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I. INTRODUCTION

Ceramics constitute an overwhelming majority of the pre-Columbian archaeological record. So large is this database, in fact, that more than 25 years ago Gordon Willey expressed some exasperation concerning what to do with "...literally tons of potsherds" (1961:230). While at times annoying, the sheer size of this database commands attention. Contemporary studies of the production, consumption, and disposal of pottery can inform us about the many ways in which ceramics reflect cultural behavior. These data, in turn, can provide insight into the social, economic, and political systems of ancient Mesoamerica.

Despite the potential of such information, there has been surprisingly little research that specifically addresses these archaeological questions. Of course, accounts of ceramic production are a common feature of the Mesoamerican ethnographic literature (see Kramer 1985; Rice and Saffer 1982; for extensive bibliographies). Many of these studies, however, do not address issues that directly concern archaeologists. In addition, there tends to be little consistency in terms of what aspects of production are studied and the amount of field time devoted to their investigation (Kramer 1985). Finally, the samples from which most of these studies are drawn is generally quite small. This characterization is especially true when considering such topics as household ceramic assemblage size and vessel use life. In fact, there are currently fewer than 5 published studies documenting New World ceramic consumption that are derived from a sample larger than 10 households! In many of these cases, therefore, the reader may be hard pressed to determine the degree to which the documented patterns are actually representative.

The purpose of this study, therefore, is to increase the present sample by one. In the following pages I discuss the production and consumption of ceramics by household potters of the Sierra de los Tuxtlas, Veracruz, Mexico. This discussion will examine four communities of potters within the study region and will present data on inter- and intra-community variability in the production and consumption of pottery. The final stage in the "life cycle" of these ceramic items, namely their disposal, is addressed elsewhere (P. Arnold 1987).

The data presented in this study were collected from 50 households during 1984 and 1985. This information was obtained through a program of interviews and participant observation. Interviews were based on questionnaires employed in other studies of ceramic production (e.g., Deal 1983; Durston 1976; Rye 1981), with modifications to suit the specific circumstances of the Tuxtlas potters. While some researchers may feel that questionnaires are unnecessarily confining (e.g., Shepard 1956:93-94), a specified series of questions can promote consistent data collection. Additional time was spent observing production techniques and travelling with the potter to raw material sources. These episodes provided a means to check the potter's activities against the information supplied during the interviews. Several days were spent gathering data from each household.

The Study Region

The Sierra de los Tuxtlas is a low volcanic mountain range rising abruptly out of the Gulf Coast plain of southern Veracruz, Mexico (Figure 1). The Tuxtlas region abuts the Gulf of Mexico to the north and east; to the south and west the sierra slopes gradually downward to meet the salt marshes and sand dunes of the Isthmanian embayment. Numerous cinder cones, craters, and volcanoes are scattered throughout the region and rise to a maximum elevation of 1660 meters. Lake Catemaco, located in the center of the Tuxtlas, separates the western (San Martin) massif from the eastern (Santa Marta) massif (Andrle 1964; Killion 1987).

Raw Materials

The potters of Los Tuxtlas are blessed with a good selection of high-quality raw materials. Tertiary marine sediments outcrop throughout the region; many of these deposits are associated with lenses of fine-grained, kaolinitic clays. These clays are preferred for two main reasons: (a) their naturally refined state requires less grinding than other clays, making them more easily utilized; and (b) their homogeneity reduces the time needed to remove foreign materials which otherwise may cause the vessel to crack during drying and firing (D. Arnold 1985).

High-quality tempering material is also widely available. Plio-Pliestocene and Holocene volcanic deposits overlie much of the marine sediments in the Tuxtlas. Volcanic ash has a comparatively low level of thermal expansion, a quality well suited for the Tuxtlas potters' emphasis on cooking vessels (e.g., Riley 1984) In addition, the irregular form of volcanic ash improves its ability to bond with the clay and strengthen the clay body (Rye 1976; Shepard 1956). Potters in Highland Guatemala, faced with a choice between marine sediments and volcanic ash deposits, overwhelmingly favor the volcanic ash (Rice 1976).

Climate

The climatic patterns of Los Tuxtlas are closely related to the physiographic characteristics of the study region. The average annual temperature in the Tuxtlas is about 25 degrees Centigrade. Warmest temperatures occur from April through September and range from 4 to 5 degrees Centigrade higher than the cooler, winter months. Higher elevations exhibit lower average temperatures throughout the year, but these differences are usually on the order of 2 degrees Centigrade or less per month.

Differences in elevation also affect precipitation. The sierra is characterized by a distinct pattern of orographic rainfall with a rainshadow effect on the southern size of the mountains. Precipitation levels decrease from an annual high of almost 5000 millimeters in the higher elevations to less than 1000 millimeters per year on the inland side of the range.

The Tuxtlas region is also characterized by a pronounced dry and wet season, which correspond to the agricultural cycles of *tonamil* and *temporal*, respectively (Killion 1987). The

