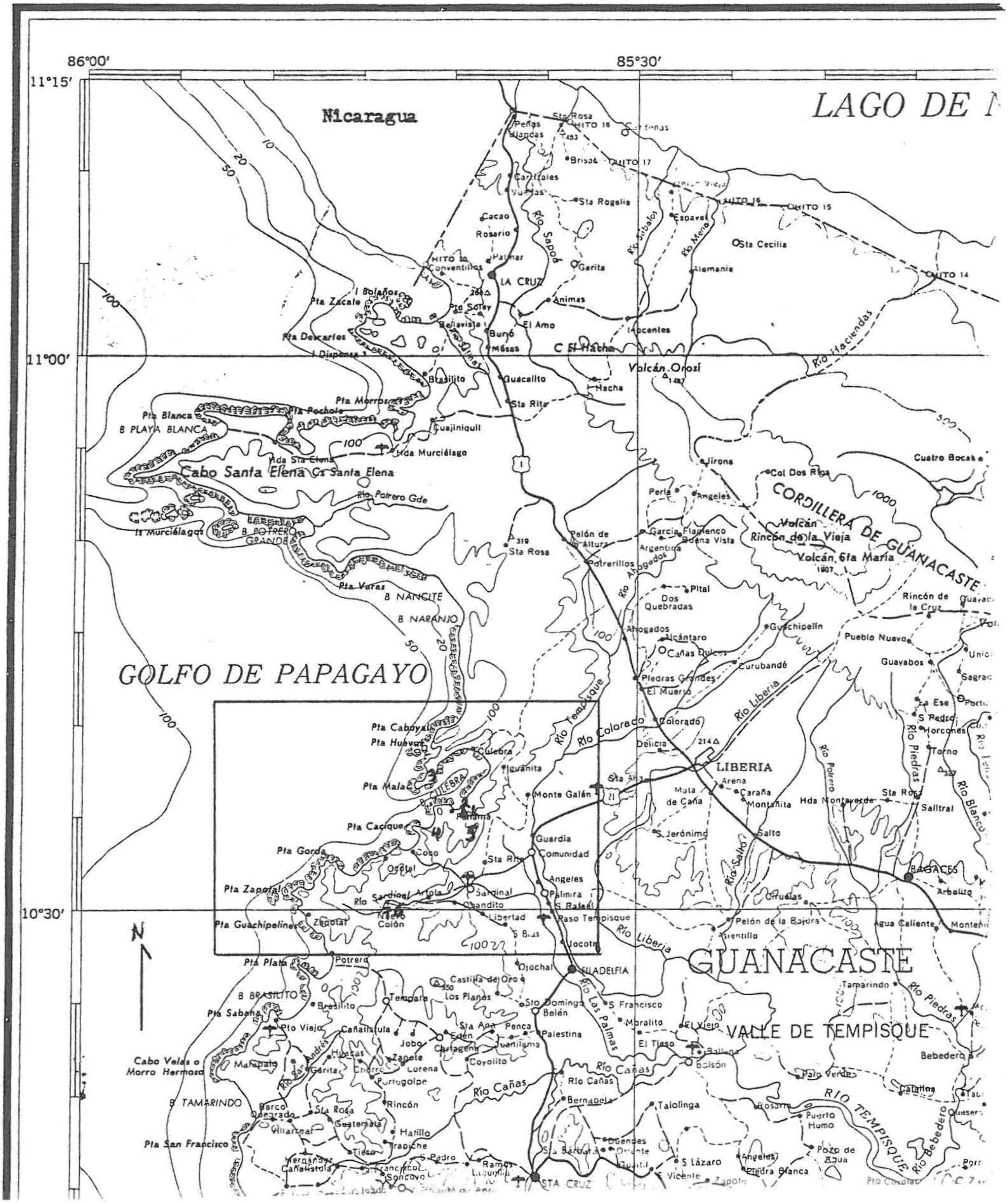
The rim of the bay consists of a number of crescent-shaped beaches, divided at frequent intervals by rocky, volcanic headlands. Numerous streams drain the surrounding hills and where they flow into the bay mangrove swamps and estuaries are usually formed. These are thought to have been especially significant to the pre-Columbian inhabitants of the bay, as they are extremely rich in mollusks, crustaceans, and many species of fish.

In modern times much of the land surrounding the bay has been

Figure 5 Bay of Culebra and Rio Sardinal sites.

1-Vidor and Cerro Soto
2-Salt Flat
3-Jicaro
4-Hunter-Robinson
5-Ruiz
6-44018
7-44020

MAPA FISICO-POLITICO 1:500.000



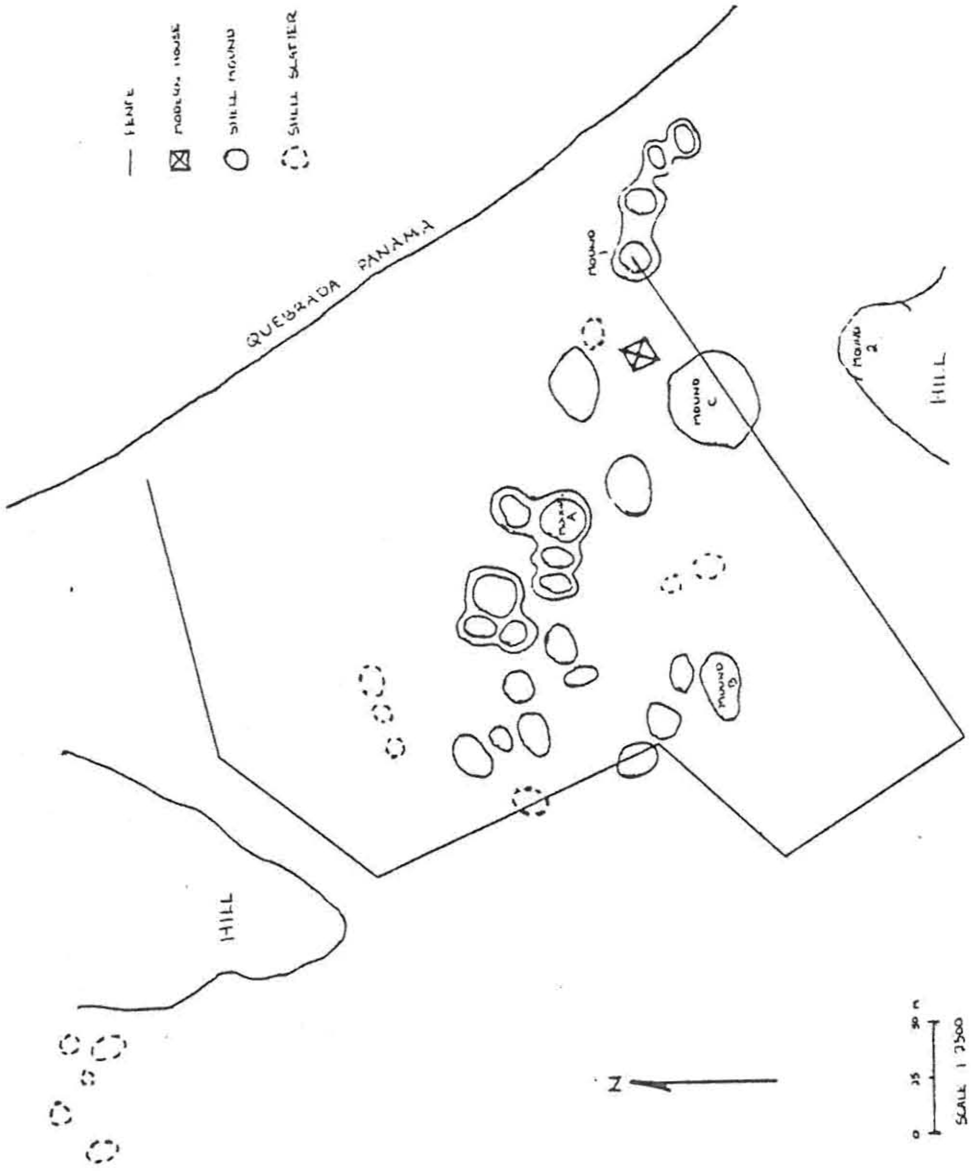
deforested for agriculture and cattle grazing, a situation present throughout Guanacaste. A tourist project of major proportions is scheduled to get underway in 1979, a development which will cause further environmental change and also endanger those archaeological resources which have, so far, escaped the *huaquero's* shovel.

Vidor (3047I-1). Discussed in Abel (1978), Accola (1978), Lange (1978), and Moreau (1978). 63 celts.

As nearly three-fourths of the artifacts included in this study were found at the Vidor site, a comparatively lengthy description of its characteristics and excavation history is in order. At present, very little data on Vidor is available in published form and I have relied heavily on Lange's (1978) recent synthesis of data from the site. Abel (1978) has analyzed two of the features located during the 1977 field season and Accola (1978) has just completed an exhaustive study of the decorated ceramics excavated in 1973. Moreau (1978) is in the process of analyzing the mollusk remains from 1973 and work is near completion on the site's large sample of human bone. In addition to the reports cited above, at least forty research papers have been written by students participating in field programs sponsored by Beloit College and the A.C.M. These are on file at the Museo Nacional de Costa Rica.

The Vidor site, located approximately one-half kilometer from the southern shore of the Bay of Culebra, is situated in a small valley along the western bank of the Quebrada Panama (Figure 6). It is thought that during prehistoric times the site may have been located closer to the bay than it is today (Accola 1978: 32; Lange 1978: 103-104). Lange (1978: 104) has tentatively proposed coastal uplift, as opposed to rising sea level, as the reason for this change. The *quebrada* flows on a seasonal basis and has been known to rise above its bank in times of

Figure 6-Vidor Site (3047I-1). From Accola (1978: 16).



particularly heavy precipitation. During dry years, flow is minimal and it is non-existent in the later stages of the dry season. At its mouth, the quebrada meets the bay, forming an estuary. Even at high tide, the waters of the quebrada do not back up as far as the Vidor site.

The site was highly visible, owing to the presence of approximately 17 artificial mounds, when Lange and students from Beloit College began work in April, 1973 (estimate of the number of mounds is from Accola 1978: 32). Since that time, all but a few of the mounds have been removed by bulldozing in order to contour the site for agricultural purposes. The mounds, consisting of midden debris (shell, ceramics, lithics, daub fragments, and bone from marine and terrestial, including human, fauna) vary greatly in size, the largest examples rising about the present ground surface by as much as two meters. Total depths of cultural deposits often approaches five meters. The midden materials usually occur in well-defined strata, divided by layers of sediment deposited either by the flooding of the quebrada or by water flowing off of the nearby hills during periods of heavy rainfall (Ronald Chavez: personal communication, 1976). Stratigraphic profiles in the mounds also show two layers of volcanic ash which are thought to have resulted from the eruption of one of the volcanos in the Guanacaste Cordillera, located approximately 35 kilometers to the northeast. Lange (1978: 104) feels that these eruptions were of a magnitude great enough "to have caused at least temporary abandonment" of the site.

During the initial field season a surface collection was made and two of the mounds, designated Mounds 1 and 2, were tested. On the basis of the surface collection it was determined that all four of the Guanacaste time periods were represented at Vidor. The test pits exposed levels belonging to the three most recent periods but it was not until 1976, when Lange returned to Vidor with a group of students from Beloit College and the A.C.M., that a Zoned Bichrome component was located in situ.

As in 1973, the 1976 excavations were confined primarily to the mounds themselves, with little attention being paid to the lower lying areas of the site. Late in 1976 major bulldozing of the site began, an event which radically altered the subsequent excavation strategy. During the course of bulldozing, a number of human burials were inadvertantly exposed, as were a number of subsurface features. In order to investigate these further, a twenty by thirty meter section of the site, located in an area not under cultivation, was intensively excavated beginning in early 1977. As the bulldozer had removed most of the Late and Middle Polychrome bearing strata, the excavation undertaken in 1977 dealt almost exclusively with Early Polychrome and Zoned Bichrome components.

Abel (1978: 11-12) lists six different categories of features found during the 1977 field season:

1. Human burials--Analysis of the human skeletal material by David Weaver and Ricardo Vasquez (personal communication) is still in progress, but the work to date has produced much data of interest. Of the 137 individuals excavated at the Vidor site, only four are adults. Fetuses and newborns were commonly interred in large inverted cermaic vessels, while the extended skeletons at the site were usually adolescents or adults. Weaver and Vasquez feel there is strong evidence to suggest that the prehistoric inhabitants of Vidor, at least those buried on the site, were a quite unhealthy group of people. Osteoporosis, a condition possibly reflecting insufficient quantities of animal fat in the diet,

was common in the lower age groups, as were a number of other conditions reflecting fat deficiency. Lange (1978: 109) has described the burials as comprising a "cemetery complex" dating to the Early Polychrome period.

2. Refuse and/or storage pits--These features are filled with marine shell and other debris.

3. Large rock concentrations.

4. Large concentrations of fired daub.

5. A pattern of post holes probably indicating the presence of some type of structure.

6. Two "burnt clay features", one of which is thought by Abel (1978) to be a pit kiln for firing pottery.

Looking at the subsistence data from Vidor as a whole, a steady increase in the importance of fishing and mollusk collecting, at the expense of hunting, can be noticed over time (Lange 1978). No mollusk remains are associated with Zoned Bichrome materials at Vidor, a situation which appears to hold true, with one possible exception (Baudez 1967: 48), for all of Guanacaste. The role of agriculture in the overall subsistence pattern is still uncertain.

Cerro Soto (3047I-7). Discussed in Abel (1978) and Accola (1978). One celt.

Cerro Soto, located just to the north of the Vidor site, is an extensive hilltop cemetery probably dating to the Zoned Bichrome and Early Polychrome periods. Much of the site has been destroyed by <u>huaquero</u> activity.

Salt Flat (3047I-2). One celt.

3047I-2 is located on a low hill directly behind the beach at

Playa Panama. It is less than one-half kilometer from sites 3047I-1 and 3047I-7, and overlooks what has been, in recent times, a tidal pond used for extracting salt from sea water. Surprisingly, given its close proximity to both the bay and the estuary formed by the Quebrada Panama, mollusk remains are relatively sparce. Exclusively Middle Polychrome, the site consists of midden debris, almost entirely undecorated red ceramic sherds. Two test pits were excavated here in 1973, while the exploration of the Vidor site was in process.

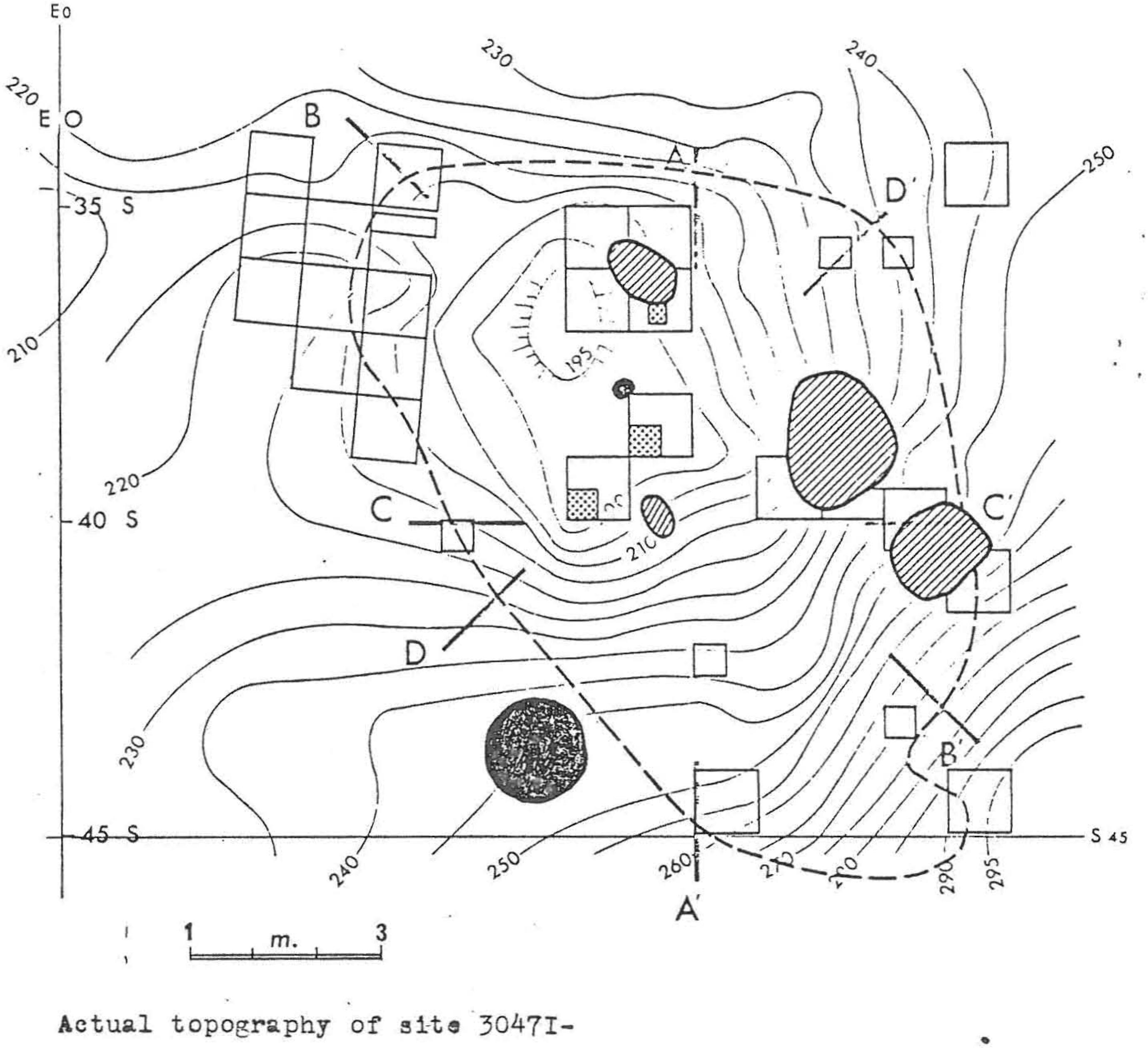
Jicaro (3047I-6). One celt.

Jicaro is located immediately behind the beach of the same name, on the northwestern shore of the Bay of Culebra. The site is in a flat area separating a quebrada from the beach. No excavation has taken place at Jicaro, and the majority of materials surface collected belong to the Late Polychrome period. Some Middle Polychrome ceramics were also found. Mollusk remains are plentiful, though no shell mounds can be seen.

Hunter-Robinson (3047I-3). Discussed in Moreau (1975, 1977). One celt.

Site 3047I-3, excavated in 1973 under the direction of Jean-Francois Moreau, is located about two kilometers from the coast (Figure 7). The descent from the site down to a small bay at Playa Hermosa is very steep, making access to marine resources somewhat difficult (Moreau 1977: 3). At least four separate shell middens are present on the site, two of which were extensively excavated by Moreau. By modern road, 3047I-3 is approximately a one hour walk from the Vidor site. On the basis of molluscan analysis, Moreau (1977: 9) estimates that the site was occupied for a period of nine or ten months by a group of ten to twenty individuals, and that it was abandoned during the long rainy season which

Figure 7
Site 3047-I-3
(Moreau 1977)



Actual topography of site 3047I-

Huaquero pit

Excavation pit

Sampling column

Tree

Approximate limits of shell accumulation extends from August to October. 3047I-3 is exclusively Late Polychrome.

Ruiz (3047I-28). Discussed in Lange (1978). Seven celts.

Lange (1978: 111) describes Ruiz as follows:

> The Ruiz site, located behind the first row of hills bordering the south side of the Bay of Culebra, is several hectares in size, shallow, and has only minimal evidence of Early and Middle Polychrome occupations. Material from the Late Polychrome component is considerably denser in concentration than material from sites on the shore of the Bay of Culebra.

Rio Sardinal Sites (2 celts).

During March and April of 1976 a survey of a portion of the area surrounding the Sardinal River was conducted by a number of students from Beloit College and the A.C.M. under the leadership of Frederick Lange. Celts were surface collected at two of the sites and they have been analyzed as part of this study.