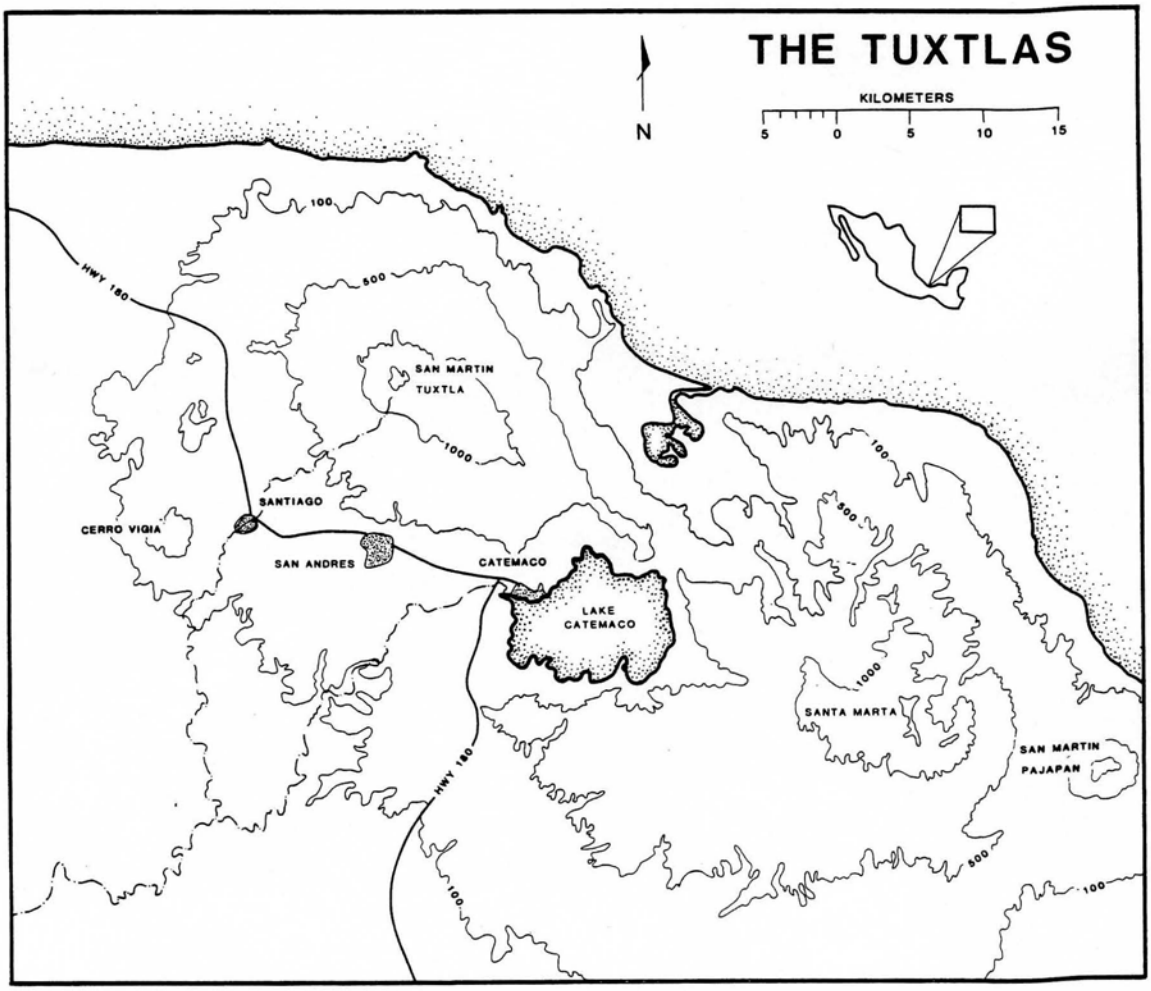

Figure 1. Sierra de los Tuxtlas study region.

dry season occurs between January and May and coincides with the coldest time of the year. May and April are usually the driest months, although the occurrence of winter storms (nortes) may alter this pattern across the region. The wet season comprises the period from June through December, with highest mensual precipitation falling between September and October. The Tuxtlas averages 60 millimeters of precipitation per month during the dry season, while the monthly rainfall during the wet season averages approximately 290 millimeters.

The Study Communities

The potting communities discussed in this study are all located within the San Martin massif of the Tuxtlas. Killion (1987) has divided this area into three habitation zones based on the distribution of settlements and the agricultural economy of the inhabitants (Figure 2). To the south are the wetlands, rolling hills, and the coastal plain of southern Veracruz. The easily cultivable, productive soils in the southern zone are generally restricted to areas adjacent to major river courses, creating a pattern of dense but dispersed rural settlements engaged primarily in subsistence agriculture. The central zone, bisected by Highway 180, is the major area of occupation. San Andres Tuxtla, Santiago Tuxtla, and Catemaco, the three largest communities in the Tuxtlas, occur within this zone. In addition, many smaller, but dense communities are situated along the highway. Agriculture in this central area tends to be intensive, with both subsistence farming and plantation and cash crop production. The northern zone includes the upland area around San Martin Tuxtla and the steep northern slopes that ultimately meet the Gulf of Mexico. Swidden agriculture and some cattle grazing are common in this region; the removal of the tropical forest over the last 30 years has increased soil erosion and significantly impacted soil fertility. Settlements in this zone are usually small and widely dispersed.

The four production communities border the massif's central zone. San Isidro Texcaltitan is located to the northwest of San Andres on the upland south-facing slopes of the San Martin massif. The community is situated at an elevation of about 400 meters and contains approximately 750 inhabitants (SSP 1982). Houselots are cut into the hillsides, giving San Isidro a terraced appearance. A dirt road, passable during the dry season, connects San Isidro with San Andres. Bus and taxi service is unpredictable, however, and the potters usually make the two hour roundtrip on foot.

In contrast to the uneven terrain of San Isidro, the remaining three communities are located within relatively flat areas along the southern border of the central zone. Sehualaca lies to the southwest of Santiago Tuxtla along the levee of the Rio Tepango. Sehualaca contains a population of about 650 persons and is the only study community adjacent to a main thoroughfare (SSP 1982). Buses and taxis are often used to transport goods to the market. In addition, potential buyers are more likely to visit the home of these potters, thereby receiving a better price for the ceramics.

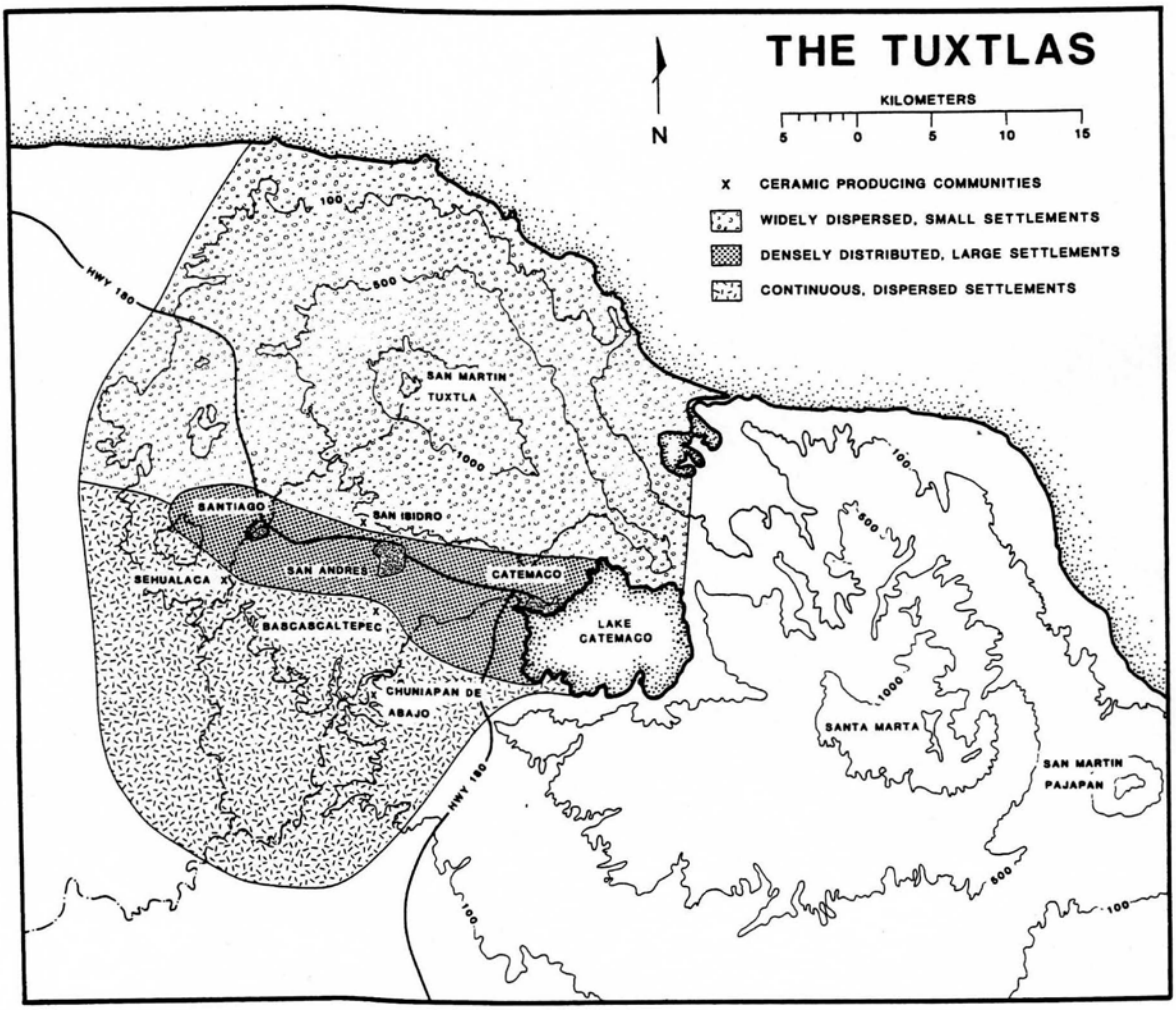

Figure 2. Major habitation zones of the study region (after Killion 1987).

Bascascaltepec is situated about 4 kilometers south of San Andres at an elevation of 240 meters. A dirt road is the main transportation artery linking this community with San Andres. With a population near 1000, Bascascaltepec is the largest of the study communities. Potters practice their craft infrequently, however, so the opportunity to gather comparative information was limited.

Chuniapan de Abajo lies along the Rio Grande de Catemaco, about 10 kilometers south of San Andres. Only 600 persons inhabit this community, making it the smallest settlement that was studied. No scheduled transportation reaches this community, although some more adventurous taxi drivers may brave the trip for the right price. Given the distance to San Andres, these potters seldom take their goods to the market. Rather, they prefer to sell their goods in some of the smaller, surrounding communities.

II. CERAMIC PRODUCTION IN LOS TUXTLAS

Ceramic production in Los Tuxtlas is performed by adult women and must be scheduled in accordance with seasonal differences in rainfall and the demands of subsistence agriculture. In addition, the female potter must juggle pottery manufacture with all of the domestic responsibilities delegated to women in a peasant society. Making pottery is thus a part-time, seasonal endeavor, one which inevitably takes a back seat to agricultural and domestic chores.

The Tuxtlas potters belong to the same mestizo cultural tradition that characterizes most of the rural population in the study region. While the Popoluca and Zoque Indians living on the southern slopes of the Santa Marta massif remained relatively isolated until the middle of this century (Baez-Jorge 1973; Foster 1966; Holmes 1952), the indigenous population of the San Martin massif was impacted more dramatically. In addition to the depopulation brought about by smallpox and other Old World diseases, this area was rapidly settled by Spanish, German, and Cuban immigrants drawn by tobacco production and cattle ranching (Andrle 1964; Killion 1987; Medel y Alvarado 1963). Consequently, the modern inhabitants of the region exhibit a thorough mixture of European and native Mexican cultural traits.

Subsistence agriculture continues to be the primary economic pursuit in these rural communities, and the ceramic-producing households are no exception. Farmers participate in the *ejido*-based system of land use, in which the male head of each *campesino* household is granted a parcel of land to cultivate (Killion 1987). Since the program's inception, however, much of the higher quality land has come under private ownership and the amount of arable ejido holdings has decreased. Many ejido plots are held by the same extended family for generations, with production rights passing to the male family members (Killion 1987). Married males and their wives often take up residence with or near the husband's family in order to secure their access right to the family's ejido land.

The women who make pottery must schedule their efforts around the labor demands of the annual agricultural cycle. As noted previously, the study communities are situated

on the border of the central agricultural zones. According to Killion, dry season farming in this zone is an important activity:

> Peak labor loads, due to the overlap in the number of crops planted for household consumption, occur between May and August, but moderate labor loads also occur in the late winter and early spring when tonamil agricultural activities can be quite demanding [1987:186].

Although the dry season provides the best conditions for making pottery, in many instances ceramic production must be delayed until the agricultural activities have been completed. Potters are thus forced to balance the manufacture of ceramics against the labor requirements of subsistence agriculture.

Of course, as the female head of the household, the Tuxtlas potter is also responsible for a plethora of every-day domestic chores. Women prepare the meals, wash the clothes, attend the market, and otherwise keep the household operating smoothly. All these requirements make added demands on the potter and take time away from ceramic manufacture. In addition to the environmental forces which condition the production of ceramics, social and economic factors also play a role in determining the organization and scheduling of production activities.

Vessel Forms

The vessel forms manufactured by the Tuxtlas potters reflect the utilitarian orientation of their products and the household focus of their economy. Ceramics are made for traditional domestic consumption with an emphasis on food preparation. As with other consumers in Mesoamerica, the Tuxtleños believe that certain foods taste better when prepared in clay containers. Despite the fact that metal pots and pans are available and are used for other purposes, households tenaciously cling to those forms associated with the two most important foodstuffs in the region, corn and beans.

The most common form produced by Tuxtlas potters is the *comal*, the flat griddle used to prepare tortillas (Figure 3). Comales are rendered in three basic sizes. The smallest griddle, the *comal de estufa*, is approximately 21 centimeters in diameter and about 3 centimeters deep at the center (Figure 3a). This form is only used in association with the gas stoves owned by some households near the three population centers.

The middle size comal averages about 28 centimeters in width and is 3.5 centimeters deep (Figure 3b). This vessel is used on the *fogon*: the traditional raised cooking hearth that is common throughout the region. Potters claim that vessels of this size can be used to cook about four tortillas at one time.

The largest griddle is called a *tostador* and is used to roast coffee and sometimes corn. Tostadores average about 37 centimeters in diameter and 7.5 centimeters deep (Figure 3c).