44018. One celt.

Site 44018 is located one mile east of the town of Nuevo Colón on the south bank of a small quebrada which is connected to the Sardinal River. Though the site has been heavily damaged by huaqueros, the survey crew was able to surface collect a sufficient number of potsherds to determine that the site had both a Middle and Late Polychrome component.

44020. One celt.

Site 44020 is located in the town of Nuevo Colón on the northern bank of the Sardinal River. The remains of marine mollusca were observed and ceramics from the Early, Middle, and Late Polychrome periods were collected.

V. Technique

In my studies of lithic artifacts I have found the distinction made by Keeley (1974: 323) between method and technique quite useful. To Keeley, technique is simply the details of observation: that is, how the archaeologist goes about accumulating his raw data. Methodology, on the other hand, refers to the processes involved in making interpretations from the observed data (Keeley 1974; 323). This portion of the report is devoted solely to the description of the specific techniques employed during the study of the celt collection. Questions of methodology are addressed in later sections of the paper.

In the attempt to describe the variation present in the celt assemblage, a large number of variables, continuous and discrete, were examined. Whenever possible, effort was made to quantify the observations in order to aid in statistical analysis. The attributes are grouped into two general categories; morphological and microwear. The morphological class is divided into metric and discrete variables.

The attributes observed, listed below, were chosen for a variety of reasons, one of the most important being force of convention. As one of the goals of this study is to compare my collection of celts with others found in Guanacaste, it is necessary that my observations conform to those made by other researchers. In addition, a number of formal attributes were selected because it was felt that they may be significant in the interpretation of function, which has, in fact, proven to be the case. As mentioned previously, many of the artifacts are not in their original complete state. In these instances, as many attributes as possible were recorded. Eight of the celts had portions of their surfaces removed a number of years ago for thin section analysis (Plates 4 and 11). These artifacts were treated in the same manner as those fragments recovered *in situ*. The raw data recorded for each artifact are contained in the appendices to this report, as are descriptive statistics for many of the attributes.

Morphological Attributes--Metric (see Figure 8 and Appendix II)

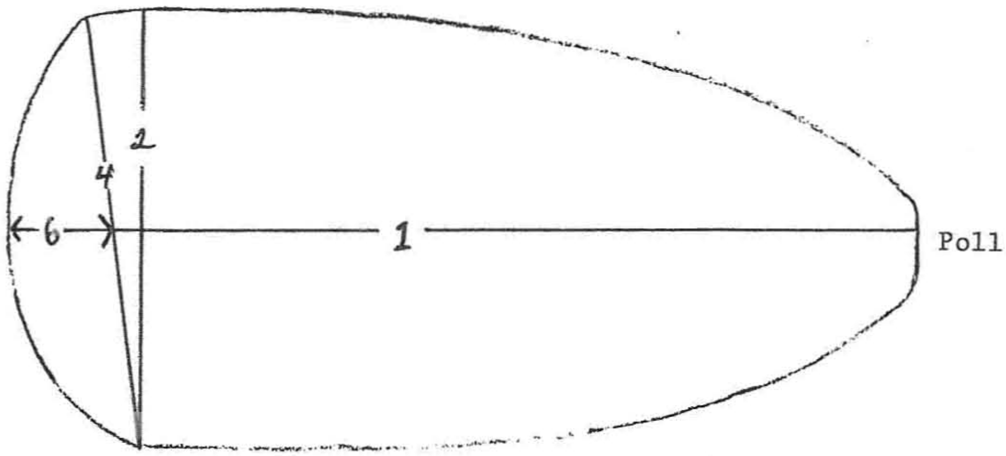
1. maximum length--measured from poll to cutting edge
2. maximum width and location
3. maximum thickness and location
4. width of cutting edge
5. edge thickness
6. depth of cutting edge.
7. edge angle--The measurement of edge angles on lithic artifacts is an extremely difficult procedure. Though there are numerous articles in the archaeological literature suggesting techniques for the measurement of this important attribute, I have found none to be completely satisfactory. The problem is much greater for artifacts such as the Guanacaste celts, which have markedly curved edges, than it is for small, sharp, chipped stone specimens, whose edges tend to be straighter. Difficulties in measurement arise from the following factors:

A. Defining precisely which portion of the artifact comprises the edge. As celts are tapered for most, if not the entirety of their length, a standardized means for defining the edge must be adopted.

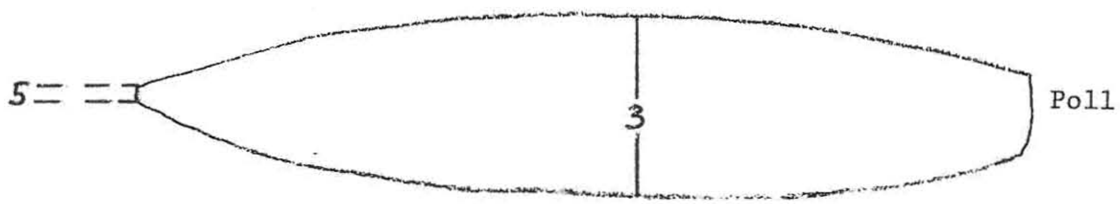
B. Deciding on what tools to use to take the angle measurements.

C. Deciding whether to take the readings directly on the artifact or on reproductions of the artifacts, such as molds, photos, or drawings.

Figure 8 - Basic Metric Attributes



Vertical Profile



Horizontal Profile

1. maximum length
2. maximum width
3. maximum thickness
4. width of cutting edge
5. thckness of cutting edge
6. depth of cutting edge

Drawings are modified versions of those found in Doperé and Vermmeersch (1978: 6).

D. Arriving at a technique for computing an angle, which is a measurement reflecting the relationship between two planar surfaces, to express the relationship between two curved surfaces, such as are found on the celts.

In attempting to solve these technical difficulties I have, at one time or another, tested most of the procedures for measuring edge angles outlined by other lithic researchers. These techniques, accompanied by my evaluation of their efficiency and accuracy, are listed below:

1. Measurement of the edge angle directly on the artifact with either a protractor or a goniometer (Beggerly 1976: 22; Hester et al 1973: 93; Tringham et al 1974: 179). This is probably the most popular technique for measuring edge angles and for chipped stone it is probably the most efficient. For my purposes it was judged inappropriate as no allowance is made for curved edges.

2. Making a negative impression of the artifact's edge with a carpenter's template and measuring the angle on the template (with a protractor), not the artifact (Crosby 1967). I found this technique unacceptable for a number of reasons. First, the individual wire teeth of a carpenter's template were judged too thick to allow for a precise impression to be made. Also, gaps in the contour of the impression, resulting from the play in the wire teeth, often occurred, creating difficulties in obtaining accurate measurements. Finally, this technique, at least as it has been described by Crosby (1967), assumes straight and precisely defined edges. George Odell (personal communication) has informed me that others have achieved success with the carpenter's template and following his suggestion I plan to work on a further refinement of this technique. The key

to success probably lies in obtaining a template with thinner and stiffer teeth than I was able to locate.

3. Other types of reproductions, aside from the carpenter's template, were also tested. These include clay molds (soft, frozen, and dried), photographs of horizontal profiles, and ink prints using hard clay molds to stamp out the prints. All of these were considered too costly and time consuming, as well as suffering the drawback of assuming straight edges.

4. The technique which was eventually adopted combines the soft clay mold strategy recently proposed by Burgess and Kramme (1978) with some of the mathematical steps suggested by Doperé and Veermersch (1978). Burgess and Kvamme made impressions of chipped stone artifacts in rectangular strips of soft clay and then measured the resultant angles with a 6X comparator "equipped with an angle measuring recticle" (1978: 482). This was the procedure followed with the Guanacaste celts, except that a small, clear plastic protractor was used in place of the comparator, following a suggestion made by George Odell (personal communication). I am of the opinion that little, if any, accuracy is lost by making this equipment substitution.

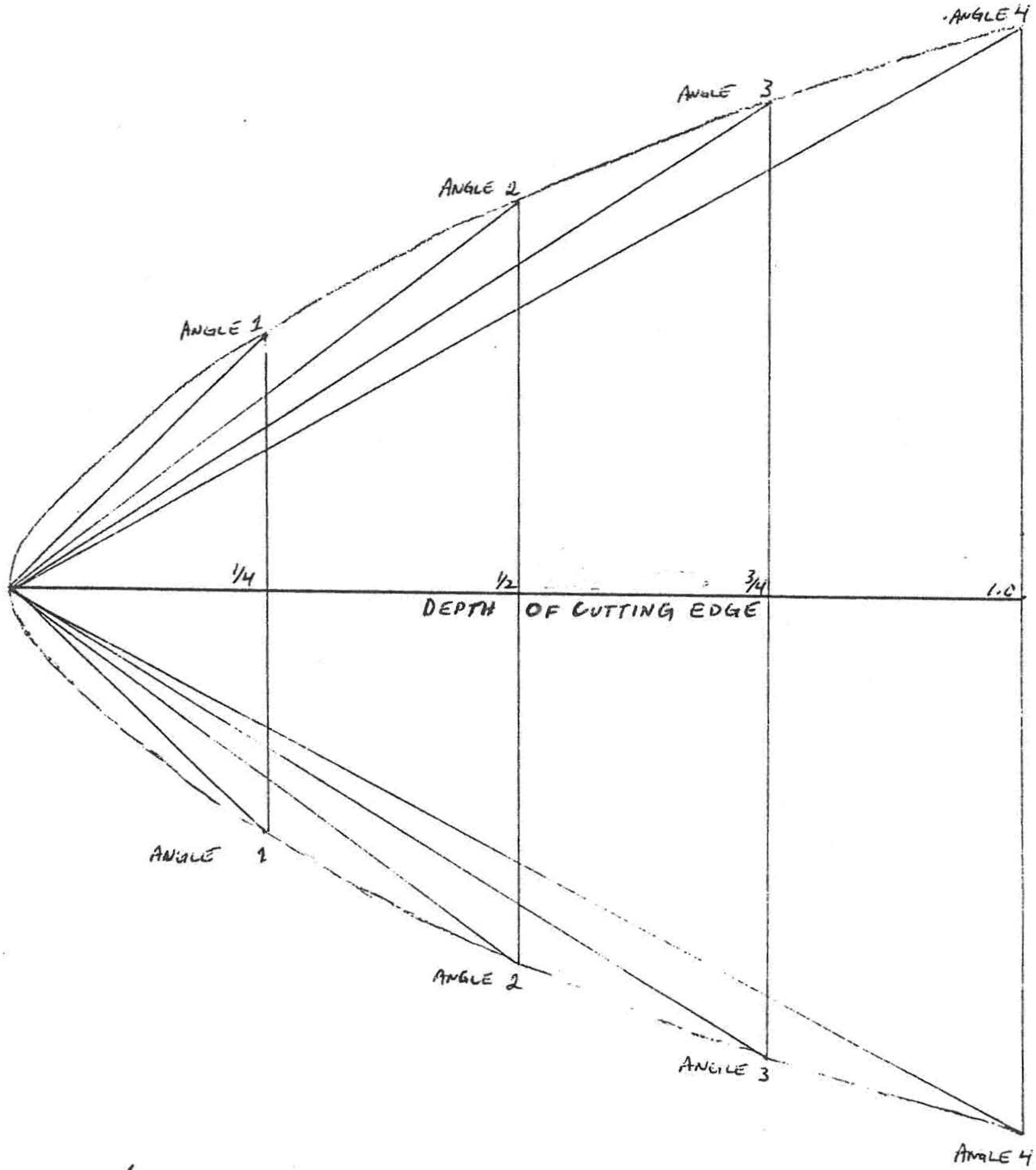
It is important to note that making clay impressions which are identical reproductions of a lithic artifact is not as easy as is often implied in the literature on the subject. One must be very careful when removing the clay, in order to keep the outline of the specimen intact. I have found the clay to be most stable after it has been allowed to "set up" for a few minutes with the celt still embedded in it, a procedure not unlike that used by cement masons who must wait awhile before removing their forms, in order to prevent the cement from losing the desired shape. Clay which is too wet will adhere to the artifact, while a too dry condition will result in the cracking of the impression. An "x-acto" knife is useful for cutting away the excess clay which builds up along the margins of the artifact as it is slowly pushed into the clay rectangle. As the mold is never allowed to harden, the same small batch of clay can be used to measure edge angles for as many artifacts as desired.

As Doperé and Vermeersch (1978: 14) have pointed out, when one measures edge angles on curved artifacts what one is actually measuring is an angle formed by lines running from the edge of the artifact to points located on its two opposing faces (Figure 9). Doperé and Vermeersch computed the angles formed by this intersection through the use of equations for describing the relationship among sides of right triangles. In short, what this amounts to is taking a series of measurements on the artifact which allow the angles formed by the intersections to be calculated. These measurements were taken by Doperé and Vermeersch at distances of 2.5, 5.0, 7.5, and 10.0 millimeters from the artifact's edge, a completely arbitrary set of intervals. The angles formed at these four points are then averaged to get one figure to represent the specimen's edge angle. This was the procedure I used, with the following modifications:

A. On the Guanacaste celts, the angles were measured on clay impressions of the artifact. This was felt to be more efficient technique than the one proposed by Doperé and Vermeersch, as it allows angles to be read directly, rather than calculated indirectly from measurements of artifact width, thickness, etc.

B. Doperé and Vermeersch do not directly address the problem of defining the artifact's edge. By implication, the edge ends 10 millimeters

Figure 9-Edge Angle



After Doperé and Vermeersch (1978: 14).

from its point, as this is where they make their final angle calculation. I chose to define the edge on the basis of the characteristics of the celts, rather than use a standardized figure which remains constant regardless of an artifact's size or form. The technique used for the vast majority of the celts is illustrated in Figure 8. In a small number of instances, marked bevels were present on the artifacts, and in these cases they were used to define the cutting edge in place of the line extending between the two corners of the edge. Once the total depth of the edge had been determined, this figure was then divided by four to determine where the angles should be measured. For example, an artifact with an edge depth of 16 millimeters would have angles measured from points 4, 8, 12, and 16 millimeters from its cutting edge. The resultant angles would then be averaged to arrive at the final figure. Edge length, the four angle measurements, and the averaged edge angle for each celt are presented in Appendix III.

Morphological Attributes--Discrete

1. side waisting (when present)--Side waisting consists of indentations made on the sides of a celt by pecking. A number of measurements, listed below, were taken on the 17 celts which show this feature (Figure 10, Plates 1 and 2, Appendix VI).

   a. length of waisted area

   b. maximum depth of waisting

   c. distance of waisting from cutting edge

2. side roughening--Intentional roughening, in a restricted area, of the sides of the celts. Similar to wide-waisting, but the sides have not been indented. Recorded for presence or absence (See Plates 3 and 4).

Figure 10- Side Waisting

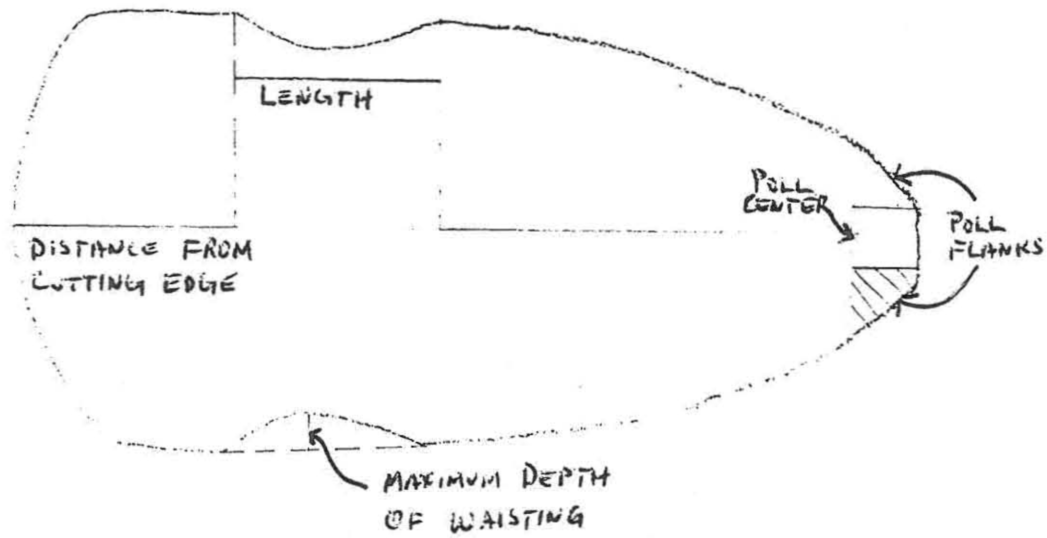
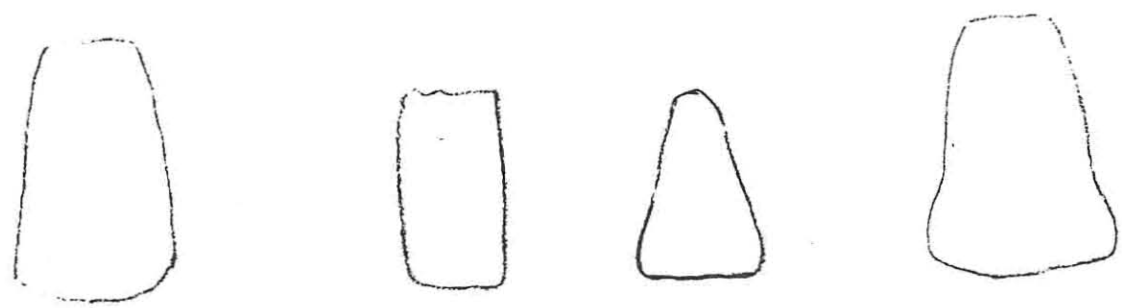
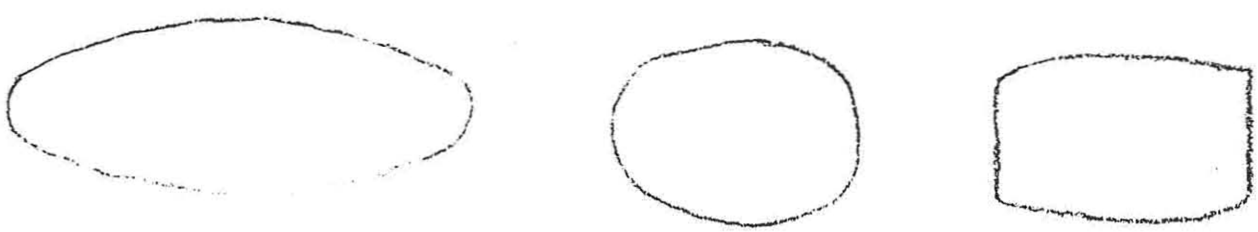


Figure 11-Vertical Profiles



trapazoidal rectangular triangular petaloid

Figure 12-Side Profiles



oval circular quadrangular

3. vertical profile--(see Figure 11). The profile terminology commonly applied in Mesoamerica and Lower Central America is used (Healy 1974: 452-3; Willey 1972: 130-133).

    a. petaloid
    b. triangular
    c. trapezoidal
    d. rectangular

4. side profiles--see Figure 12 and Appendix IV.

    a. oval
    b. circular
    c. quadrangular

5. poll form (when present)--see Figure 10 and Appendix V.

    a. pointed
    b. flat
    c. rounded
    d. ground down to form two intersecting planes
    e. irregular

6. poll texture--see Appendix V.

    a. completely roughened or pecked
    b. roughened or pecked on only one flank
    c. roughened or pecked on both flanks and not the center
    d. roughened or pecked only on the center
    e. completely smoothed and finished

7. symmetry or asymmetry of horizontal profile (Figure 8).