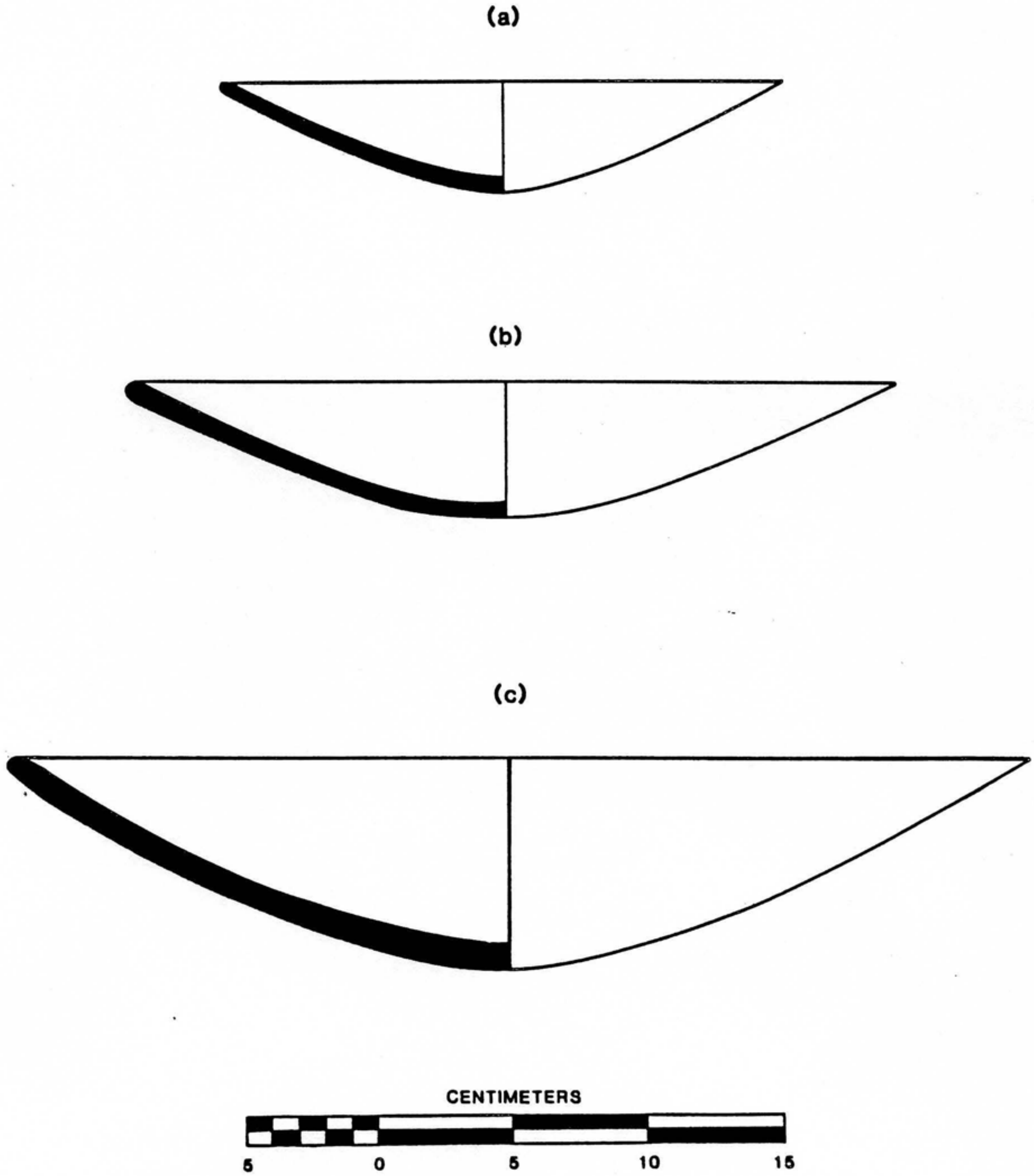

Figure 3. <u>Comal</u> and <u>tostador</u> forms made by Tuxtlas potters.

Now that coffee is more widely available in the market, the production of tostadores is declining rapidly.

Another common vessel type is the bowl, or *tecualon*. Tecualones are multi-purpose in nature; their use ranges from mixing ingredients to serving food to storing small items (Figure 4a). Tecualones are usually about 18 centimeters in diameter with a depth of 6 centimeters.

Cazuelas are also frequently produced in the Tuxtlas. These vessels are basin like, with walls 12 centimeters high and a diameter of 25 centimeters (Figure 4b). In some communities this vessel is called a *fridera*. Cazuelas are used to prepare soup and rice as well as to fry eggs, fish, and meat.

Ceramic producers also make two kinds of pots or *ollas*: one for soaking and cooking beans, and one for cooking corn (Figure 5). Ollas tend to show the greatest variety in terms of shape, in some cases the vessel neck is pronounced and the mouth relatively restricted (< 12 centimeters in diameter), while in other cases there is no prominent neck and the mouth is about 20 centimeters in diameter. In either case the vessel has an outflaring lip. As with the other ceramics in the Tuxtlas, no glazes are applied to these vessels.

Tuxtlas potters may also produce several other items. One potter has become somewhat of a specialist in manufacturing ashtrays (*ceniceros*). This woman sells her ashtrays to the hotels and restaurants of the area, and thus has developed a market system that exceeds the distributional network of the more common cooking wares. The potter claims that working with larger vessels is too physically demanding and therefore specializes in smaller items. Other potters are now beginning to experiment with ashtray production.

Miniature vessels and small animal figures (*juguetes*) are manufactured on occasion. Potters also produce a cone-shaped vessel, set on an out-flaring base. This form is called an *incensario* and is used to burn incense during votive offerings. Potters have also begun making bodies for *piñatas*, based on the form of ollas. Finally, some producers are making flower pots (*maceteras*), which are similar to the cazuela form but may be decorated with an undulating rim.

Production Frequency And Learning Frameworks

Because of the part-time nature of production activities, production frequency was measured as the number of days per week during the dry season devoted to production activities. While some researchers prefer a comparative measures based on number of vessels produced per manufacturing episode (D. Arnold, personal communication), this approach was not selected for one simple reason. There is no necessary relationship between the amount of time invested in production and the number of goods produced. Some potters may take much longer to manufacture a single vessel than others; this fact may be especially true for artisan producers (e.g., Foster 1965). Thus, two potters may spend equal amounts of time in vessel manufacture and produce significantly different