Microwear

When undertaking microwear analysis, the initial problem encountered is usually how to go about determining which tools in an assemblage have been utilized and, more specifically, what portions of their surfaces show evidence of use. This problem, though often troublesome when working with chipped stone artifacts, particularly unretouched specimens, has not been a difficult one to overcome in this study. All of the celts show evidence of utilization and in the overwhelming majority of cases, this can be identified with the naked eye. Keeley and Newcomer (1977: 37) list three criteria which they feel can be called upon to define whether or not an edge has been utilized: microwear polish, striations, and edge damage in the form of scars. All of the celts show at least two of these characteristics. The size (often greater than one or two milimeters) and distribution of the edge scarring, is an easily observable indicator of use. In addition, approximately two-thirds of the celts are not considered to be complete artifacts, the assumption being that they were broken during use. Odell has mentioned "edge rounding" as a possible indicator of use (1975: 229). This feature can be observed without the aid of a microscope on the celts.

As in all types of lithic analysis, microwear studies have traditionally focused on chipped, rather than ground stone tools. I have found that, in general, the techniques developed for the microscopic examination of chipped stone artifacts can be successfully applied to the study of ground stone. Other researchers, most notably Semenov (1964) and Ranere (1975), have also found this to be the case, but they caution, as do I, that ground stone does present certain unique problems. These questions are addressed in later sections of the report.

Each celt went through at least two, and usually three, stages of microwear analysis. During the first phase the artifacts were observed under the microscope and general descriptions of their characteristics were recorded. As I gained familiarity with the materials and the procedures involved in this type of study, it became apparent that a more systematic method for data recording was required and, to this end, a number of attributes thought to be significant were isolated (see below). The second round of microwear analysis proceeded with the goal of retrieving this information. Finally, a third examination was performed after a functional classification system had been formulated in order to check the accuracy of the first two observations.

The Olympus SZ111 Stereoscopic Zoom Microscope was used in the wear analysis. This microscope has a magnification range of 7X-40X, which can be increased to 80X with the addition of a 2X lens piece. All micro-photography was performed with an Olympus PM-6 35 mm. camera, using Kodak Panatomic-X film (ASA 32). Photographic information appears in Appendix VIII.

At the outset, microwear analysis concentrated on the observation of three basic attributes of wear: striations, scarring, and polishing. It should be mentioned that these three features are <u>not</u> the only characteristics of the celts which resulted from use, but, rather, are the only ones which must be observed with the aid of a microscope. Edge angle, edge thickness and various forms of damage found on the polls of the celts, all significant in functional interpretation, are observable with the naked eye.

1. Striations

Striations are shallow and narrow grooves produced on an artifact's surface by abrasion. They may result from steps taken during the manufacturing process, use, or from post-depositional factors.

In the recent literature on lithic analysis there has been much discussion of the value and practicality of observing these traces. Semenov (1964) and Keeley (1974) feel striations to be very valuable in functional analysis, while Tringham et al. (1974: 175) and Odell (1975: 229-231) have expressed reservations about the exclusive use of striations in interpreting use. It has been stated that striations are not always produced in the course of use and that the high magnifications needed to observe these traces makes their study difficult, if not impossible, using the common binocular microscope (Tringham et al. 1974: 175).

In the case of the Guanacaste celts, I have found striations to be readily observable under relatively low magnifications (10X-80X). Striations, resulting from both use wear and manufacture can be easily seen, though photography of these traces is very difficult due to the irregular nature of the micro-topography found on artifacts, such as these, which are mineralogically heterogeneous.

When using striations in microwear analysis it is of the utmost importance to be able to distinguish those produced during the manufacture of the artifact from those occurring as a result of use (Keely 1974: 126). The most desirable way of distinguishing between these two categories of microscopic features is through experimentation, but as experiments were not run as part of this study, for reasons discussed more fully below, I have had to rely on other forms of reasoning. On the basis of location and form, I feel confident that I can distinguish two types of striations found on the Guanacaste celts: one produced during the final stages of the manufacturing process and the other resulting from use. Long, thin, shallow striations occur over most surfaces of the celts and there is no doubt that they were produced by light grinding in the course of the final finishing of the artifacts (Plates 5 and 6). In contrast, short, deep striations, better described as elongated nicks, occur on the cutting edges of the celts, and these have been interpreted as use related (Plates 8-10). I am quite sure that the latter form of lineal feature did not result from a step taken during manufacture. The striations do not serve either to smooth or to sharpen the artifact but, rather, due to their large size and coarse nature, contribute to dulling the edge and roughening the surface. There does not appear, at least to me, to be any way of explaining their utility in the construction of an efficient and aesthetically satisfactory artifact, two goals which were clearly on the mind of the prehistoric Guanacaste stone worker.

The following information was recorded for those striations determined as having resulted from use:

A. density
    1. absent
    2. light
    3. dense

B. location
    1. bifacial
    2. unifacial
    3. most frequent on, or near, the corners
    4. most frequent on, or near, the central portion of the edge

C. orientation
    1. perpendicular to the edge
    2. diagonal to the edge
    3. other

2. Edge Scarring (Plates 7, 11, and 12)

Edge scarring has been defined as "the tiny chips removed from the edge of a stone tool under pressure" (Odell 1975: 229). In wear analysis of chipped lithic artifacts an enormous amount of attention has been paid to the observation of these features. Odell (1975: 231) and Tringham _et al_ (1974: 171) have found scarring to be a very sensitive indicator of function and have suggested a number of characteristics of this type of edge damage which can be isolated. When applying these concepts, developed for chipped stone analysis, to ground stone, the essential differences in the composition of the raw materials used for these two classes of artifacts must be kept in mind. Specifically, chipped stone tools are usually manufactured of lithic materials which are isotropic and relatively homogeneous. In contrast, the Guanacaste celts are mineralogically heterogeneous, a factor which affects the scarring patterns found on their edges. Regularities in the _shape_ of scars, among different artifacts, are as likely to occur as a result of similar mineral composition and grain size among the specimens as they are to be a product of similar mode of use. An artifact high in feldspars, for example, can be expected to flake differently from one with a dense concentration of quartz crystals. For this reason, I have chosen to focus attention on the location and distribution of the scars. I have found the statement made by Odell (1975: 231) on this subject particularly useful: "The important aspect of edge damage by scarring is not only in the frequency of this or that type of scar, but in the _pattern_ of these scars along an entire edge or used surface."

As with the striations, location of scarring was recorded for the celts. Special attention was paid to whether scarring occurred bifacially or unifacially, the relative size of the scars, and recognition of the most heavily scarred areas.

3. Polish

Polish, defined here as a smooth and light refractive finish, was the most difficult type of wear to record. As with the scarring, the problems encountered resulted, to a large extent, from the nature of the raw material. Quartz and some other minerals, such as pyroxene, are highly lustrous when abraded, an action used in the final finishing of the celts. Fine grinding of igneous rocks produces polish through the reduction of microtopography and flattening of the individual mineral crystals. For this reason, one cannot be content with merely noting the presence or absence of polish; most surfaces of the artifacts are polished to some degree. What is significant though, is the presence or absence of <u>differential</u> polishing. Whenever this feature was isolated, which was infrequently, its presence and distribution were noted.

VI. Discussion of Results: The Analysis of Form

As stated previously, one of the central goals of this analysis is to determine the relationship of form and function in the case of the Guanacaste celts. Originally, it was hoped that the results of the examination of form would allow for the construction of a traditional artifact typology based solely on the morphological and technological features of the celts, which could then be compared with the functional "types" which were isolated during microwear analysis. During the course of analysis, though, it became apparent that this would be a somewhat vacuous excercise. The reasons for this evaluation are based on considerations of the size and nature of the sample, as well as the belief that not enough ancillary data (particularly dating) are presently available to enable a meaningful system of rigidly structured, formal classification to be developed. Specifically, though a "complete" sample was analyzed, in the sense that all <u>recovered</u> artifacts have been examined, the relatively small total number of celts (86) makes it doubtful that there are enough artifacts to allow for a typology to be formulated. In addition, of the 86 celts, only 29 of the specimens are felt to be complete artifacts; the remaining 57 are viewed as fragments.

For a typology based on form to be useful it must have some concrete external referents from which it derives its meaning. Traditionally, this has meant that it serves to help define discrete units of time, space, peoples, ideas or functions. To test a typology's utility there must be enough data available so that judgements can be made as to just what the system is classifying. In the case of this study, it is felt that not enough of this type of information is available, due to the fact that most of the sites from which the celts come have not been analyzed in even the most cursory manner. As of this writing, relative dates are available for only 31 celts. Of the remainder, approximately 45 will probably <u>never</u> be given firm dates due to the fact that they were recovered during surface collection at multi-component sites or because they were excavated in mixed or disturbed contexts, such as plow zones. This paucity of temporal data, combined with the scattered geographical distribution of the celt collection (at eight of the sites only one celt was found) makes it very difficult, at this time, to begin actual typological analysis. Finally, and most importantly, I do not feel that the construction of a tightly defined artifact typology would necessarily provide a more efficient means for gauging the relationship of form and function than the system used here. For these reasons, more modest objectives, listed below, were adopted for the examination of the formal attributes of the celts.

1. To isolate certain formal attributes, or combinations of attributes, which will serve to generate working hypotheses regarding the function of the celts.

2. To examine the ground stone tool assemblage in light of current concepts, methodologies, and classificatory systems used in Lower Central American lithic studies.

3. To compare this assemblage of celts with those which have been described from other sites in the region.

4. To provide a detailed description of the celt assemblage so that other researchers studying Lower Central American prehistory can com-

pare their artifacts with those analyzed during the course of this project.

5. To address certain problems of technique, especially the measurement of edge angles, commonly encountered in lithic analysis.

As mentioned previously, little attention has, in the past, been paid to the prehistoric lithic artifacts from the Greater Nicoya area. The major site reports written over the last 12 years have done little to rectify the situation (Baudez 1967; Healy 1974; Lange 1971a; Sweeney 1975). Ceramic ordering and related problems of chronology have been the primary research subjects.

In the specific case of ground stone celts, only Healy (1974: 451-3) has made an attempt to integrate his material, though his efforts were hindered by the very small sample (9) of these artifacts found at his Rivas sites. These were classified through placement in one of three categories:

> Very Small Variety Celt (1) Only one example of this variety was found from Rivas. It measured 5.7 cm. long . . . The shape was slightly trapezoidal . . . Chisel-like celt (1) One thin, finely polished, chisel-like celt was recovered from Rivas. This had a diameter of 3 cm. and a width of 3.5 cm. . . Medium Variety Celt (7) There were seven Medium sized celts recovered. These ranged from 6-10 cm. in size. Shape is rectanguloid to petaloid . . . (Healy 1974: 452-453)

The system of classification is, according to Healy (1974: 453), based on the typology used by Willey (1972) to describe the celts from the Maya area. In his report on the Altar de Sacrificios excavations (1972: 130-133) Willey lists four celt varieties, based on maximum length, which he feels can be used for formal classification:

1. very small (less than 60 mm. in length) 2. small (65-83mm.)

3. medium (80-150mm.) 4. large (over 150mm.). The range of widths and thicknesses for each category are also provided, as are brief descriptions of some other formal characteristics.

At first glance, this seems a rather simplistic way of categorizing the celts, but maximum length does seem, at least for my celt assemblage, to be a quick and easy way of representing the artifact's overall size. In fact, any of the four basic measurements (length, width, thickness, width of cutting edge) can serve to indicate, in a general sense, the overall size of the artifact. To test this, I compared the measurements, one with the other, to see if they increased and decreased together. The results of this comparison are presented graphically in the scatter diagrams in the appendices. As can be seen in these graphs, there is a marked tendency for an increase in one dimension to be accompanied by a corresponding increase in the others. No graph is presented for "width of cutting edge" since this measurement was usually taken at the point of maximum width. This is because the overwhelming majority of the celts taper towards the poll, at least slightly, when viewed vertically.

The Pearson Product-Moment Correlation was used to test the strength of the relationship of these variables (Thomas 1976: 383-389). This test of association was judged to be superior to the more commonly used chi-square and Cramer's V procedures (Sackett 1966: 367), as it avoids the pitfall of arbitrarily dividing continuous variables into discrete categories (Doran and Hodson 1975: 170-172). With the Pearson Product-Moment Correlation the integrity of each measurement is preserved in the final calculation.

When calculating the correlation coefficients only complete artifacts were used. This was done to keep the degrees of freedom constant, as well as to insure maximum comparability of results. The means of the measurements for the 29 complete artifacts do not differ by more than one or two millimeters from the means computed for the whole assemblage. All results show strong correlation at the .001 confidence level for 27 degrees of freedom (Table 2).

Table 2--Pearson Product Moment Correlations for Basic Metric Data

	LENGTH	WIDTH	THICKNESS	WIDTH OF CUTTING EDGE
LENGTH	-	.81	.92	.86
WIDTH	-	-	.89	.99
THICKNESS	-	-	-	.88
WIDTH OF CUTTING EDGE	-	-	-	-

n=29 df=27

What this suggests is that length, thickness, and width tend to vary in a predictable manner--as one dimension increases, so do the others. The Willey (1972) typology, for all its simplicity, does seem to be adequate for describing at least the total size of a celt. A problem, though, is encountered when the boundaries of the categories are fixed. This is demonstrated graphically on two of the scatter diagrams in the appendices (length/width and lengh/thickness). On these two diagrams Willey's divisions (based on artifact length) are represented by thick, black lines. The boundaries of the categories appear to be arbitrary and it is clear that they do not define discrete clusters of measurements.

Like the Rivas celt collection, the Guanacaste assemblage is dominated by artifacts rectangular or trapezoidal in form when viewed vertically (Table 3).

TABLE 3 - Profile Counts

VERTICAL PROFILES

Rectangular	15 celts	(42%)	Oval	66 celts	(89%)
Trapezoidal	12	(33%)	Circular	5	(7%)
Triangular	7	(19%)	Oval with one flat face	3	(4%)
Irregular	2	(6%)			

What is particularly interesting, when considering vertical profiles, is the distribution, by size, of the triangular shaped celts--six of the seven smallest celts in the assemblage are triangular (see length/width scatter diagram). Given the sample size involved here, it would be presumptuous to emphasize this correspondence to any great extent, but it is suggestive of some type of formal selection criteria. In addition, it is important to note that none of the celts in this size range shows any evidence of either side waisting or side roughening (Plate 13). It is very possible that these small, triangular celts represent a grouping with some functional significance. This hypothesis was marked for future testing by microwear analysis.

The trapezoidal and rectangular profile groups are not necessarily as distinct as the division implies. Both forms are found in the total range of sizes and at this state of analysis, the value of distinguishing between these two forms is solely descriptive. The same generalization seems to hold true for the side profiles. The oval category includes much variation--flat ovals, ovals with nearly parallel sides, and the so-called "lenticular cross-section". Just as it is often superfluous to distinguish between a rectangle and a trapezoid, there is frequently little real difference between what are here termed oval and circular cross-sections. It is interesting to note that no celts with the characteristic "petaloid" vertical profile were found at any of the Guanacaste sites included in this study. I have seen the petaloid celts which Healy (1974: 452) mentions from Rivas, and they do appear to be quite different, in outline, from the Guanacaste artifacts.

A number of archaeologists studying formal variation in artifacts similar to the Guanacaste celts have found ratios of measurements to be particularly valuable for isolating discrete categories. Green and Dessaint (date unknown), for example, have classified Polynesian adzes on the basis of thickness/width ratios; concluding for their sample ". . . width and thickness do not increase proportionally to length, so that a short adze will be proportionally thicker and wider than a long one." (p. 7) Green and Dessaint employed two techniques to arrive at this conclusion:

> As the aim was to employ minimal statistical manipulation of these commonly recorded adze measurements to discover significant typological and structural facts, once the measurements had been taken, scatterplot graphs were constructed for each of the relations between length and shoulder index [ratio of thickness to width]. The latter allows us to represent three dimensions on a two-dimensional graph. Frequency correlation analysis was then performed by grouping measurements in ten millimeter blocks . . . (p. 5)

This is the same procedure which was followed with the Guanacaste celts, except that measurements were <u>not</u> grouped when the correlation coefficients were computed. The reasons for this have been discussed above. I used two different thickness/width ratios: one resulting from thickness and width measurements taken at the point where the cutting edge was said to begin for purposes of computing edge angles, and a second using the maximum thickness and width readings. Both of these ratios are compared with artifact length in scatter diagrams found in the appendices. The two ratios are termed "blade pudginess" and "T/W" respectively. Pearson Product Moment Correlations were computed to test for association between celt length and both of the ratios. The results are nearly identical: .43 for "blade pudginess" and length, .42 for "T/W" and length. Both of these figures hover around the cut-off point for correlation at the .01 confidence level and surpass it slightly at .05 (27 degrees of freedom). This was <u>not</u> considered to reflect a high correlation between the ratios and celt length, a condition also demonstrated in the scatter diagrams. The similarity between the two Pearson Product-Moment Correlation figures results from the fact that maximum artifact width usually occurs at the corners of the edge.

A considerable amount of effort was devoted to the refinement of the techniques involved in the measurement of edge angles. The main purpose for computing edge angles is to arrive at a figure which gives an indication of an artifact's taper and sharpness. While the figures for the Guanacaste celts most definitely reflect these attributes, in this specific case there appears to be a more economical way of obtaining this information. Edge thickness (Figure 8) which is quite variable (less than one-17 millimeters), seems to provide a servicable measurement. It should be kept in mind though that edge thickness does not reflect original manufacturing design, but rather, results from the intensity and manner of use. Here I am, of course, assuming that all the celts were sharp in the beginning of their life cycles. Edge angle and edge thickness were compared, as with the other metric attributes, through the use of the Pearson Product Moment Correlation. All celts with intact edges (65), not just complete artifacts, were studied in the attempt to get the best possible picture of the relationship between the two figures. The computed figure, .66 (63 degrees of freedom), indicates correlation between the two measurements at the .001 confidence level. For the purpose of formal analysis, there seems to be little value in comparing edge angles among celts whose edge thicknesses are significantly different. If a large sample of celts with relatively undamaged edges (less than one or two milimeters) were available, then the variability of this attribute, in its unaltered state, might be better addressed.

Aside from the correspondence of triangular vertical profiles with the smallest celt specimens, the most conspicuous formal attribute noticed was the presence of side waisting (18 celts) and side roughening (26 celts). Metric data for the side-waisted artifacts are presented in the appendices. Side roughening was recorded for presence or absence (Plate 1). These two characteristics are actually quite related; both result from pecking on the artifact's sides after the celt has already assumed its final form. A waisted celt is always roughened, but here there are visible (greater than .5 millimeters) indentations on the flanks of the artifact. There is a marked tendency for the larger celts to be side roughened and/or waisted (see scatter diagram for length/ width). Nine of the 11 longest celts show one or both of these features, while it is absent on all specimens shorter than 66 millimeters. They are both absent on all of the artifacts which would fall into Healy's (1972: 452) "very small" category.

Only four celts have asymmetrical horizontal profiles (numbers 23, 48, 52, and 80). None of these is a complete specimen, but a rough estimate of their assumed original dimensions indicates that artifacts 48, 52, and 80 fall in the small range, while number 23 is one of the largest artifacts represented. Side waisting and roughening are absent on all four. One other artifact (17) can also be considered anomolous, as it is the only "shouldered" celt (see Plate 14).

VII. Discussion of Results: The Analysis of Function

In the interpretation of the functions of the Guanacaste celts both macromorphological and microscopic characteristics of the celts were considered. The results of the examination of the large scale formal attributes were used to generate hypotheses regarding the prehistoric uses of the artifacts and these were then tested through microwear analysis. This procedure called for a broad range of features to be examined and allowed functional analysis to procede "by methods which would employ all categories of use traces, the location on the tool, the form of the tool, edge angles, and any other relevant index which might bring us closer to a realistic and multivariate appraisal" (Odell 1975: 230 following Tringham 1972: 46).

As mentioned previously, experiments were not performed in the course of the analysis of the celts. The unavailability of suitable raw materials contributed heavily to the decision not to incorporate experiments into the research procedure, as did considerations of the scope of this work. In my interpretation of function I have drawn heavily on published reports which describe, in detail, the results of experiments with lithic artifacts. These findings have been applied critically to the case of the Guanacaste celts. In addition, I have utilized Semenov's (1964) "kinematic" approach which involves determining "how the implement would have had to have been used to produce the various features of the microwear and utilization damage present" (Keeley and Newcomer 1977: 37). I am fully aware of the problem which the lack of an experimental component to this study presents. For this reason, functional interpretations are couched in cautious terms, though in most cases I feel them to be quite sound.

The first type of formal data considered were those which were felt to shed light on the manner, if any, in which the Guanacaste celts were hafted. Hafting, the way in which a tool is secured to a handle, may take a variety of forms. The type of haft used on a specific tool is a result of the following factors:

1. the activity or activities to be performed by the tool
2. the form and size of the handle to be secured
3. the form and size of the tool to be hafted
4. the types of material available to the person fitting the handle to the tool
5. the amount of force to be applied during work
6 individual eccentricity in the selection of style and materials.

A handle and haft are as essential to stone tools as they are to their modern metal counterparts. A modern axe blade, for example, is not considered the same tool when separated from its handle. When a craftsman visualizes his final product the requirements of prehension are integrated with considerations of function and style.

Reconstructing hafting techniques is made difficult by the fact that handles and hafts are rarely preserved archaeologically, as they are usually made of organic materials which are quick to decay under most conditions. Under unusual circumstances, such as the bogs of northern Europe, handles occasionally are preserved, providing unique insights into prehistoric tool use. Obviously, this advantage was not present in the case of the present study and I have had to rely, instead, on interpretations made from the detailed study of the characteristics of the celts, certain published ethnographic observations, and a number of mechanical principles.

The first functional class postulated for the Guanacaste celts, based on evidence of hafting, are axes. An axe is, by definition, a cutting tool whose handle is mounted perpendicular to the axis of the artifact or parallel to the cutting edge (Blackwood 1950: 13; Coughlin 1943: 29; Semenov 1964: 125). The strongest evidence for this manner of prehension in the Guanacaste celt assemblage is the presence of side-waisting (Figure 10, Plates 1-4), a feature which has been defined in a previous section of this report. I have interpreted these characteristic indentations, present on 18 celts, to be indicative of the hafting of these specimens as axes. Those celts with side-roughening (eight in addition to those with waisting) were also postulated to have functioned as axes. The assumption here is that these altered regions on the flanks of the celts served to increase the strength of the bond between blade and handle through the increase in friction caused by roughening and by providing a channel for the haft (in the case of side-waisting). This is similar to the function performed by the grooves on the "full-grooved" and "three-quarter grooved" axes found in many parts of the Americas (Ford 1969: 49). A few possible ways in which the handles could have been secured through the use of slots are illustrated in Figure 13. It is also quite possible that the hafts were made of leather thongs and were wrapped around the celt and tied to a wooden handle (Plate 15).

It should be noted that side-waisting and roughening are manufacturing steps which were taken _after_ the celts were more-or-less in a finished state. These attributes should not be confused with "incomplete grinding", such as that described by Semenov (1964: 69), which is merely a situation which results from leaving certain strategic areas of the artifact unfinished in order to increase the purchase of the bond between blade and handle. Side-waisting and, to a lesser extent, roughening, are reduction steps in the manufacture of ground stone tools, just as is retouch or fluting in the case of chipped stone.

The presence of side-waisting does not, in itself, completely eliminate the possibility of a celt functioning as something other than an axe, but the evidence strongly favors its use in this manner. As discussed below, the microwear traces found on the edges of these tools generally support this contention.

One final characteristic of the side-waisted and/or roughened celts which tends to indicate that steps were taken to increase the strength of a haft attached at right angles to the axis of the artifacts is the slight roughening, produced by light pecking, of the areas on the body of the celts lying midway between the modified regions of the sides. I have termed this feature, present on all but four of the side-waisted specimens, "body roughening". In three of the cases where body roughening is not observable it may have once been present, but the critical portions of the celts are now missing due to breakage during use. In the final instance it is definitely absent. On only one specimen which shows neither side-roughening nor waisting is body roughening present (artifact 38).

At first glance, the distance of the side-waisting from the edge of the celt appears to be so small (mean=30.7 millimeters) that the haft could possibly interfere with the cutting action of the tool if it were used, as postulated here, as an axe. Consideration of three points suggests that this would not necessarily be the case. First, the overwhelming majority of the celts have had their edges reduced in length

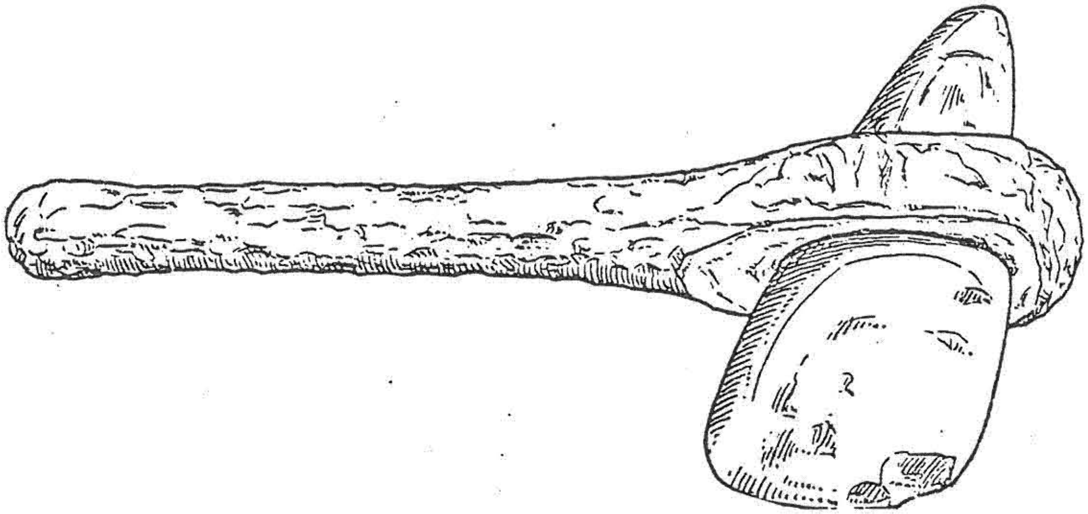
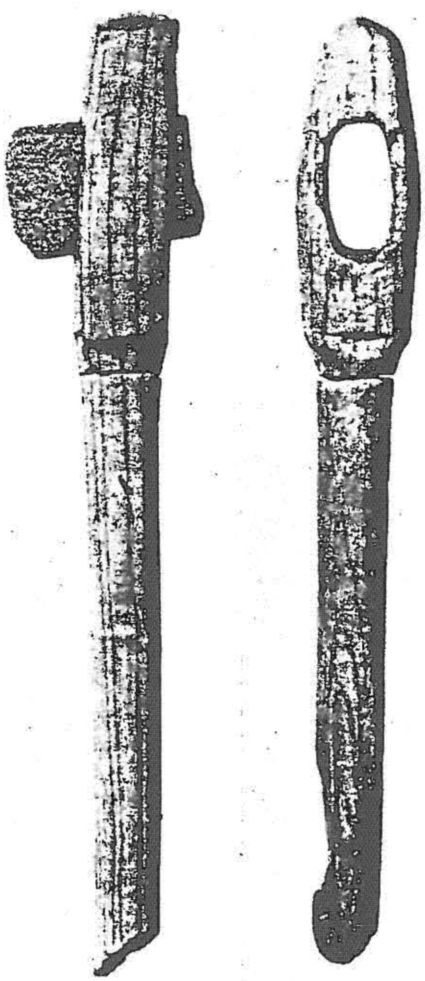


Figure 13a. "Slot" haft (from Coughlam 1943: 39)



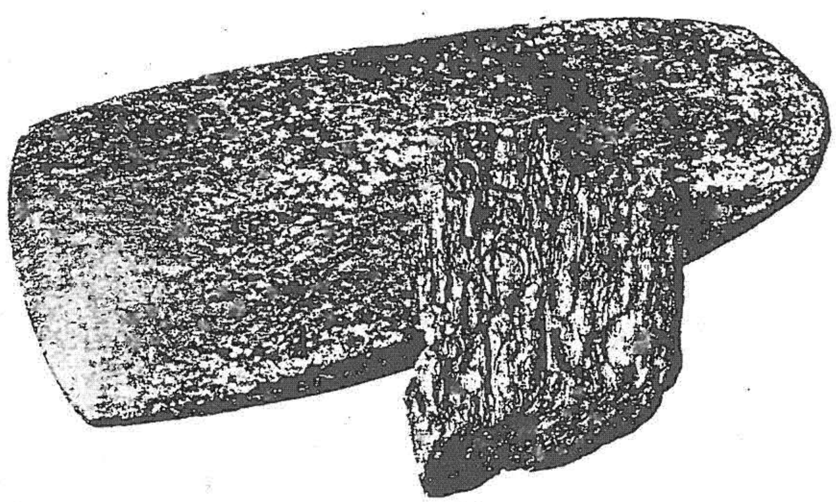


Figure 13c. Wooden haft (from Becker 1945:156)

Figure 13. Possible methods of hafting axes.

Figure 13b. Hafted celts (from Becker 1945: 157) through use, sometimes probably by as much as ten millimeters. This means that at one time the distance from the region where the haft was secured to the cutting edge was significantly greater. Secondly, it is quite possible that the waists are longer than the area actually covered by the haft, a factor which would also serve to increase the distance to the edge.

The third piece of information to be considered involves the manner in which stone axes are used, a subject dealt with in a number of experimental studies (see below). The main thrust of these arguments is that stone axes are not used in the same way as their modern, metal equivalents. While a metal axe is swung with great force, causing the blade to deeply embed itself in the wood, success with a stone axe is achieved by short blows designed to peel off small chips of wood (Semenov 1964: 129). Iverson (1956: 37-38) describes an experiment, performed by two of his colleagues, which was designed to test the efficacy of this method:

> After making a number of hafted axes fitted with Stone Age man's blades, the two archaeologists together with two professional lumberjacks, went forth into the forest in September, 1952. When the party attacked the trees, it soon became apparent that the usual tree-chopping technique, in which one puts his shoulders and weight into long, powerful blows, would not do. It often shattered the edge of the delicate flint blade in two. The lumberjacks, unable to change their habits, damaged several axes. The archaeologists soon discovered that the proper way to use the flint axe was to chip at the tree with short, quick strokes, using mainly the elbow and wrist.

The efficiency of the "short, quick stroke" using raw materials similar to the Guanacaste celts, has been demonstrated by Star (1976), who found diorite axe heads to be appropriate for felling trees of varying thicknesses. Pond (1930: 94) has noted similar findings using North

American materials. It would seem, then, that the Guanacaste celts were not unfit to be hafted as axes, but rather would have been well suited to this task.

The initial hypothesis that the side-waisted and roughened celts functioned as axes was tested with the microwear techniques outlined in a previous section of this report. The microwear attributes originally thought to characterize axes are the following:

1. Striations. The most important aspect of striations produced by chopping wood is that they occur on both faces of the artifact's edge (Keeley and Newcomer 1977: 46; Semenov 1964: 21). This results from the blade being embedded in the wood during use. Semenov feels that aside from being bifacial in distribution there is another significant characteristic of the striations found on the edge of axes:

> The axe in use has a very marked linear form of movement which is therefore very well defined by striations. Seen sideways the arc's trajectory is curved, but from the front it is straight. At the moment of striking an object its axis is not vertical but inclined to 50°-60°. Consequently its blade (parallel to the handle in an axe) is inclined at a similar angle to the striking surface. Striation traces on an axe therefore run diagonally and occur uniformly on both faces. (1964: 21)

Other researchers, most notably Keely and Newcomer (1977: 46), find that chopping produces striations oriented perpendicularly, not diagonally to the edge.

2. Edge scarring. There is agreement that chopping wood produces damage on both faces of the artifact's edge (Keller 1966: 503; Keeley and Newcomer 1977: 46). This results from the fact that during use pressure is applied to both edge faces. In addition to this feature, the location (corners or center of edge) of the damage was also noted during the course of microwear analysis.

3. Differential polish. Keeley and Newcomer (1977: 39) note a very distinctive type of polish which is produced by chopping wood with experimentally made tools of chipped black chalk flint. Their specific results are not applicable to this study, as the lithic materials used in the two cases are greatly different, but I did look for differential polishing (no exact type) on the surfaces of the celts. The location of polishing could conceivably have shed light on the depth of penetration of the blade.

As mentioned above, 26 of the Guanacaste celts were hypothesized to have functioned as axes prior to microwear analysis. Of these 26 artifacts, 13 are complete specimens. The size distribution of these celts, when plotted on a scatter diagram (see appendices), demonstrates that they dominate the upper size ranges. This tends to indicate their usefulness in relatively heavy tasks such as chopping wood. In general, the results of the microwear analysis support this contention, but certain reservations and problems warrant discussion.

The examination of striations, as discussed earlier in this report, is a complex procedure involving considerably more effort than merely looking for scratches on the edge of an artifact. With ground stone tools, such as the Guanacaste celts, striations are found on some portion of nearly every artifact, though their characteristics show a good deal of variation. The procedure used to distinguish striations produced by use from those resulting from steps taken during the manufacturing process has already been discussed. In the case of the celts postulated to have functioned as axes, striations can be observed on both faces of 24 of the 26 specimens. One celt is too highly weathered for these features to be observed (artifact 10), while on the final example (artifact 32) striations appear to be absent even though the surface of the artifact has not been substantially altered. This wear pattern conforms well to that which was originally posited for this group of artifacts (Keeley and Newcomer 1977: 46). The orientation of the striations however, does not show the diagonal pattern felt by Semenov to characterize axes (1964: 21). The majority of the celts in this group (18) have edges showing striations running both diagonal and perpendicular to the edge. Only three specimens have edges on which the overwhelming majority of striations are oriented diagonally. When all 26 celts are considered together the total amount of diagonal striations is only slightly greater than the number of perpendicular striations. Even though this finding conflicts with the expected pattern, I do not feel that it severely threatens the hypothesis that the side-waisted and/or roughened artifacts functioned as axes. Semenov (1964: 21) is unique in considering this feature to possess interpretative significance and common sense, as well as practical experience with axes suggests strongly that it is unwise to expect an axe to strike its target at the same angle every time it is swung. The bifacial nature of the striations, indicating that the blade of the celt has encountered resistance as a result of penetration, is a much more significant wear attribute. This, of course, assumes that the celts were not first used in a manner which would produce unifacially distributed wear traces and then reversed in their hafts.

The distribution of edge damage in the form of scarring also supports the hypothesis that the side roughened and/or waisted celts functioned as axes. On 24 of the 26 specimens in this category edge scarring is clearly bifacial (Table 4). The two remaining artifacts (32 and 37) have damage on both faces of their edge, but attrition is markedly heavier on one of their faces, thus suggesting that the edge was not always encountering equal resistance from the material being worked. It is possible that neither of the artifacts are axes, but rather, were used in a manner which would produce unequally distributed edge wear. On artifact 37 this might be the case, as it is a relatively light and slender specimen and its edge does not show the heavy attrition characteristic of the celts in the side-roughened category (it was not waisted). The final celt, though not a complete artifact (its end was removed for thin section analysis), does show the robust features of the celts in this formal category. For the moment, the unifacial nature of its edge damage remains problematical.

As may be seen in Table 4, no clear pattern emerges from the distribution of scarring along the cutting edges of the 26 celts in this category. The data presented in Table 4 reflect only the locations of the severest and most numerous forms of damage, as nearly all the celts show at least minor attrition on most portions of their edges.

STRIATIONS

Location		Orientation	
bifacial	24	diagonal and perpendicular	18
none clearly observable	1	majority diagonal	3
artifact too weathered to allow for observation	1	majority perpendicular	1
		irregular	2
		none clearly observable	1
		artifact too weathered to allow for observation	1
total	26	total	26

SCARRING

Location		Density	
bifacial	24	heaviest in center of edge	12
unifacial	0	heaviest on corners of edge	8
bifacial but markedly heavier on one face	2	evenly distributed	5
		fragment (cannot be determined)	1
total	26	total	26

Table 4. Summary of microwear data for side roughened and/or waisted celts.

Differential polish proved quite useless as an attribute for interpreting function. As discussed above, the examination of polish has been demonstrated to be significant in determining the use of certain types of chipped stone tools (Keeley and Newcomer 1977). This was not the case for the Guanacaste celts in the side roughened and/or waisted category. The most significant problem is that it is virtually impossible, at this point, to distinguish the polish created by the light abrasion used in the final stages of manufacture from that produced by use. Unlike striations and scars, which by their distribution tend to indicate that they resulted from use, the location of polish does not provide such information. In order to achieve a finely made and aesthetically pleasing final product, the manufacturers of the Guanacaste celts polished much of the artifact's surface to a high gloss. Nearly all of the celts in the side-waisted or roughened category are polished over their entire surface except for those areas intentionally roughened to aid in hafting, the poll, and the cutting edge. On all 26 artifacts the edge was less polished than the immediately adjoining regions, indicating that use destroys rather than creates polish. It is quite possible that tightly controlled laboratory experimentation may eventually help in distinguishing use from manufacture polish, but at this stage of analysis the issue stands unresolved. The degree of success achieved by Keeley and Newcomer (1977) with microwear polish in interpreting the function of chipped stone artifacts will probably never be duplicated with ground stone tools due to the differing techniques used in the manufacture of the two types of artifacts.

In conclusion, it appears that microwear analysis lends support to the original hypothesis of the side-roughened or waisted celts having functioned as axes in 23 of 26 cases. In the remaining three instances, one artifact (10) is too weathered for microwear to be observed. On artifact 32 no striations are clearly observable and edge scarring is markedly unifacial. Artifact 37, while showing the expected pattern of striations, also is characterized by the unifacial distribution of attrition.

The second category of celts which emerged from the anlaysis of form were those with asymmetrical horizontal profiles. These four celts were hypothesized to have functioned as adzes. An adze is differentiated from an axe on the basis of hafting technique, which in turn governs the manner in which the tool is used and, most importantly, the angle at which it strikes the material being worked (Figure 14). While an axe is hafted at right angles to the axis of the tool, the handle of an adze is attached transversely to the tool's axis (Coughlan 1943: 29). The essential factor when considering the "kinematics" of adze use is that the tool is generally swung in a manner which causes pressure to be applied <u>differentially</u> to the artifact's edge (Semenov 1964: 125). Simon Best (1978) has recently shown, through the performance of a number of "stress tests", that tools with asymmetrical horizontal profiles are ideal for use in this manner. He has also effectively demonstrated that tools with symmetrical cutting edges <u>cannot</u> be used as adzes, thus lending strong support to the argument that none of the artifacts in the Guanacaste celt assemblage, other than the four asymmetrical examples are discussed here, could have been used in this manner. The symmetrical cutting edge ("equal bevel"in Best's terms), when hafted as an adze and swung in an arc, will not efficiently penetrate the material being worked (Best 1978: 313) and is subjected to damaging stress. Best (1978: 332) concludes from his study of Maori materials that:

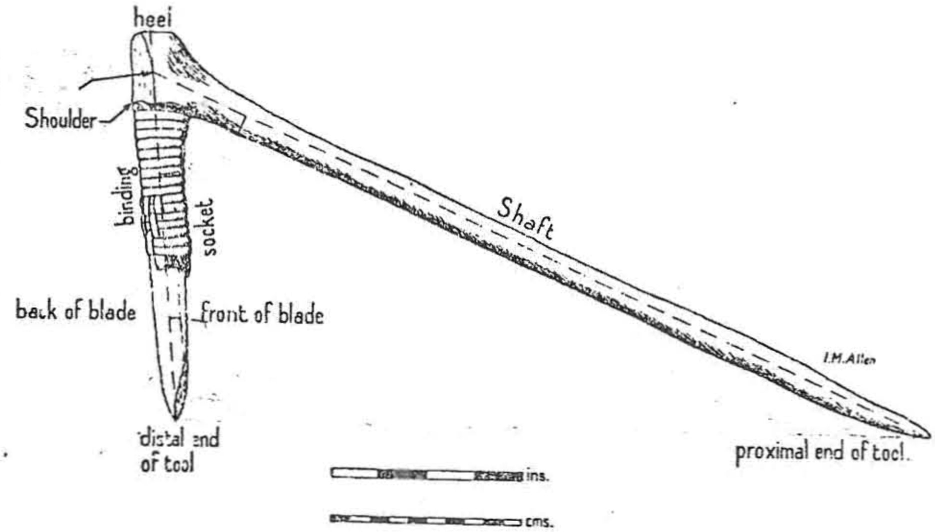


Figure 14. Hafted adze. From Blackwood (1950: 13).