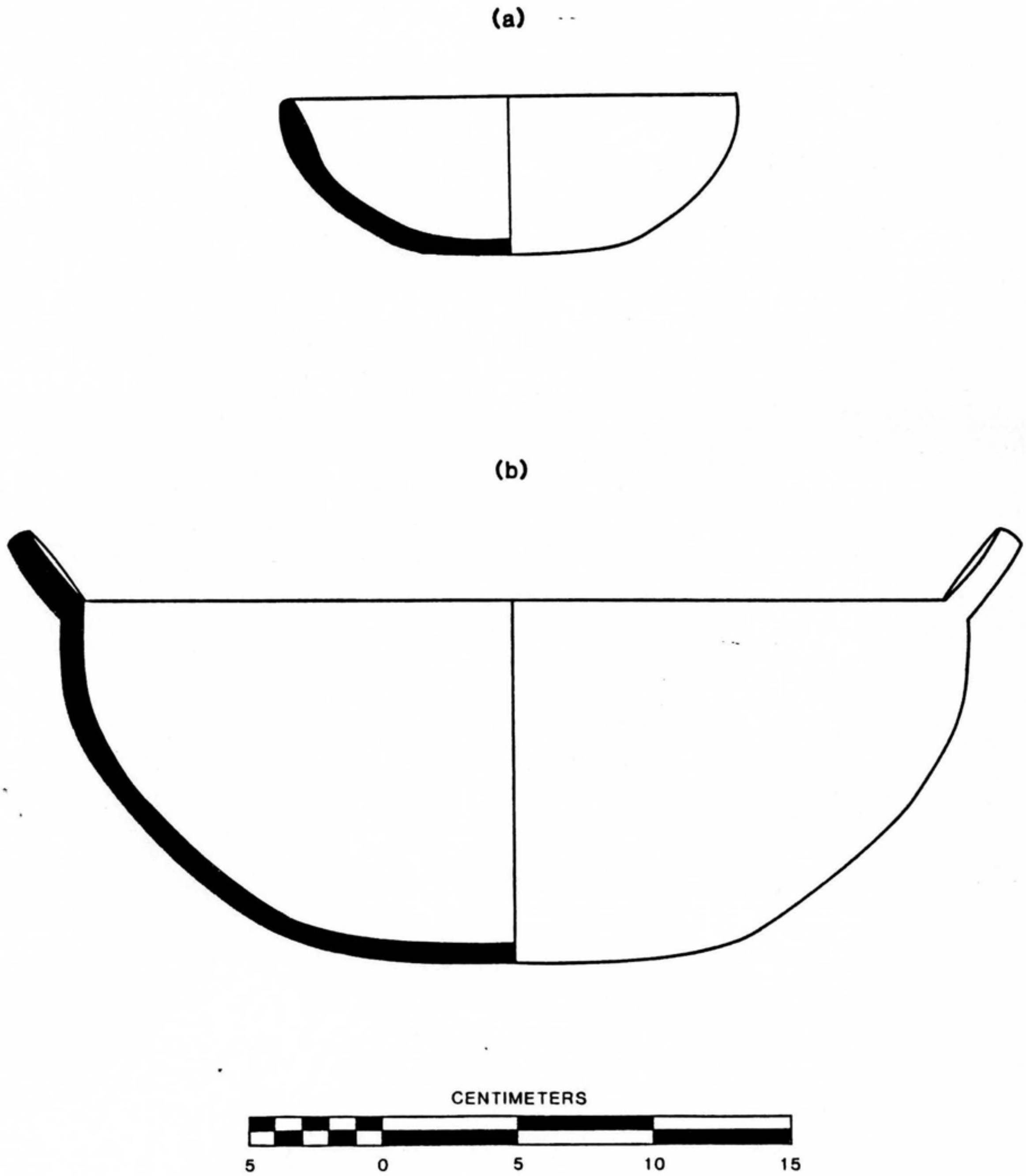

Figure 4. Tecualon and cazuela forms made by Tuxtlas potters.

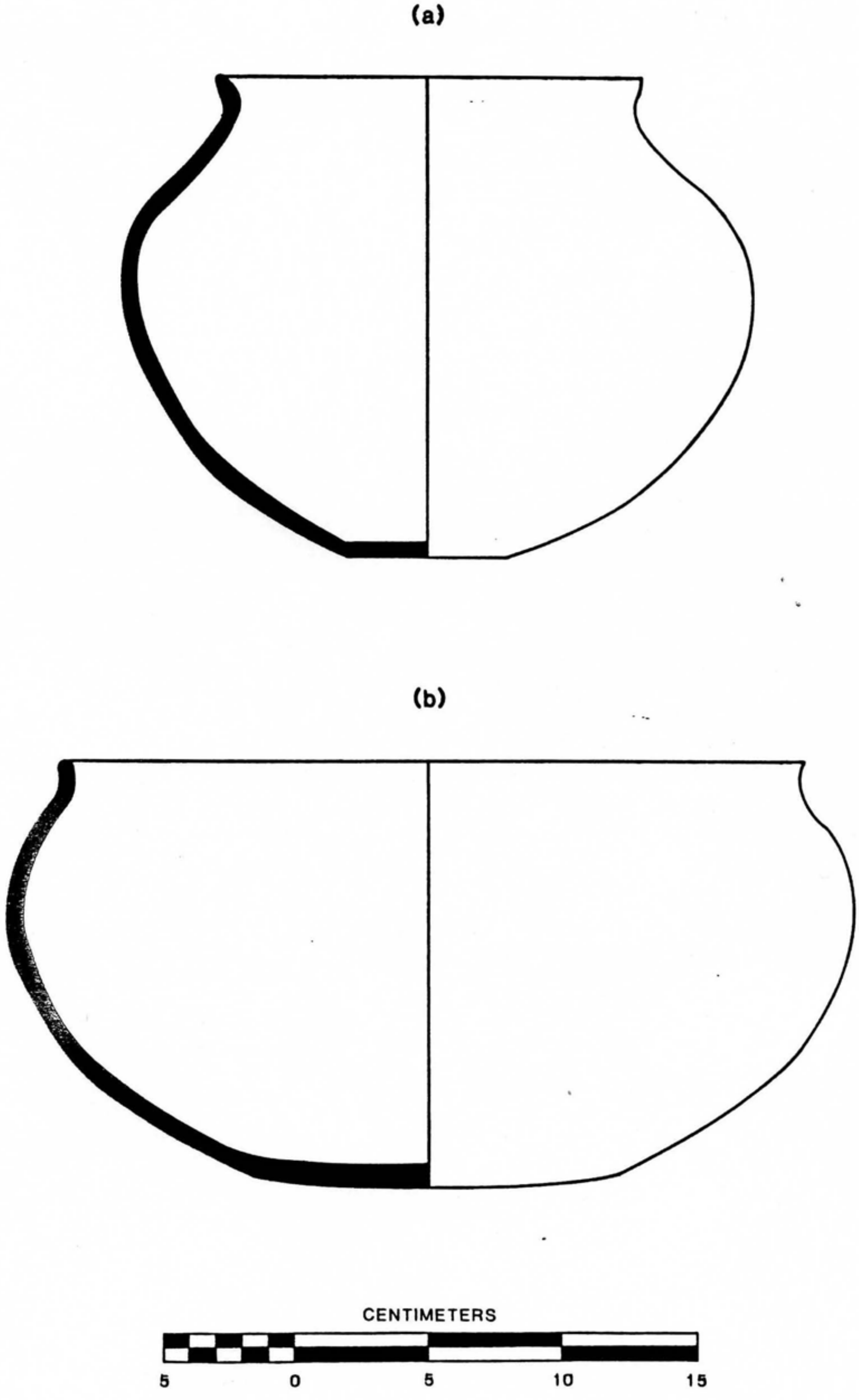

Figure 5. Olla forms made by Tuxtlas potters.

numbers of goods. Conversely, similar amounts of pottery may reflect very different time investments among different potters. In this sense, the focus of this study was more on the behavioral and technological inputs of production than the numeric outputs of production.

Table 1 presents the production frequency information for the four study communities. These data suggest the presence of two groups: (a) San Isidro and Sehualaca, and (b) Chuniapan de Abajo and Bascascaltepec. A Mann Witney U test was performed to evaluate the validity of these groupings. This nonparametric statistic has the advantage of requiring neither a large sample nor one that exhibits a normal distribution (Blalock 1972; Conover 1980). When grouped together, San Isidro and Sehualaca are significantly different from the remaining two communities ($U=136.5$, $Z=3.36$, $p<.05$). Moreover, there is no significant difference in production frequency between San Isidro and Sehualaca ($U=89.5$, $Z=1.10$, $p>.05$), while such a difference does exist between San Isidro and Chuniapan de Abajo ($U=51$, $Z=3.35$, $p<.05$) and Sehualaca and Chuniapan de Abajo ($U=49$, $Z=2.55$, $p<.05$). In no case did Bascascaltepec differ from the three communities, probably because of the small number of observations. Despite this fact, the small values for Bascascaltepec do suggest a low production frequency.