> The equal bevel is useless as an adze. It was most likely used for splitting timber, or, possibly as a chisel and used as a tree-scarfing instrument.

Due to the differential pressure applied to the edge of an adze during use, a wear pattern in which the majority of traces are located on only one face of the edge is to be expected. Semenov (1964: 125) states that:

> . . . the wear traces on an adze are sharper on its front face away from the handle, precisely because this side encounters direct resistance from the worked material. In addition, the striations lie, not diagonally, but more or less parallel to the adze's axis.

Following Semenov, the celts postulated to have functioned as adzes on the basis of morphology, were examined for unifacially distributed and parallel striations. It was also hypothesized at the outset of microwear analysis that unifacial scarring and polishing should also be present, a result of the same differential distribution of pressure which causes striations to be located on only one face. As the number of celts thought to have been adzes is quite small, descriptions of each artifact and conclusions regarding their function are presented below:

Artifact 23

Form-Artifact 23 is one of the largest celts in the entire assemblage. One of its faces is concave when viewed "blade-on" while the other is convex. On the concave face there is an indentation extending for almost the entire length of the celt, but it is not straight nor is it centered. This leads to the conclusion that it did not serve to aid in hafting the tool. The poll has been removed for thin section analysis making it impossible to determine if this portion of the celt was altered to facilitate hafting.

Striations-Striations appear on both faces of the edge and in a variety of orientations. There is no clear consistency to the pattern.

Scarring-Scarring is bifacial but appears slightly heavier on the concave face, owing primarily to the presence of one very large scar (5 x 9 millimeters).

Polish-The edge is somewhat more highly polished than the remainder of the artifact. It is confined to the edge itself and does not extend on to the body of the celt.

Conclusion-There is little solid microwear evidence to suggest that this artifact functioned as an adze. It is quite possible that artifact 23 functioned as an axe, but the evidence is inconclusive at this point.

Artifact 48 (Plate 16)

Form-The two faces are markedly different: one being steeply beveled and the other gradually contoured. The steep face has a broad, regular groove extending from a point 21 millimeters from the edge of the celt and continuing for the remainder of its length (Plate 16). The interior of the groove has been roughened and it is quite reasonable to assume that this feature served to facilitate the hafting of the celt as an adze. The manner in which the celt was probably hafted is illustrated in Figure 15. This would make the countered face the "front face" in Semenov's (1964: 125) terms.

Striations-Striations are more frequent on the "front face", though some do appear on the opposite face. In addition to being more numerous, the striations on the "front face" are deeper and longer. Most striations approach ninety degrees (to the edge), but there is a fair amount of variation in orientation.

Scarring-Scarring is relatively light. While it appears on both faces, scarring is more frequent and severe on the steep face, indicating that the most intense pressure was absorbed by the "front face". This corresponds to the striation pattern observed on the edge of the artifact.

Polish-No areas of marked differential polishing are observable, but in general the distal end is smoother and more lustrous than the proximal end.

Conclusion-There is good evidence, both from the examination of form and the observation of microwear traces, that this celt functioned as an adze.

Figure 15. Hafted adzes (from Best 1978: 313)

Artifact 52

Form-One face is relatively flat while the other is convex. The poll has been broken off and there is no apparent evidence from which to interpret hafting technique.

Striations-Striations are relatively sparse and occur with comparable frequency on both faces. Most are oriented at angles approaching ninety degrees (to the edge).

Scarring-Scarring occurs bifacially and is realtively light. It is very slightly heavier on the convex face.

Conclusion-There is no solid microwear evidence to suggest that this celt functioned as an adze. The microwear traces are somewhat similar to those observed on the axes, but the small size of this celt argues against this functional interpretation.

Artifact 60 (Plate 17)

Form-The distal region on one face is convex, while the opposite face is concave or "shovel-shaped". There is a narrow region of slight roughening extending from the poll approximately 40 millimeters towards the celt's edge. This feature is not readily observable, but may reflect the same manner of hafting as suggested for artifact 48 (Figure 15).

Striations-Striations appear on both faces, but are slightly more numerous and deeper on the concave face.

Scarring-Scarring is bifacial, but much more numerous and severe on the concave face. On this face the central portions of the area immediately adjoining the cutting edge have been severely altered (Plate 17).

Polish-The edge is, in general, more highly polished than the remainder of the artifact, though the areas where scarring has occurred are rougher.

Conclusion-The marked difference in attrition between the two faces tends to indicate that the celt was used as an adze, though the evidence is not as clear as it is for the artifact 48.

Microwear analysis lends support to the hypothesis that the celts with asymmetrical horizontal profiles functioned as adzes in two of four cases. The functions of the remaining two specimens are, for the moment, unclear. It is of course quite likely that they too were adzes, but that the microwear techniques employed in this study are not exact enough to detect subtle differences in the distribution of wear traces between the two edge faces.

Small celts with triangular vertical profiles comprise a very discrete formal grouping (Plate 13). Of the seven smallest complete celts in the collection, six have triangular vertical profiles. These artifacts are also distinctive due to the sharpness of their cutting edges: only artifact 50 has an edge which is at all dull. In addition, there is only a ten degree range (72°-82°) in the edge angles of the six artifacts (Appendix 111). The celts in this category were hypothesized to have functioned as some kind of light, intermediate tools, such as chisels. I have defined intermediate tools as those artifacts which, during the course of use, are held in the hand and have pressure applied to their proximal ends with a second tool. The pristine nature of the edges indicates that the manner in which these artifacts were used did not involve the application of heavy force (artifact 50 is an exception). On five of the six triangular celts the polls have been slightly pecked or roughened, indicating that the proximal ends of these artifacts were receiving light percussion blows. Artifact 8 shows little of this type of damage on its poll and, in fact, exhibits only slight evidence of use. Finally, none of the celts shows any features which would lead one to believe that it had been hafted, a factor which lends further support to the contention that they served as intermediate tools.

The results of microwear analysis do not contradict the original hypothesis, though I do not have as much confidence in these findings as

I do for the axes and the adzes, with little experimental evidence to draw on. The observed wear traces were very similar on all five triangular celts with sharp edges. Artifact 50 is unique, as to be expected given the thickness of its edge (six millimeters). Light striations are observable on both faces of all five of the sharp celts. They are distributed across the entire edge, but are usually denser near the corners on all five specimens. If these celts did function as light intermediate tools it is very likely that they were used in a manner which caused their corners to receive the full effect of applied force. As with the axes and adzes, little information can be extracted from the examination of differential polish. One artifact (46) does have a bevel which is very highly polished in comparison to its proximal regions, but it is a result of steps taken during the manufacturing process, as evidenced by the very light striations (attributed to manufacture) which can be observed running perpendicular to the axis of the tool.

As mentioned above, artifact 50 is anomalous as it has a very thick edge. It also differs from the other small celts in that its poll has been ground down to form two intersecting planes. Additionally, it is quite clear that the edge of this artifact was, at least during the last stages of its life-cycle, used for some type of grinding or abrasion. On the edge itself, long striations can be observed running parallel to the edge, indicating the direction in which the artifact was used. It is quite likely that artifact 50 was used as a chiseling or cutting tool prior to its use as a grinder or abrader. Re-use such as this is not uncommon in the Guanacaste celt assemblage, but it is relatively rare on the very small artifacts (see below).

Regardless of whether or not the small, triangular celts functioned as intermediate tools, as is hypothesized here, it is quite evident that they do form a group in which there is a high congruence between general form and function (as represented by microwear traces). They are clearly differentiated from the other celts in the assemblage on the basis of size, vertical profile, sharpness of edge, and lightness of microwear traces. It is likely that the Guanacaste craftsmen had certain uses in mind when they set out to manufacture a celt, and the form which the artifact eventually assumed was designed to meet specific functional imperatives.

After microwear analysis had been completed for the three formal categories discussed above (side roughened and/or waisted; asymmetrical horizontal profiles; and small, triangular), there were a large number of celts remaining in the assemblage which did not readily lend themselves to classification based on morphological criteria. These celts were examined individually using the same techniques that were employed for the other artifacts and interpretations as to their functions were made whenever possible.

Axes-artifacts 7, 16, 20, 21, 22, 26, 36, 68, 84, and 88.

These ten artifacts all showed the microwear features, discussed earlier in this chapter, thought to be diagnostic of celts used as axes. I was unable to locate any clear-cut evidence for hafting on any of these celts. Only three are complete specimens, the remainder being fragments, but all are at least one-half their estimated original size. All fall into the size range of the side roughened and/or waisted group.

Percussors (Plates 18 and 19). Artifacts 14, 47, 54, and 82.

Evidence for use as percussors is found on a number of celts. I do not consider percussion to be a "primary" function of the celts, but rather view it as the re-use of tools which originally served as axes, adzes, or intermediate tools. There does not seem to be any reason why a stoneworker would take the trouble to produce a complete and highly polished celt in order for it to be used for rough tasks such as percussion and grinding. They were clearly designed to be used, at least originally, as cutting tools. After the celts lost their utility in the performance of these tasks as a result of breakage or prolonged wear, they were frequently used for other purposes. Scarring and pitting characterize re-use as percussors. These two types of traces show great variability in size, density, and location (Plates 18 and 19 illustrate some of the severest forms). Pecking of ground stone tools, chipping of flaked artifacts, and opening of mollusc shells are all possible functions for the percussors. In addition to the four celts listed above, it is likely that a number of other artifacts were used occasionally for tasks requiring percussion but their wear patterns are not distinctive enough to allow them to firmly classify as percussors.

<u>Grinders</u> (Plate 20). Artifacts 45 and 67.

Only two artifacts are listed here as definitely having served as grinders. As with percussion, grinding is not considered a "primary" function, but rather an example of re-use. Evidence of this function consists of the grinding down of protuberances on the celts which causes the original form of the artifact to be altered. It is interesting to compare artifact 45 (Plate 20) with artifact 82 (Plate 18). Though the two artifacts are not identical in size, their forms are very similar. Both artifacts have been re-used, but artifact 82 shows evidence of percussion while artifact 45 has clearly been used as a grinder.

A large number of celts (26) analyzed as part of this study are too fragmentary to allow for the interpretation of their functions. Of these, 12 are polls and data on their form and wear are presented in Appendix V. Two of the fragments are pieces of celt mid-sections. The final 12 are blades, but as very little of the other portions of the artifacts remains, I have chosen not to include the blades in the function counts (Appendix VII), though they do provide an interesting insight into discard behavior. All but two of these small blade fragments have very sharp edges (Plates 21 and 22) and wear in the form of striations and scarring is perceptibly lighter than on the other celts. This indicates that when a celt broke into a fragment which was too small to be re-hafted or held in the hand it was disposed of outright. In contrast, the larger fragments were used until their edges were so heavily damaged that they were no longer functional (Plate 3). At this point, re-use in the form of grinding and/or percussion sometimes occurred.

In conclusion, it can be said that five different functions have up to now been isolated for the Guanacaste celts in this assemblage: axes, adzes, intermediate tools, percussors, and grinders. For the first three classes there appears to be a strong correlation between form and function. Axes are large and quite often have their sides reduced. Adzes are smaller and are distinctive because of their charactistic asymmetrical horizontal profiles. Intermediate tools are very small, have triangular vertical profiles, and are usually roughened on their polls. A word of caution is in order here. A level of sophistication and accuracy has not yet been reached where one can pick up a celt in the field and, after taking a quick glance at its form, issue a firm pronouncement regarding its use in prehistoric times. Though I am confident in the modest interpretations offered in the preceding pages, I still feel the results need further testing through experimentation. The one exception may be the side-waisted and roughened celts, which appear certainly to have been axes.

Finally, I would suggest that there are two functions commonly attributed to ground stone artifacts, such as the Guanacast celts, for which there is no evidence in this assemblage. The wear patterns produced by hoeing have been intensively investigated by Sonnenfeld (1962), who found "scour-grooving", located both on the edge faces and the sides of the artifact, to be characteristic of this activity. These "scour grooves" continue for more than "one or two inches from the edge" and are readily visible on ground stone tools which have been used for tilling the soil (Sonnenfeld 1962: 61). This wear pattern was absent on all 86 of the celts from Guanacaste.

Secondly, it also appears that the celts were not used as wedges. Though the battered nature of many of the polls would, at first inspection, suggest this as a possible function, the absence of microwear features in the form of either differential polishing or striations, further than three or four millimeters from the edge, indicates that the celts were not used in this manner. Ranere (1975: 187) has, through experimentation, documented the fact that wedges will ordinarily show wear traces "in an area extending from the bit back two-thirds or three-fourths of the length of the tool". This type of wear is absent on all of the celts included in this study. Also, the continuous appearance of light striations (Plates 5 and 6) resulting from manufacture indicates that deep penetration has never occurred. If deep penetration had, in fact, been present these light striations would have probably been erased, or at least altered.

VIII. Conclusions.

All of the findings of this study have been discussed in the preceding pages of this report, but a reiteration of some major points may serve to clarify a number of the earlier statements. First, and most important, it has been shown that the celts, as a class, had at least five separate functions and that the form of a particular artifact is often an indicator of its use in prehistoric times (Appendix VII). Clearly, considerations of function, as well as style, were taken into account by the Guanacaste stoneworker before he set about manufacturing a ground stone artifact. The category "celt", it would seem, is a term, albeit a convenient one, which describes a general class of artifacts on the basis of form but which has little functional significance. It is quite possible that the only mental connection made by the manufacturers of these tools between the small, triangular celts and the large axes, for example, was that they entailed the use of similar raw materials and some of the same production procedures. For this reason, I have suggested that the term "celt" should be stripped of all functional connotations and that systematic examination of the characteristics of these tools should be undertaken before patterns of useage can be understood. This study is, hopefully, a step in this direction.

The problem of the celts' place, if any, in agricultural activities remains unresolved. Possibly the large axes were used for clearing swidden plots, as Linares (1977: 309) and Sweeney (1975: 55) have suggested, but they could have also been used for a large number of other tasks requiring felled timber. At the Vidor site, in particular, there is evidence for wood construction and the use of large amounts of wood for fuel in the firing of ceramics (Abel 1978). There is also no evidence to suggest that the celts were used for hoeing, breaking ground, or any other activity commonly associated with plant domestication.

It is of the utmost importance that archaeologists in lower Central America begin to take a closer look at the lithic assemblages from their sites. In tropical areas preservation is generally quite poor and even at the Vidor site, where bone may survive in reasonably good condition after 500-2000 years, vegetal materials are rarely encountered (Lange and Carty 1975). At many sites, generations of intense huaquero activity have destroyed much contextual information. For these reasons it is essential that we take advantage of the potential information which lithic analysis can provide.

The results of this study should not be considered the last word on stone celts from Guanacaste, Costa Rica. The analysis of ground stone is nowhere near as advanced as it is for chipped stone. Very few studies of these materials have been published and, to my knowledge, this is the first time that large-scale examination of their microwear traces has been attempted in Central America. If nothing else, I hope that this report provides an impetus for more detailed description of lithic artifacts so that those archaeologists who are interested in this field of enquiry will have, at the very least, some comparative data at their disposal. The appendices to this report are an example of what I consider to be the minimal amount of data necessary to describe an assemblage of ground stone celts.

APPENDIX 1. Provenience data.

ARTIFACT*	SITE	UNIT	LEVEL	TIME PERIOD**
1	3047I-1	Mound B S2-NO/O-W2	level 1	MP or LP
2	3047I-1	N51.5/W19-20	0-30cm.	EP or MP
3	3047I-1	N51.5/W17-18	0-30cm.	LP
4	3047I-1	N56.5-57.5/W5-6	60-80cm.	undetermined
5	3047I-1	N56.5-57.5/W17-18	20-40cm.	MP
7	3047I-1	N48.5/W12-13	30-40cm.	EP or MP
8	3047I-1	N44.5-45.5/W8-9	0-20cm.	undetermined
9	3047I-1	N52.5-53.5/W7-8	0-20cm.	LP
10	3047I-1	N90.5/W2	0-15cm.	undetermined
11	3047I-1	N51.5/W12-13	60-80cm.	EP
12	3047I-1	N56.6-57.5/W7-8	40-60cm.	undetermined
13	Sapoa-26	N28/EO	0-50cm.	lp
14	3047I-1	N51.5/W15-16	20-40cm.	undetermined
15	3047I-1	N44.5-45.5/W5-6	30-50cm.	EP
16	3047I-1	N59.5/W15-16	60-80cm.	MP
17	3047I-1	N48.5/W10-11	20-40cm.	MP or LP
18	3047I-1	N44.5-45.5/W8-9	40-50cm.	MP or LP
20	3047I-28	S70/E100	surface	MP or LP
21	3047I-1	N46.5-47.5/W8-9	60-70cm.	undetermined
22	3047I-1	Mound B S14-15/E3-4	plow zone	undetermined
23	unknown	--	--	--
24	3047I-1	N58.5-59.5/W5-6	40-60cm.	MP
25	3047I-28	E80-88/S75	surface	MP or LP
26	3047I-1	surface collection	surface	undetermined
27	3047I-2	surface collection	surface	MP
28	Sapoa-65	surface collection	surface	MP or LP
29	3047I-1	Mound 1	surface	undetermined
30	3047I-28	N16/E190	surface	MP or LP
31	Sapoa-26	N17/E2	20-35cm.	LP
32	3047I-1	surface collection	surface	undetermined
33	3047I-1	N54.5-55.5/W11-12	20-40cm.	MP
34	3047I-1	N46.5-47.5/W8-9	0-20cm.	MP
35	3047I-1	N54.5-55.5	40-60cm.	EP
36	Sapoa-26	N14-14/EO	20-30cm.	LP
37	3047I-1	N54.5-55.5/W7-8	20-40cm.	MP or LP
38	3047I-1	Mound 1	surface	undetermined
39	Sapoa-26	S11/EO	0-15cm.	MP or LP
41	3047I-1	N60.5-61.5/W9-10	60-80cm.	MP
42	3047I-1	N40.5-41.5/W12-13	0-20cm.	MP or LP
43	3047I-1	surface collection	surface	undetermined
44	3047I-1	N47.5-48.5/W19-20	0-20cm.	undetermined
45	Sapoa-26	N14-15/EO	22-40cm.	LP
46	3047I-1	Mound 1	surface	undetermined
47	3047I-1	Mound 1	surface	undetermined
48	3047I-1	N60.5-61.5/W19-20	20-40cm.	undetermined
49	3047I-7	surface collection	surface	ZB or EP
50	3047I-1	N44.5/W11-12	0-20cm.	MP

APPENDIX 1. Provenience data (continued).

ARTIFACT*	SITE	UNIT	LEVEL	TIME PERIOD**
51	Sapoa-26	N16-17/E0-W1	60-75cm.	LP
52	3047I-1	N42.5-43.5/W15-16	20-30cm.	EP or LP
53	3047I-1	N52.5-53.5/W7-8	20-40cm.	MP
54	3047I-1	N44.5-55.5/W7	20-40cm.	undetermined
55	3047I-1	surface collection	surface	undetermined
56	3047I-1	N45.5/W12-13	0-20cm.	undetermined
57	3047I-1	N59.5/W15-16	level 1	MP
58	3047I-1	N48.5/W12-13	0-20cm.	LP
59	3047I-1	N50.5-51.5/W5-6	20-40cm.	MP
60	3047I-1	N44.5/W11-12	0-20cm.	undetermined
61	3047I-1	N44.5-55.5/W10-11	20-40cm.	LP
62	3047I-1	N52.5-53.5/W16-17	40-60cm.	MP
63	3047I-1	N48.5/W10-11	0-20cm.	undetermined
64	3047I-1	N45.5/W12-13	0-20cm.	EP or MP
65	3047I-1	N4/04	80-100cm.	EP
66	3047I-1	N90.5/02	0-15cm.	undetermined
67	3047I-1	N56.5-57.5/W20	20-40cm.	undetermined
68	3047I-1	N59.5/W11-12	36-50cm.	MP
69	3047I-1	N46.5-47.5/W17-18	60-80cm.	undetermined
70	3047I-1	N5/05	40-50cm.	EP
71	3047I-1	N52.5-53.5/W5-6	20-40cm.	LP
72	3047I-1	Quad 4	surface	MP or LP
74	Sapoa-62	surface collection	surface	LP
75	3047I-1	N48.5-49.5/W33-34	surface	undetermined
76	3047I-1	N3/02	10-20cm.	MP or LP
77	3047I-1	N3/W5	50-60cm.	EP
78	3047I-28	S20/W5	surface	MP or LP
79	3047I-28	S20/W5	surface	MP or LP
80	44018	surface collection	surface	MP or LP
81	3047I-1	Mound A N10-11/E3-5	level 1	MP or LP
82	3047I-28	S14/E135	surface	MP or LP
83	3047I-3	S36/E9	disturbed	LP
84	3047I-28	S30/E60	surface	MP or LP
85	44020	surface collection	surface	undetermined
86	3047I-1	N49.5-50.5/W14	20-40cm.	undetermined
87	3047I-1	N52.5-53.5/W14-15	50-60cm.	undetermined
88	unknown	--	--	--
89	3047I-1	N54.5-55.5/W17-18	0-20cm.	undetermined
90	3047I-1	N44.5-45.5/W8-9	20-40cm.	undetermined

* No artifacts are numbered 6, 19, 40, or 73

** ZB-Zoned Bichrome, EP-Early Polychrome, MP-Middle Polychrome
LP-Late Polychrome

APPENDIX II. Basic metric attributes.

Abbreviations for location of measurement:

AE - across the artifact's edge
P - at the artifact's proximal end
B - at a point on the artifact's body between AE and P

All measurements in millimeters. For edge thickness "LP" means less than.

ARTIFACT	MAX. LENGTH	MAX. WIDTH (LOCATION)	MAX. THICKNESS (LOCATION)	EDGE WIDTH	EDGE THICKNESS
1	-	43(AE)	25(B)	43	LT 1
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	-
5	114	68(AE)	39(B)	68	4
7	83	46(B)	29(B)	43	LT 1
8	55	22(B)	13(B)	21	LT 1
9	92	50(AE)	31(B)	50	3
10	-	-	-	59	6
11	-	67(AD)	-	67	2
12	-	60(B)	-	59	LT 1
13	84	68(AE)	36(P)	68	7
14	-	-	-	48	LT 1
15	-	-	-	-	-
16	85	55(B)	24(P)	51	3
17	126	77(AE)	51(B)	77	10
18	-	54(AE)	-	54	LT 1
20	-	-	-	45	2
21	-	47(AE)	-	47	5
22	-	51(AE)	27(B)	51	1
23	-	78(AE)	40(B)	78	LT 1
24	103	67(AE)	44(P)	67	11
25	92	69(AE)	30(P)	69	17
26	-	-	-	-	LT 1
27	-	50(AE)	29(B)	50	LT 1
28	98	77(B)	42(P)	75	6
29	-	58(AE)	-	58	13
30	103	63(B)	42(P)	60	10
31	-	65(AE)	-	65	6
32	-	68(AE)	-	68	5
33	-	-	-	-	-
34	-	54(AE)	-	54	9
35	93	55(AE)	36(P)	55	1
36	-	-	-	50	4
37	-	54(AE)	-	54	2
38	-	50(AE)	-	50	2
39	85	66(B)	32(P)	61	3
41	-	-	-	-	-
42	-	-	-	40	LT 1
43	-	-	-	59	9
44	-	-	-	-	LT 1
45	-	-	-	-	-
46	58	41(AE)	22(B)	41	LT 1
47	86	48(AE)	26(B)	48	LT 1
48	-	-	-	36	LT 1
49	-	35(AE)	28(B)	35	LT 1

APPENDIX II. Basic metric attributes (continued)

ARTIFACT	MAX. LENGTH	MAX. WIDTH (LOCATION)	MAX. THICKNESS (LOCATION)	EDGE WIDTH	EDGE THICKNESS
50	64	34(AE)	21(B)	34	6
51	-	-	-	59	LT 1
52	-	32(B)	16(B)	27	LT 1
53	51	31(AE)	16(B)	31	LT 1
54	-	-	-	-	-
55	-	57(AE)	-	57	6
56	97	57(AE)	30(B)	57	5
57	-	-	-	67	3
58	-	-	-	-	-
59	82	50(AE)	33(P)	50	16
60	79	40(AE)	22(B)	40	1
61	-	-	-	54	LT 1
62	-	-	-	39	-
63	66	41(AE)	19(B)	41	LT 1
64	-	-	-	-	-
65	-	-	-	-	-
66	-	-	-	-	-
67	70	44(AE)	28(B)	44	9
68	-	-	-	64	LT 1
69	67	46(AE)	20(P)	46	2
70	52	35(B)	23(B)	32	3
71	81	40(AE)	25(B)	40	7
72	-	-	-	49	LT 1
74	-	-	-	55	LT 1
75	78	49(AE)	26(B)	49	1
76	-	-	-	-	-
77	-	44(AE)	-	44	LT 1
78	75	-	-	-	-
79	111	-	-	-	-
80	103	41(AE)	28(B)	38	4
81	-	48(AE)	-	48	7
82	-	-	-	-	-
83	-	-	-	-	-
84	-	52(AE)	29(B)	52	3
85	-	-	-	-	-
86	59	39(AE)	23(B)	39	LT 1
87	-	-	-	-	LT 1
88	88	58(B)	37(B)	54	6
89	-	45(AE)	26(B)	45	-
90	-	63(AE)	39(P)	63	8
RANGE	75	56	38	57	16.5
MEAN	83.3	52.1	28.8	51.4	3.7 **
S.D.	18.9	12.8	8.3	12.2	4.0 **

* No artifacts are numbered 6, 19, 40, or 73

** .5 used in calculations for those artifacts with edge thicknesses less than 1mm.

APPENDIX III. Edge angle measurements.

c-corners of edge used to define edge. b-bevel used to define edge.

	DEPTH OF	ANGLES IN DEGREES				
*ARTIFACT	CUTTING EDGE	1	2	3	4	EDGE ANGLE**
1 b	18mm.	91	81	72	64	77
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5 c	31	100	86	74	68	82
7 c	16	95	88	80	74	84
8 c	6	94	85	79	68	82
9 c	16	102	91	80	72	86
10 c	20	92	75	70	67	76
11 c	20	92	81	75	66	79
12 c	25	91	76	66	61	74
13 c	21	117	93	75	66	88
14 c	18	92	86	75	68	80
15	-	-	-	-	-	-
16 c	12	92	83	72	65	78
17 c	20	121	97	85	75	95
18 c	22	95	67	60	51	68
20 c	15	95	91	85	75	87
21 c	12	101	92	88	80	90
22 c	20	91	75	68	61	74
23 b	30	80	70	62	59	68
24 c	26	104	86	75	68	83
25 c	16	126	103	88	77	99
26 c	20	80	75	69	63	72
27 c	14	65	61	58	53	59
28 c	28	96	80	64	60	75
29 c	19	111	94	76	66	87
30 c	23	107	91	75	65	85
31 c	20	95	84	73	65	79
32 c	18	104	92	82	75	88
33	-	-	-	-	-	-
34 c	15	110	93	83	77	91
35 c	21	91	75	69	63	75
36 c	12	92	77	70	66	76
37 c	25	74	61	52	46	58
38 b	17	92	75	68	62	74
39 c	20	81	72	66	61	70
41	-	-	-	-	-	-
42 b	14	82	76	72	67	74
43 c	22	104	90	75	67	84
44	-	-	-	-	-	-
45	-	-	-	-	-	-
46 b	14	84	77	71	67	75
47	-	-	-	-	-	-
48 c	14	95	86	74	67	81
49 b	17	90	77	71	67	76
50 b	18	96	81	70	61	77
51 c	26	92	77	67	58	74
52 b	18	65	61	50	44	55

APPENDIX III. Edge angle measurements (continued).

*ARTIFACT	DEPTH OF CUTTING EDGE	ANGLES IN DEGREES 1	2	3	4	EDGE ANGLE**
53 b	12	89	77	69	65	75
54	-	-	-	-	-	-
55 c	24	92	80	70	63	76
56 c	23	97	75	64	56	73
57 c	20	94	86	76	70	82
58	-	-	-	-	-	-
59 c	21	121	94	76	67	90
60 b	21	70	65	56	50	60
61 c	20	75	61	55	51	61
62	-	-	-	-	-	-
63 b	12	88	81	75	70	79
64	-	-	-	-	-	-
65	-	-	-	-	-	-
66	-	-	-	-	-	-
67 c	12	112	101	93	84	98
68 c	21	82	72	66	62	71
69 c	19	85	73	56	52	67
70 b	9	100	91	82	75	87
71 c	12	100	85	71	66	81
72 b	15	95	85	73	66	80
74 c	25	82	65	56	50	63
75 c	14	85	75	70	67	74
76	-	-	-	-	-	-
77 b	32	83	72	62	55	68
78	-	-	-	-	-	-
79	-	-	-	-	-	-
80 b	17	102	86	77	66	83
81 c	19	100	89	80	72	85
82	-	-	-	-	-	-
83 c	26	90	75	67	60	73
84 c	16	107	92	75	67	85
85	-	-	-	-	-	-
86 b	17	85	74	66	61	72
87 b	15	91	81	70	61	76
88 c	20	101	81	72	66	80
89	-	-	-	-	-	-
90 c	19	109	94	77	71	88

* No artifacts are numbered 6, 19, 40, or 73.

** Edge Angle = $\frac{\text{ANGLE 1 + ANGLE 2 + ANGLE 3 + ANGLE 4}}{4}$

APPENDIX IV. Vertical and side profiles.

ARTIFACT	VERTICAL	SIDE
1	-	oval
2	-	oval
3	-	-
4	-	*
5	trapezoidal	oval
7	trapezoidal	oval
8	triangular	oval
9	trapezoidal	oval
10	-	oval
11	-	oval
12	-	oval
13	rectangular	oval
14	-	oval
15	-	oval
16	-	oval
17	irregular	oval
18	-	oval
20	rectangular	circular
21	-	oval
22	trapezoidal	oval
23	trapezoidal	oval
24	rectangular	oval
25	rectangular	oval
26	-	oval
27	trapezoidal	oval
28	rectangular	oval
29	-	oval
30	rectangular	oval
31	rectangular	oval
32	-	oval
33	-	-
34	-	oval
35	rectangular	oval
36	-	oval
37	rectangular	oval
38	-	oval
39	rectangular	oval
41	-	oval
42	-	oval
43	-	oval
44	-	circular
45	-	circular
46	triangular	oval
47	trapezoidal	oval
48	-	*
49	-	circular
50	-	oval
51	-	oval
52	rectangular	-
53	triangular	oval
54	-	oval
55	-	oval
56	-	oval
57	-	oval
58	-	oval
59	rectangular	oval
60	-	-
61	-	-
62	-	oval
63	triangular	oval
64	-	-
65	-	-
66	-	*
67	irregular	oval
68	-	oval
69	triangular	oval
70	trapezoidal	oval
71	trapezoidal	oval
72	-	oval
74	-	-
75	trapezoidal	oval
76	-	-
77	-	circular
78	-	-
79	-	-
80	triangular	oval
81	rectangular	oval
82	-	oval
83	-	-
84	-	oval
85	-	oval
86	triangular	oval
87	-	oval
88	rectangular	oval
89	triangular	oval
90	rectangular	oval

* Oval with one flat face.

APPENDIX V. Poll form and texture.

ARTIFACT	A	B	C	D	E	F	G	H	I	J
5		x							x	
7					x	x				
8	x									x
9					x	x				
13		x				x				
16					x	x				
17		x				x				
24		x				x				
25				x	x					
28					x	x				
30		x				x				
35					x	x				
39		x				x				
46		x							x	
47			x			x				
50			x			x				
53	x						x			
56					x	x				
59		x				x				
60		x				x				
63	x								x	
67				x		x				
69					x	x				
70			x							
71	x					x				
75			x			x				
80	x					x				
86	x					x				
88			x							x

Form

a - pointed
b - flat
c - rounded
d - ground down to form two intersecting planes
e - irregular

Texture

f - completely pecked or roughened
g - pecked or roughened on only one flank
h - pecked or roughened on both flanks and not the center
i - pecked or roughened only on the center
j - completely smoothed and finished

APPENDIX VI. Side-waisting: Metric Data (all measurements in mm.)

ARTIFACT	SIDES 1	SIDES 2	LENGTH 1	LENGTH 2	LENGTH Avg.	MAXIMUM DEPTH 1	MAXIMUM DEPTH 2	MAXIMUM DEPTH Avg.	DISTANCE FROM CUTTING EDGE
10	x	x	25	28	26.5	.5	1.5	1.00	32
11	x	x	*	*	*	2.5	2.0	2.25	31
13	x	x	25	24	24.5	2.5	1.0	1.75	27
17	x	x	-	38	-	-	1.5	-	41
24	x	x	35	39	37.0	3.0	4.0	3.50	32
25	x	x	23	27	25.0	.5	.5	.50	25
29	x	x	26	28	27.0	1.5	3.0	2.25	30
30	x	x	30	28	29.0	.5	.5	.50	42
34	x	x	*	*	*	1.5	1.5	1.50	30
35	x	x	34	31	32.5	2.0	1.5	1.75	35
39	x	x	28	26	27.0	2.0	.5	1.25	34
55	x	x	28	25	26.5	.5	.5	.50	32
56	x	x	30	30	30.0	2.0	2.0	2.00	29
57	x	x	*	*	*	.5	1.0	.75	28
59	x	x	35	33	34.0	3.0	4.0	3.50	20
78	*	x	*	22	-	*	1.0	-	29
81	x	x	25	21	23.0	2.0	1.5	1.75	23
90	x	x	21	19	20.0	.5	1.0	.75	32

* Fragment.

APPENDIX VI.A. Artifacts with Side Roughening.

ARTIFACT	
5	34
9 (one side only)	35
10	37
11	39
15	55
17	56
24	57
25	59
28	69
29	77
30	78
31	81
32	90

APPENDIX VII. Summary of Function Determinations.