Table 1. Production frequency data from Tuxtlas communities.

	Production Frequency		
Community	Mean	Median	N
San Isidro	3.88	3.00	18
Sehualaca	3.15	3.00	13
Chuniapan de Abajo	2.29	2.00	17
Bascascaltepec	1.62	1.62	2
TOTAL	3.06	3.00	50

The frequency of pottery making is also associated with variability in learning the ceramic craft. Two variables are important here: (a) the student's kinship relation to the teacher, and (b) the age of the student. The majority of Tuxtlas potters (32) were taught by a member of their matriline. Twenty-seven producers learned from their mother, three were taught by their mother's sister, and two learned from their maternal grandmother. In contrast, only four potters were taught by members of their husband's family, and the remaining 14 producers learned by watching a neighbor or indicated that they were instructed by no one in particular.

Of note is the fact that Chuniapan de Abajo potters constitute more than half of all the producers who did not learn from a matrilineal relative (10 of 18). One possible conditioner of this pattern is the age at which pottery making is learned. These data are presented in Table 2. The potters in San Isidro and Sehualaca begin at a mean age of about

16, while the average producer in the other communities does not start until she is at least 20.

Table 2. Age at which pottery making is learned in the Tuxtlas.

Community	Mean	Median	Minimum	Maximum	N
San Isidro	16.58	15.00	8.00	27.00	17
Sehualaca	16.33	16.50	9.00	25.00	12
Chuniapan de Abajo	20.62	20.00	10.00	37.00	16
Bascascaltepec	25.50	25.50	25.00	26.00	2
TOTAL	18.27	16.00	8.00	37.00	47

The relatively late age at which pottery production is learned in Chuniapan de Abajo helps to clarify why so many of these potters do not learn through their matriline. Most of the potters are married and have children by the age of twenty. As noted previously, married couples usually reside with or near the husband's family. Thus by the time most potters in Chuniapan de Abajo learn how to make ceramics, they are more likely to be instructed by someone in the husband's family or by a neighbor than by a matrilineal relative. The network through which a potter is taught, therefore, is apparently related to her age. Furthermore, it appears that potters operating at a higher level of production teach their daughters at a younger age. A similar pattern has also been noted among Guatemalan potters. According to Hayden and Cannon (1984), the majority of ceramic producers were taught by a member of the potter's matriline. In addition, the daughters of potters working more frequently were more likely to learn ceramic production at a younger age than the daughters of less intensive producers.

Raw Material Acquisition

Clay

Tuxtlas potters exploit a number of different clay sources within the study region (Table 3). Clays differ primarily in terms of natural aplastic inclusions; some clays have more organic matter while other clays exhibit a sandier matrix. Like other traditional potters, ceramic producers in the study region are aware of the various firing properties of these different materials. Decisions concerning which deposits to use, however, are primarily conditioned by access to resources.

San Isidro potters exploit two clay deposits. *Colorado* clay, a dark red/brown material, is relatively high in iron oxides and organic material. The deposit is located on

the property of a local farmer who occasionally charges an access fee. This fee is usually paid in the form of fired pottery valued at approximately 150 pesos. San Isidro potters prefer the colorado clay because of their emphasis on producing cooking vessels. Clays rich in organic material are often favored for such vessels, as the organic matter burns away and the resulting pores in the clay body aid in arresting cracks (D. Arnold 1985; Rye 1981). Clays that fire to a darker color also improve the thermal retention of cooking vessels (D. Arnold 1985).

Some producers in San Isidro use a light brown/tan, fine-grained clay called *amarillo*. These potters manufacture the same suite of vessel types as their neighbors; the difference is that they are not charged to use the amarillo deposit. Mining activities consist of digging a shallow pit about 1 meter wide and 0.5 - 1 meter deep. Amarillo clay occurs in relatively thin lenses, so a number of these small mines are scattered throughout the area.

Table 3. Mean distance to clay sources used by Tuxtlas potters.

Community	Clay	Distance[1] Kilometers	Hours	N
San Isidro	Colorado	1.2	0.30	13
	Amarillo	1.0	0.25	7[a]
Sehualaca	Blanco	5.0	1.20	12
	Amarillo	3.0	0.80	3[b]
Chuniapan de Abajo	Amarillo	4.0	1.00	15
	Negro	8.0	2.00	2
Bascascaltepec	Amarillo	1.6	0.40	2

[1] Measured as mean round-trip distance to source.
[a] Includes 2 potters who also use colorado clay.
[b] Includes 2 potters who also use blanco clay.

Sehualaca producers also utilize two clay deposits. In neither case are the potters charged to mine these materials. The vast majority of producers, however, favor the *blanco* clay: a white, fine-grained material that fires to a pale orange. This clay is especially rich in kaolin and is preferred for its plasticity and ability to hold a shape during manufacture.

The second clay, amarillo, is located closer to the community but is only used by three potters. These three are older women who rely on the inferior clay if they have no one to help collect the raw material. In addition, the amarillo source is often flooded during the dry season when brief, but intense winter storms occur. During these periods, potters are forced to collect their clay from the more distant blanco deposit. Weather and the availability of labor thus play important roles in determining what raw materials are used at any given time (D. Arnold 1985; Kramer 1985).

The clays used in Chuniapan de Abajo include a yellow material with a sandy matrix (amarillo) and a somewhat darker clay (*negro*) with a similar matrix that contains more organic matter. In neither case do the potters pay for the raw material. Amarillo clay is preferred because it is located closer to the community. Since no pack animals are used to transport the raw material, it is more efficient to use the amarillo clay than the negro clay. The two potters who favor the negro clay, however, believe that it produces more durable vessels. This assumption is partially borne out; the comales manufactured by these potters exhibit some of the longest use-life values for this vessel type.

The potters of Bascascaltepec utilize a fine-grained, medium brown clay that is low in organic inclusions. The amarillo clay becomes a dark yellow/brown when dry and fires to a dark orange. The deposit is located about 0.8 kilometers to the north of the community and the potters do not pay to mine the clay.

Temper

The kinds of temper used by a potter can affect the manufacturing technology as well as the quality of the finished product. As noted above, volcanic ash is widely available throughout the study region. Tertiary and Quarternary sediments also segment the geological landscape, however, and in some cases significantly increase the distance to ash deposits. Under these circumstances the potter is forced to rely on other tempering material.

The potters in San Isidro find themselves precisely in this situation. Although this community is located on the edge of the Tertiary sediment/Quarternary volcanic series, there are no exposed ash strata in close proximity. Consequently, these potters utilize a Tertiary marine sand deposit that contains ground shell and quartz (Table 4). When available, a burro may be used to carry as much as 70 kilograms of temper back to the house. If a burro cannot be borrowed or rented, the potter simply collects smaller quantities of the temper.

Table 4. Mean distance to temper sources used by Tuxtlas potters.

Community	Temper	Distance[1] Kilometers	Distance[1] Hours	N
San Isidro	Sand with quartz/shell	3.00	1.00	18
Sehualaca	Volcanic Ash	0.90	0.18	13
Chuniapan de Abajo	Volcanic Ash	0.96	0.20	17
Bascascaltepec	Volcanic Ash	5.50	1.50	2

[1] Measured as round-trip distance.

Ceramic producers in the three remaining communities exploit deposits of volcanic ash, all of which are exposed along stream courses near the village. As in the case for San Isidro, no fee is charged for the temper. The average round-trip distance for the entire sample of potters is 1.86 kilometers.

Fuel

The availability of fuel is also closely linked to both the production technology and the quality of the finished product. In Los Tuxtlas, the distribution of fuel is a function of the climatological patterns of the study region, but fuel availability is conditioned by the intensity of agriculture and the associated deforestation. Consequently, the Tuxtlas potters often have different fuels from which to choose (Table 5).

Table 5. Mean distance to fuel sources used by Tuxtlas potters.

Community	Fuel[2]	Distance[1] Kilometers	Distance[1] Hours	N
San Isidro	Hardwood	21.20	5.0	3
Sehualaca	Palm Fronds, Hardwood and Cow Dung	4.82	1.00	13
Chuniapan de Abajo	Palm Fronds	5.28	1.20	11
	Palm Fronds and Hardwood	5.60	1.40	6
Bascascaltepec	Hardwood and Palm Fronds	15.00	3.00	2

1 Measured as round-trip distance.
2 Listed in order of importance.

Potters in San Isidro have the most difficulty in acquiring fuel, be it for firing ceramics or household cooking. Because most of the forest around San Isidro has been removed, firewood must either be purchased or obtained from a considerable distance. Given the time required to gather wood, the majority of potters buy their fuel. In fact, only three potters did not purchase wood from a vendor.

Potters in the remaining communities can obtain their fuel more easily. These three communities are located in the southern zone where the high evergreen selvas of the

sierras give way to the savannas, grasslands, and palm stands of the coastal plain. In Sehualaca the potters use a combination of fuels, including hardwood, palm fronds, and cow dung. Palm stands become the dominant vegetation around Chuniapan de Abajo, a fact reflected in the preference for palm fronds when firing ceramics. Bascascaltepec, which is closest to the central agricultural zone, is subject to increased deforestation. Potters continue to collect their own palm fronds and hardwood, but future pressure on these resources may create a situation like that in San Isidro.

Raw Material Processing

Most of the raw materials in Los Tuxtlas occur in a naturally refined state. The quality of the clay is high and is generally low in aplastic inclusions. Tempers, especially ash, frequently occur in size-sorted deposits. When purchased from vendors, wood has already been cut and requires little additional attention. Potters who collect their own fuel select the oldest, driest material possible, further reducing processing time. Raw material preparation requires minimal effort when compared to the other production activities.

Clay

After the clay has been collected it is brought back to the houselot and set out to dry. Given the heavy rains that can occur in the Tuxtlas, clay deposits are often saturated, even during the dry season. Drying the material is a necessary first step in processing.

Once back at the house, the clay is spread out in a cleared area of the houselot. In some instances the material is laid out on a piece of plastic, but more often it is simply distributed across a small portion of the patio surface. Depending on the weather, the clay may be left out for several days before it has dried. Once dry, the potter stores the clay in a large plastic bag (*costal*). The potter will crush any remaining large clumps of clay with her hand, but no attempt is made at refining the entire batch by pounding or grinding, as is common in other parts of Mexico (e.g., Diaz 1966; Lackey 1982; Papousek 1981; van de Velde and van de Velde 1939). The clay is simply put aside until it is time to mix it with the temper and begin vessel formation.

Temper

Temper undergoes a similar, albeit even less intensive processing stage. The temper is brought back to the household and spread out to dry, again with little concern that it might be mixed with dirt in the patio. The temper dries more quickly than the clay, so it is rarely left out for more than one day. After it has dried, the potter places the temper in another costal or a even plastic tub, whichever is available. No attempt at crushing the material is made, although the potter will remove any roots or other organic matter found in the temper.

Fuel

Fuel undergoes no processing to speak of, apart from the removal of the green portions. It may be cut into appropriate sized pieces when it is time to fire, but this activity is more ad hoc than regularized. No attempts are made to dry the wood or otherwise make it more readily usable. In fact, unlike the clay and temper, the wood is rarely covered and protected from rain. Wood, however, is consumed more quickly than the other materials. As noted above, wood is used for a variety of purposes while clay and temper are not.

Mixing the Clay Body

After the clay and temper have been adequately dried and are ready to be used, they are mixed to obtain a clay body of appropriate consistency. Mixing the clay body is performed in two ways, depending on the desired quantity. The potter will wedge small amounts of clay on a piece of flat wood, while larger amounts are processed by placing the clay on the ground, adding temper, and mixing the entire mass with the feet. This procedure is usually performed by the potter, although the husband and children may also help with this task.

Whether the potter mixes small quantities by hand or uses her feet to produce larger amounts, combining clay and temper is usually performed indoors (Table 6). Forty-three of the 50 potters mix the clay body inside their houses, five conduct the activity outdoors on the patio, and two perform the task within a separate facility (i.e., covered area), specially used for pottery manufacturing. The time required to complete this activity varies as a function of the amount being prepared: amounts combined by hand (usually under 10 kilograms) can be mixed in about 30 to 40 minutes, while quantities up to 50 kilograms require several hours.

As Table 6 indicates, there are two potters in Sehualaca who conduct production activities within special structures. These structures are roofed-over areas of the patio that are used entirely for ceramic manufacture. Both of these potters devote more than four days per week to production activities and noted that production is more efficient if all materials and tools are located in the same place. It appears that these potters are responding to increased production intensity by establishing distinct activity areas within the compound. The allocation of space in this fashion thus serves to minimize task interruption and helps insure higher levels of production output (P. Arnold 1987). The use of special production areas under conditions of increase production intensity has been documented among other household producers in Mesoamerica (Krotser 1974; Reina and Hill 1978).

Vessel Formation

The ceramic producers in the Tuxtlas actually practice two methods of vessel formation, although one is by far the more common. In either case, the technology is decidedly primi-

Table 6. Location of material preparation activities within the houselot.

Community	INSIDE HOUSE	Storage		OUTSIDE HOUSE	Storage		OUTSIDE HOUSE IN SPECIAL FACILITY	Storage	
	Mixing	Clay	Temper	Mixing	Clay	Temper	Mixing	Clay	Temper
San Isidro	17	11	11	1	7	7	-	-	-
Bascascaltepec	2	2	1	-	-	1	-	-	-
Chuniapan de Abajo	15	15	16	2	2	1	-	-	-
Sehualaca	9	10	11	2	1	-	2	2	2
TOTAL	43	38	39	5	10	9	2	2	2

tive; the potter either models the vessel from a solid lump of clay or used a simple mold to form the object. No separate rotating device is used, such as the potter's wheel or the Mayan *kabal* (e.g., Foster 1955; Thompson 1958). Nor are any vessels constructed in separate episodes, with the upper and lower portions formed at different times. This method of formation, however, was observed by Krotser (1974) in a lowland community to the southeast of the study region.