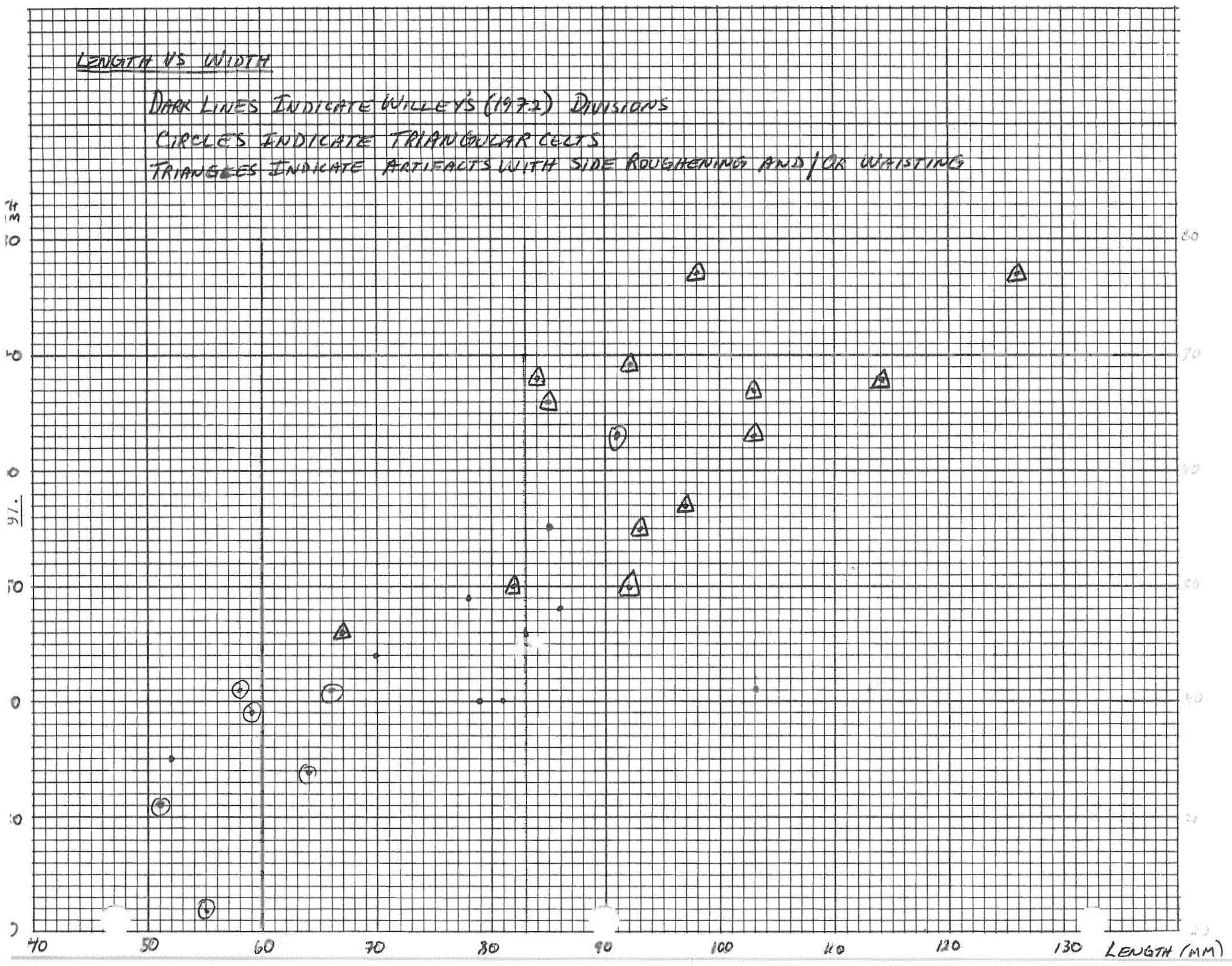
ARTIFACT*

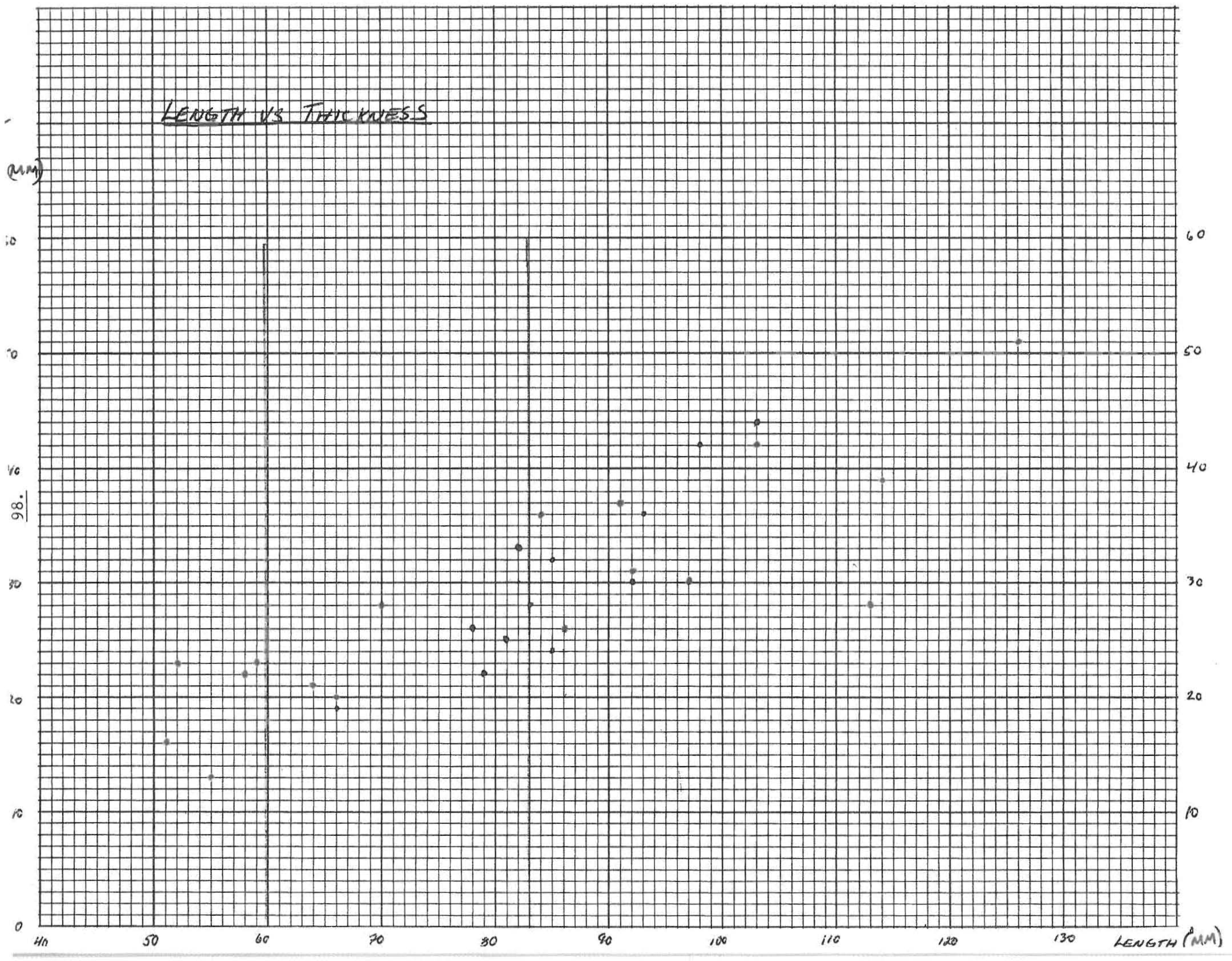
1. Undetermined
2. Poll fragment
3. Poll fragment
4. Poll fragment
5. Axe
7. Axe
8. Intermediate tool
9. Axe
10. Undetermined (weathered)
11. Axe
12. Blade fragment
13. Axe
14. Blade fragment
15. Percussor
16. Axe
17. Axe
18. Blade fragment
20. Axe
21. Axe
22. Axe
23. Undetermined
24. Axe
25. Axe
26. Axe
27. Undetermined
28. Axe
29. Axe
30. Axe
31. Axe
32. Undetermined
33. Poll fragment
34. Axe
35. Axe
36. Axe
37. Undetermined
38. Blade fragment
39. Axe
41. Poll fragment
42. Blade fragment
43. Blade fragment
44. Poll fragment
45. Grinder
46. Intermediate tool
47. Percussor
48. Adze
49. Undetermined
50. Intermediate tool and grinder
51. Blade fragment
52. Undetermined
53. Intermediate tool
54. Percussor
55. Axe
56. Axe
57. Axe
58. Poll fragment
59. Axe
60. Adze
61. Blade fragment
62. Blade fragment
63. Intermediate tool
64. Poll fragment
65. Poll fragment
66. Poll fragment
67. Grinder
68. Axe
69. Grinder
70. Undetermined (weathered)
71. Undetermined (weathered)
72. Blade fragment
74. Blade fragment
75. Undetermined
76. Poll fragment
77. Axe
78. Axe
79. Midsection fragment
80. Undetermined
81. Axe
82. Percussor
83. Fragment
84. Axe
85. Poll fragment
86. Intermediate tool
87. Undetermined (weathered)
88. Axe
89. Undetermined
90. Axe

* No artifacts are numbered 6, 19, 40, or 73.

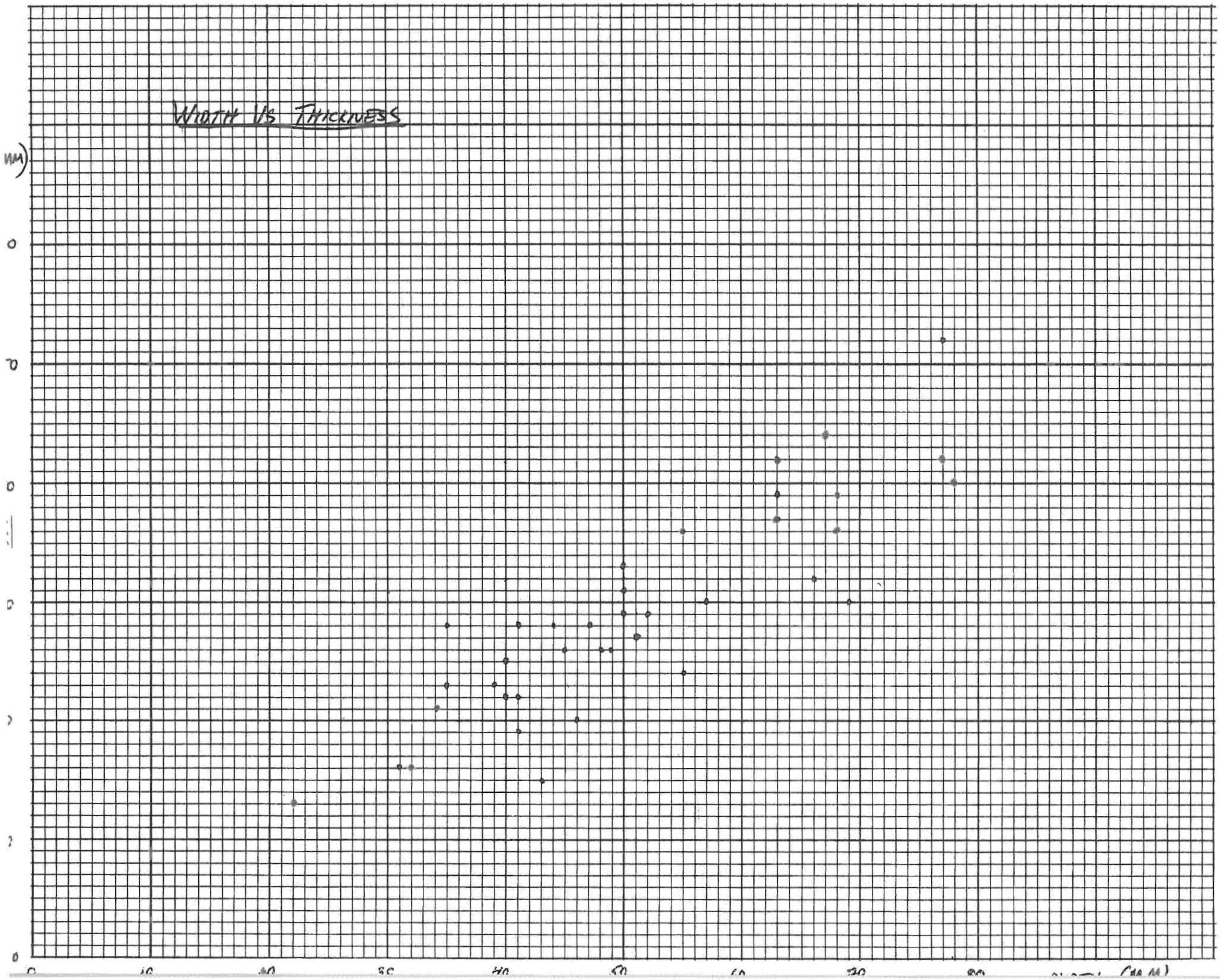
APPENDIX VIII. Photographic Information.

		PHOTOGRAPHY		PRINTING	
PLATE	SCALE	F-STOP	SHUTTER SPEED	F-STOP	TIME
1	Actual size	f.11	1/4 sec.	f.8	32 sec.
2	Actual size	f.5.6	1/30 sec.	f.8	29 sec.
3	Actual size	f.16	1/3 sec.	f.8	29 sec.
4	Actual size	f.16	1/2 sec.	f.8	18 sec.
5	Approx. 3.25mm.	f.5.6	4 min.	f.11	5 sec.
6	Approx. 8.5mm.	f.5.6	2 min.	f.8	7 sec.
7	Approx. 12mm.	f.5.6	1 min.	f.8	9 sec.
8	Approx. 2.5mm.	f.5.6	2 min.	f.11	5 sec.
9	Approx. 8.5mm.	f.5.6	2 min.	f.8	10 sec.
10	Approx. 12mm.	f.5.6	1 min.	f.11	8 sec.
11	Actual size	f.8	1/30 sec.	f.11	8 sec.
12	Approx. actual size	f.8	1/30 sec.	f.11	4 sec.
13	Actual size	f.8	1/60 sec.	f.16	9 sec.
14	Actual size	f.8	1/30 sec.	f.8	7 sec.
15	Approx. 1/2 size	f.8	1/30 sec.	f.8	9 sec.
16	Actual size	f.8	1/60 sec.	f.8	10 sec.
17	Approx. actual size	f.8	1/60 sec.	f.8	7 sec.
18	Actual size	f.8	1/30 sec.	f.8	22 sec.
19	Actual size	f.8	1/15 sec.	f.11	10 sec.
20	Actual size	f.8	1/60 sec.	f.8	7 sec.
21	Actual size	f.8	1/30 sec.	f.16	9 sec.
22	Actual size	f.5.6	1/8 sec.	f.11	7 sec.

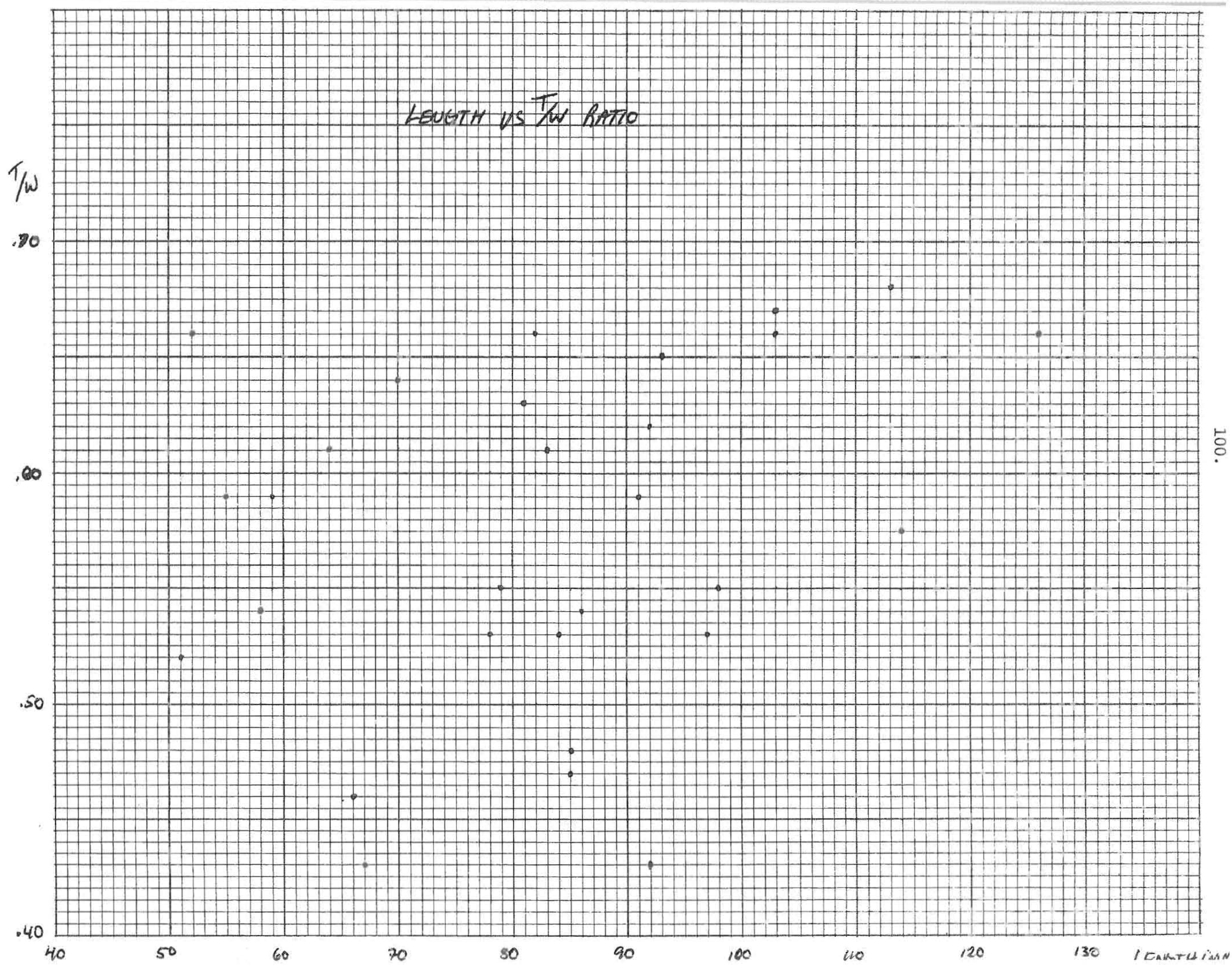

LENGTH VS WIDTH
DARK LINES INDICATE WILLEY'S (1972) DIVISIONS
CIRCLES INDICATE TRIANGULAR CELTS
TRIANGLES INDICATE ARTIFACTS WITH SIDE ROUGHENING AND/OR WAISTING
40
50
60
70
80
90
100
110
120
130
LENGTH (MM)



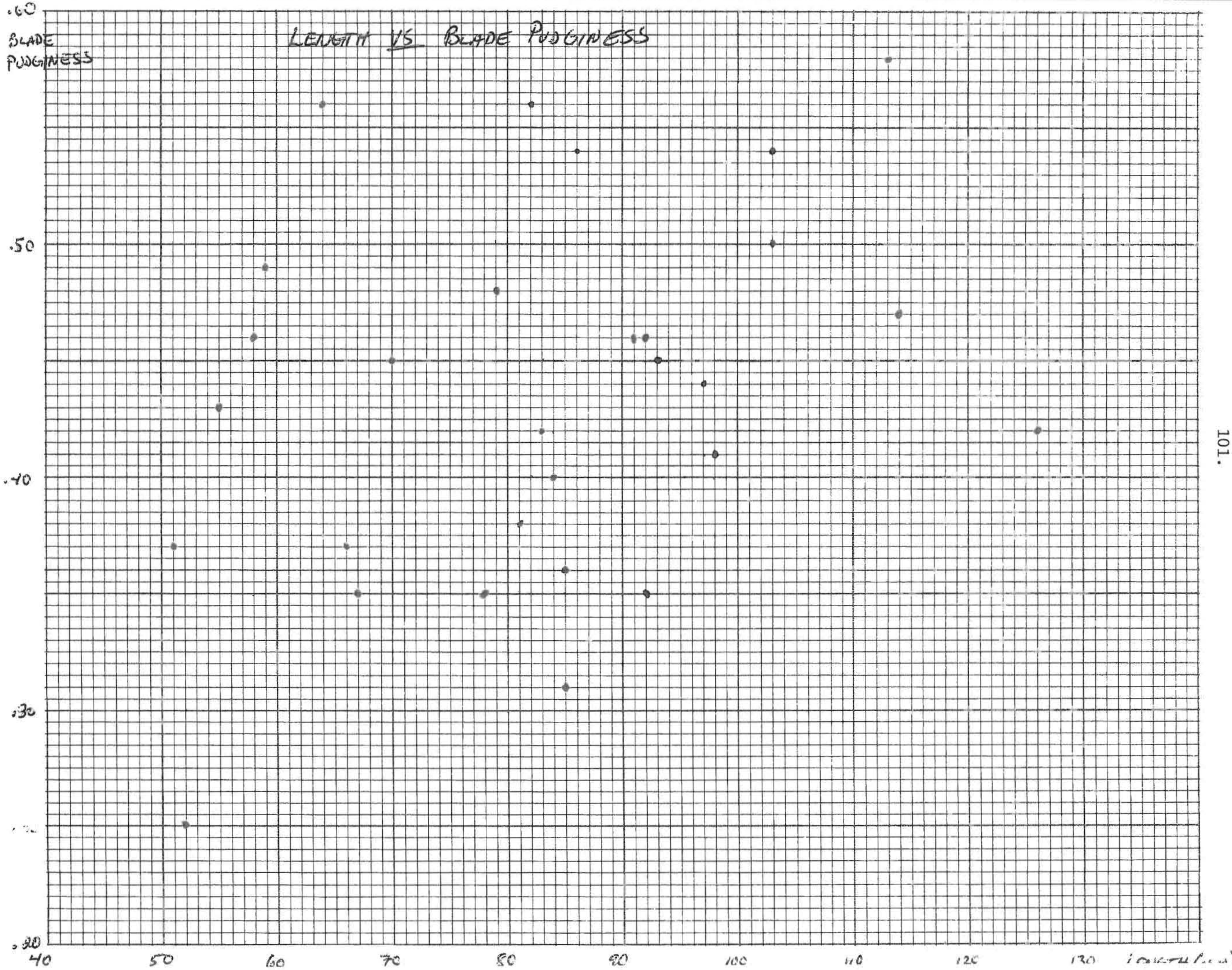
LENGTH VS THICKNESS
(MM)
LENGTH (MM)
98.



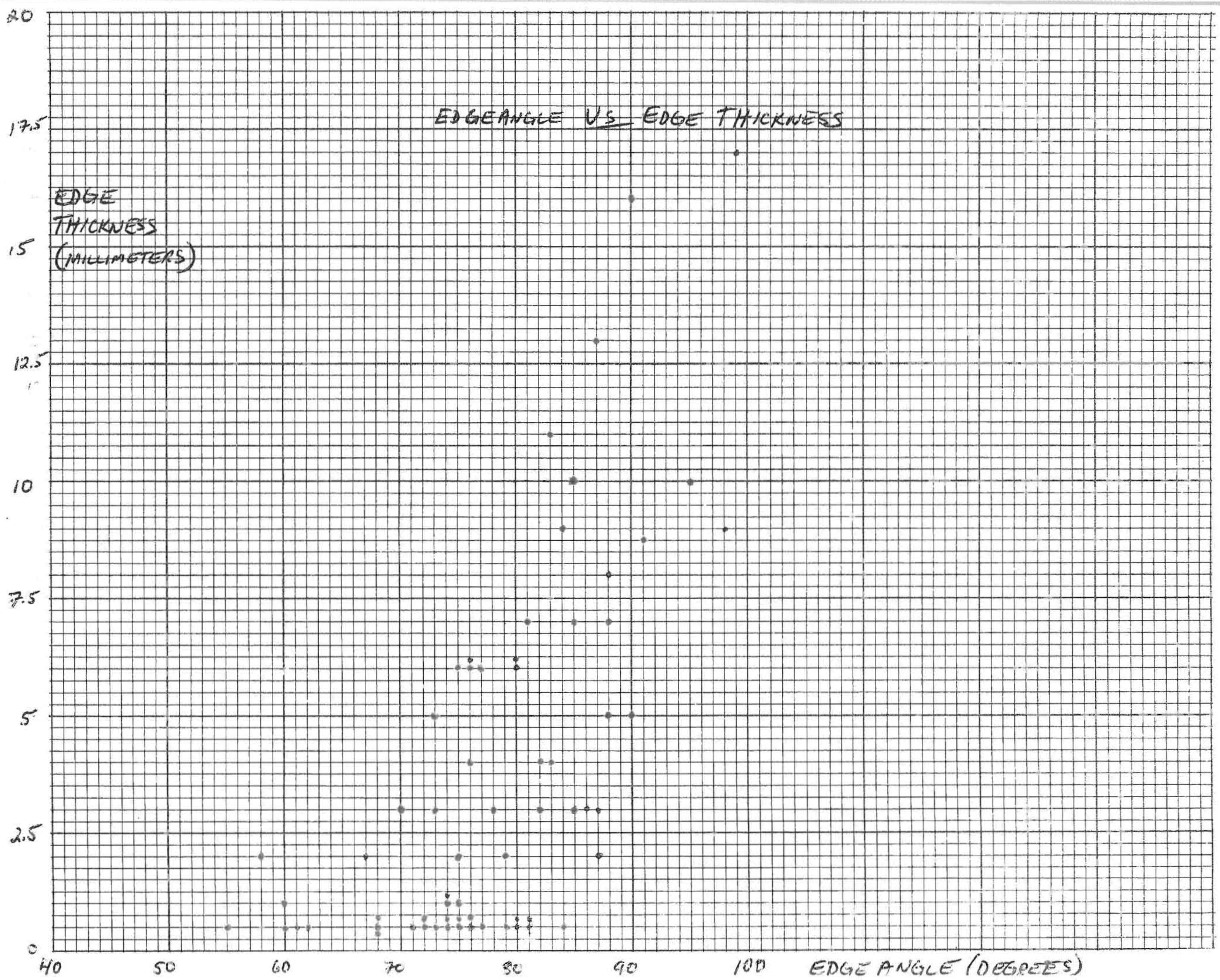
WIDTH VS THICKNESS

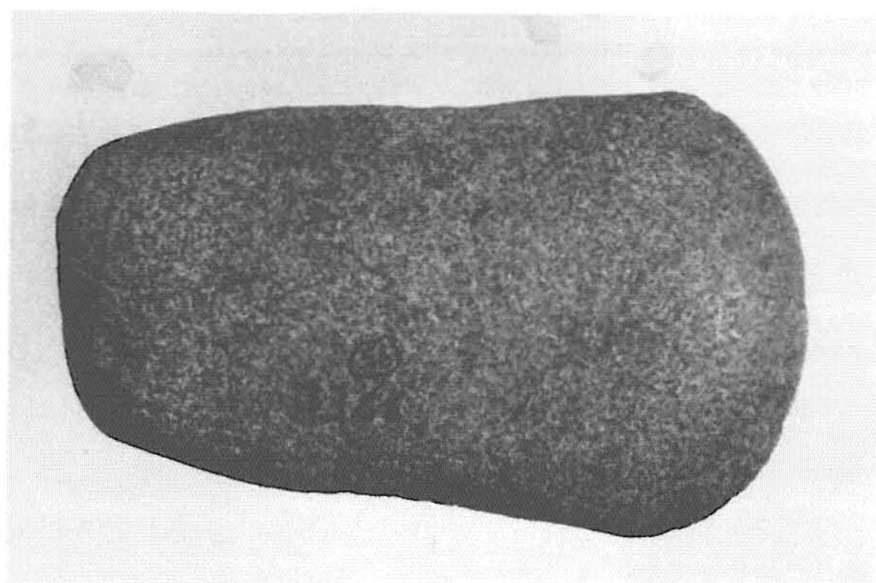


LENGTH VS T/W RATIO
T/W
.70
.60
.50
.40
40
50
60
70
80
90
100
110
120
130
LENGTH

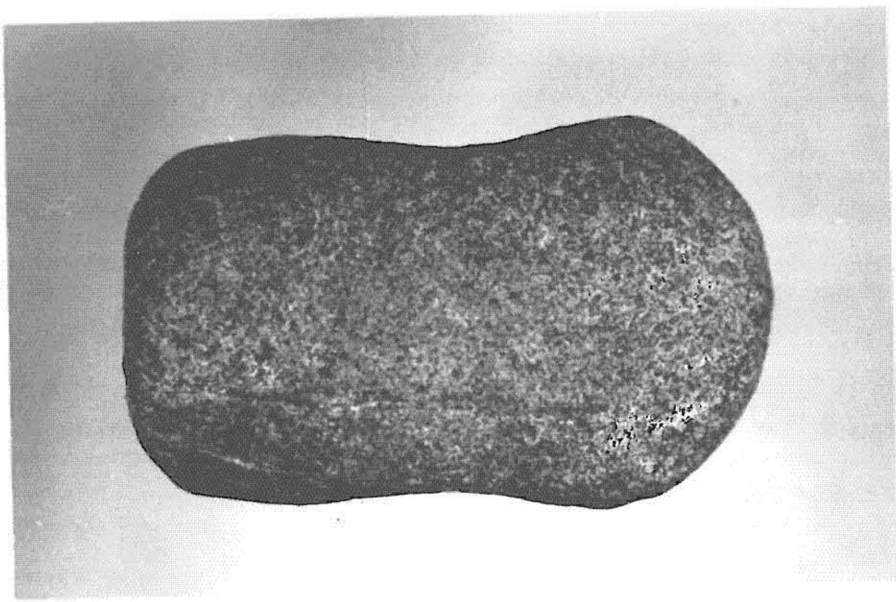


LENGTH VS BLADE PUDGINESS
BLADE PUDGINESS
.60
.50
.40
.30
.20
40
50
60
70
80
90
100
110
120
130

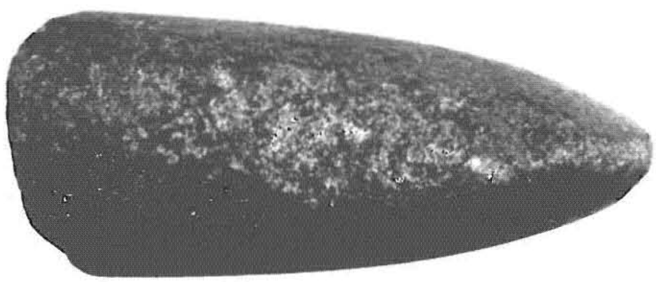

EDGEANGLE VS EDGE THICKNESS
EDGE THICKNESS (MILLIMETERS)
EDGE ANGLE (DEGREES)
0
2.5
5
7.5
10
12.5
15
17.5
20
40
50
60
70
80
90
100



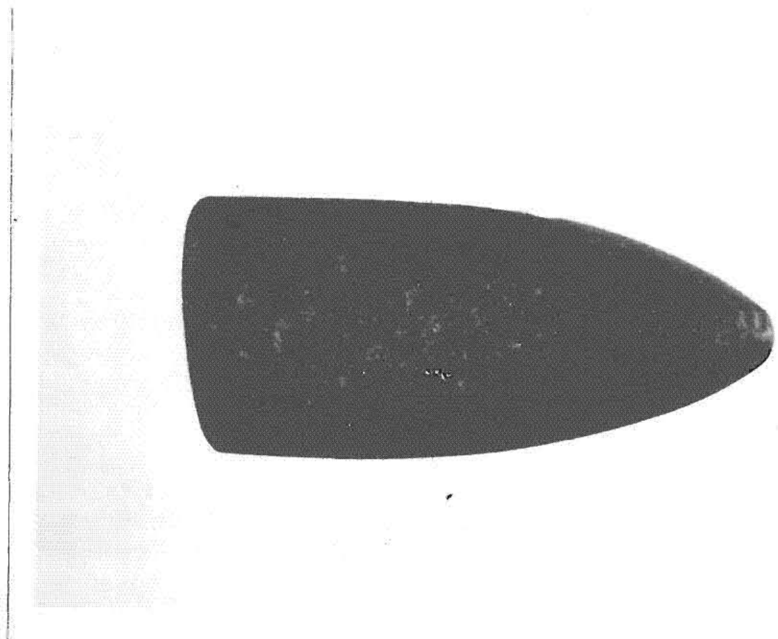
1. Side-waisted axe. Actual size.



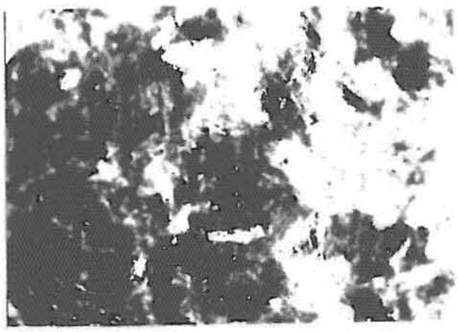
2. Side-waisted axe. Actual size.



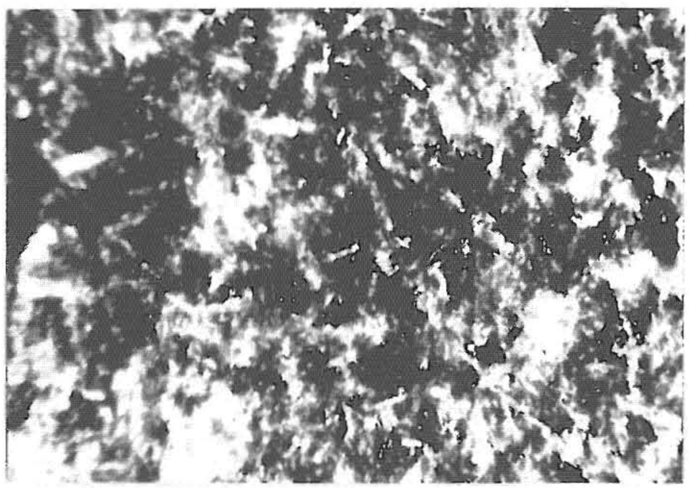
3. Side-waisted axe. Note thickness of edge. Actual size.



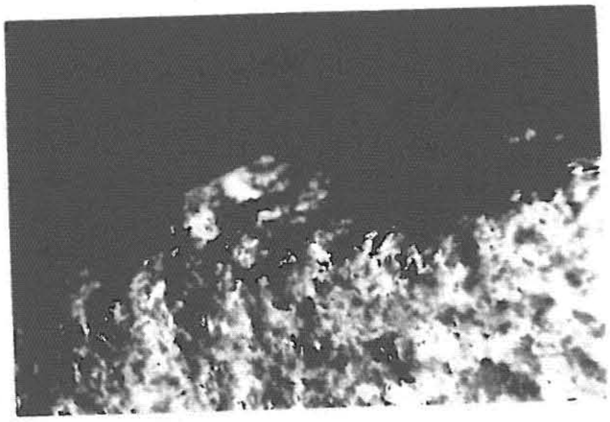
4. Side roughened axe. Poll was removed for thin section analysis.
Actual size.



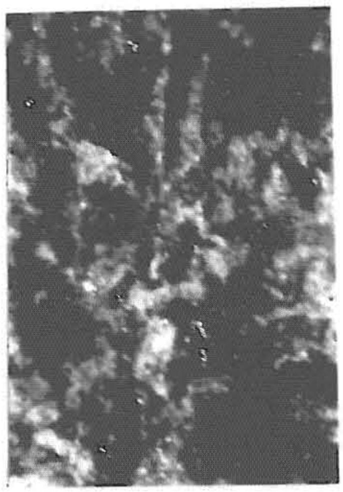
5. Striations resulting from grinding during manufacture. Approximately 3.25 mm. is shown.



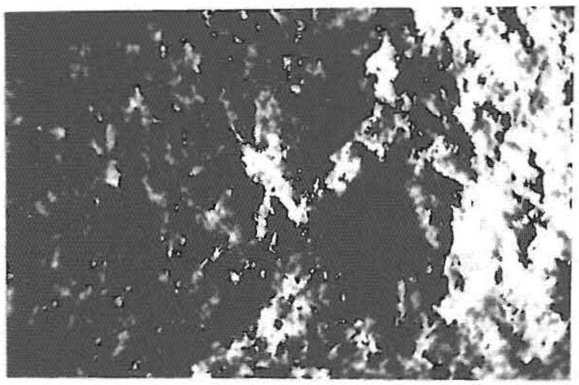
6. Striations resulting from grinding during manufacture.
Approximately 8.5 mm. is shown.



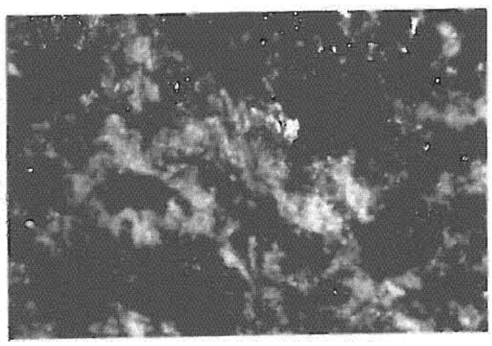
7. Striations resulting from use. Approximately 12 mm. is shown.



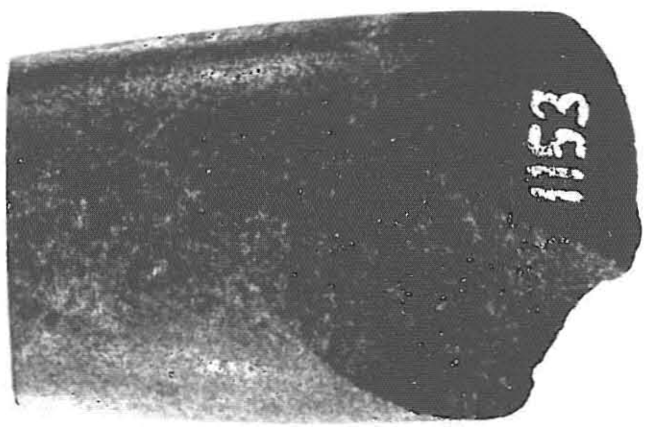
8. Striations resulting from use. Approximately 2.5 mm. is shown.



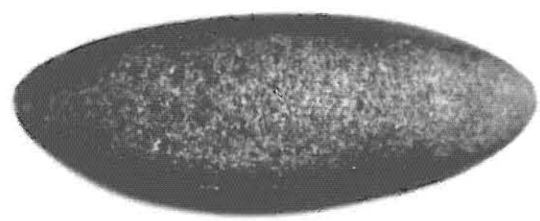
9. Striations resulting from use are located in upper center.
Approximately 8.5 mm. is shown.



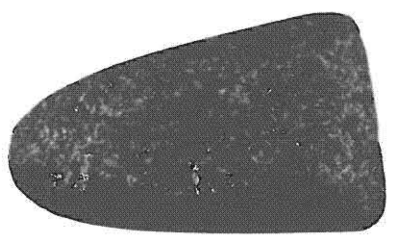
10. Striations resulting from use. Approximately 12 mm. is shown.



11. Axe showing extremely large flake scar.
Poll was removed for thin section analysis. Actual size.

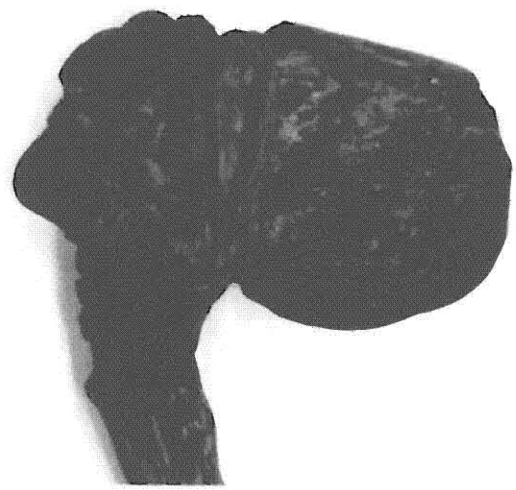


12. Axe showing scarring on opposite faces of edge.
Approximately actual size.



13. Small, triangular celt. Actual size.

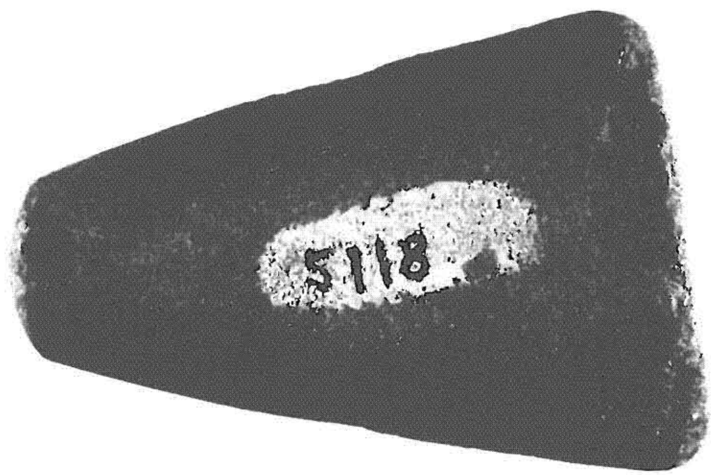
14. Shouldered celt. Actual size.



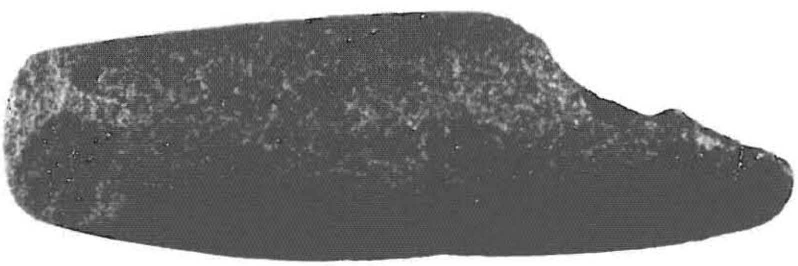
15. Possible method of hafting axes. This aftifact is not from Costa Rica but is presented to demonstrate the use of leather thongs in hafting. Approximately one-half actual size.

16. Adze with centrally located groove.
Groove is located at bottom center of photo. Actual size.

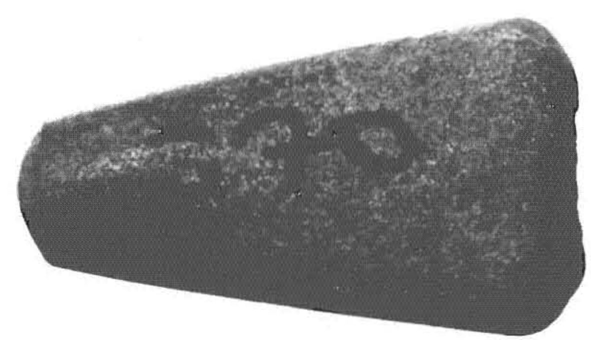
17. Adze showing uneven distribution of edge wear and asymetrical profile.
Approximately actual size.



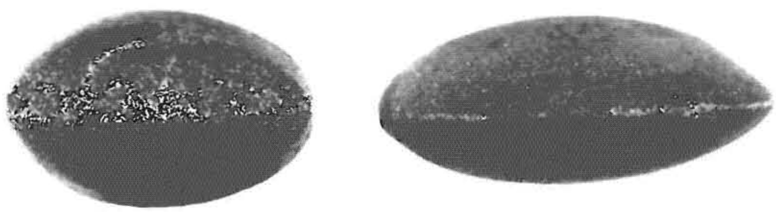
18. Celt re-used as percussor. Actual size.



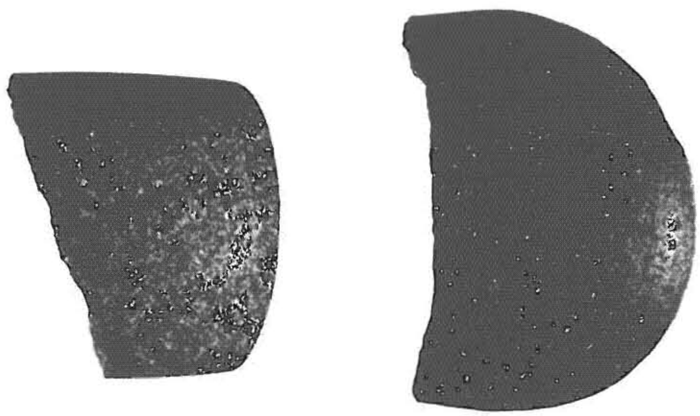
19. Celt re-used as percussor. Actual size.



20. Celt re-used as grinder. Actual size.



21. Small blade fragments with very sharp edges.
Viewed blade on. Actual size.



22. Small blade fragments (vertical view) with very sharp edges. Actual size.

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