Parado

The most common method of vessel formation in the Tuxtlas is called *parado* ("standing upright" or "standing on end") and consists of shaping the entire vessel from a single mass of solid clay. This same process and terminology are also used by potters outside the Tuxtlas; it may refer to the actual creation of the vessel, or it may reflect the fact that most potters conduct this activity while standing (Krotser 1980; Whitaker and Whitaker 1978).

There are five main production tools used in parado construction. The most important is the locally available jicara gourd (Crestentia cujete). Potters use small pieces of this gourd during the entire formation process, first to shape the vessel body and later to smooth the interior of the vessel. The second tool is a sieve (*cernidor*), usually made of a discarded sardine can with a perforated bottom. Potters use the cernidor to add small amounts of temper to the clay and to coat the work surface with a thin layer of temper. A small can or plastic cup holds the water that is continually added to the clay body. Pieces of jicara are also stored in this container. A section of old cloth (*trapo*) is the fourth tool. The potter uses the trapo to create a smooth rim on the finished vessel. The final tool is called a *raspador*: a flat, sharp-edged piece of metal made from an exhausted machete blade, knife, or any other available material. The raspador is used to shave the walls of the dried vessel and to remove the solid base of clay that is a characteristic of parado construction.

The potter prepares the work surface by placing a handful of temper in the cernidor and covering the work area with a lens of sand or volcanic ash. Depending on the size of the desired vessel, a mass of clay weighing between 0.5 and 1 kilogram is then placed on the board and is wedged with the temper. The potter kneads the mass for about five minutes, occasionally adding temper, until she is confident that the correct proportion of temper has been achieved and is properly distributed throughout the clay body. The potter then forms the clay into a cone and sets it aside while the process is repeated. When a sufficient number of these cones has been made, the potter is ready to begin formation.

A small amount of water is sprinkled on the work surface to keep the clay from sticking to the wood. The potter then places the cone upside-down, so that the small end rests on the board and the larger end extends upward. It is from this larger end that the vessel will be formed. The small end serves as a support so that the clay mass can be rotated. After the vessel has dried, this lower support is cut away and the clay is reused for another vessel.

The potter begins formation by using her fingers to extract small amounts of clay from the center of the large end; the entire mass is rotated, and the clay is pushed against the palm of the other hand to begin forming the vessel walls (Figure 6a). After several rotations, sufficient clay has been built up along the edges of the cone. At this point, the potter takes a piece of jicara and repeats the process, slowly turning the cone while the gourd fragment is use to push the clay wall upwards and outwards (Figure 6b). One of two strategies can be followed, depending on the type of vessel. If a comal is being made, the potter continues shaping and thinning the vessel walls until they extend outward at about a 70 degree angle and the vessel is approximately 28 centimeters in diameter (Figure 6c). If a jar or bowl is the end product, the vessel walls are pushed upwards and inwards while the lower portion is extended outwards until the desired shape is achieved (Figure 6d). At the same time the potter continues to pour small amounts of water on the work surface. The potter will also use various sized pieces of jicara to smooth the vessel interior.

Finally, the potter takes a damp piece of cloth and, holding it over the rim of the vessel with one hand, uses the other hand to spin the vessel thereby creating a smooth and regular rim (Figure 6e). The rim is the only portion of the vessel that is prepared in this fashion, although scraping the vessel interior with the gourd also produces a relatively smooth finish. Once the vessel is finished, it is put aside, another cone is selected, and the sequence is repeated.

The spinning motion attained during this procedure is never pronounced, so it does not provide the centrifugal force achieved with the potter's wheel or even the slower, continuous lathe-like motion noted for some potters using the kabal (e.g., Thompson 1958). The parado technique does make production somewhat easier and more rapid, however. A potter forming a medium size comal can finish in approximately 10 minutes, while a small bowl (tecualon) requires about 8 minutes and a larger jar (olla) or basin (cazuela) can be completed in 15 or 20 minutes.

<u>Palmeado</u>

The second, and less common, form of vessel production is called *palmeado*. It used only to manufacture comales and tostadores. This procedure employs a technique reminiscent of concave mold-making (e.g., Foster 1955), although the "mold" in this case is not a specialized implement. The potter begins by sprinkling a small amount of temper on the work surface, but considerably less time is devoted to wedging the clay. Once the clay body is prepared, the potter uses her palm to flatten out the clay, much like she would a tortilla (Figure 7a). The clay is usually set on a circular piece of plastic so it does not stick to the wood surface and can be more easily turned. When finished, the clay has been pressed into a flat disk, about 2 centimeters thick and approximately 28 centimeters in diameter.

The potter then places this flat disk into a makeshift mold, consisting of a plastic or metal tub (*palangana*) that has been covered with a piece of cloth (Figure 7b). The cloth is

(a)

(b)

(c)

Figure 6. Vessel formation using parado technique.

(d)

(e)

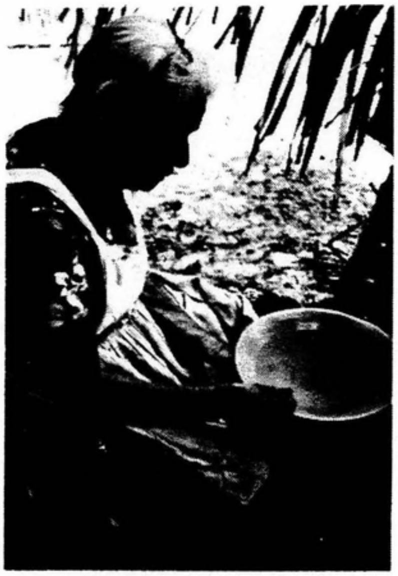

Figure 6. (Continued).

secured by tying its corners together underneath the tub. A piece of string may also be wound around the lip of the tub to further secure the cloth. Even so, the cloth is not rigid and there is slight depression where it is stretched over the mouth of the tub.

Potters practicing this technique own an average of 6 palanganas, although the number varies widely. Some potters may own several tubs but primarily use one or two. Vessel size is determined by the diameter of the clay disk prepared by the potter, not the palangana.

After the clay has been set atop the cloth, the potter will wet a piece of jicara and use it to smooth the clay disk (Figure 7c). The pressure applied during smoothing, in addition to the weight of the clay, causes the cloth to sag and give the clay disk a concave appearance. The potter uses her finger, rather than a wet cloth, to smooth the edges of the clay. When the vessel is sufficiently uniform the tub is set aside until the clay has dried and is ready to be fired (Figure 7d). This process results in a comal that is similar to those produced by the parado technique, although they are usually flatter and more shallow. The palmeado procedure requires less skill on the part of the potter. Comales can be completed in about 6 minutes using this technique.

The vast majority of Tuxtlas potters favor one method of production. Table 7 presents information on the distribution of these techniques and the average production frequency associated with them.

Sixty-eight percent of the potters (34) exclusively practice parado formation, while 84 percent (42) practice it alone or in combination with palmeado production. Sixteen percent (8) use only the palmeado technique.

From the perspective of production frequency, the data are suggestive but not conclusive. In order to determine whether or not there was a significant difference among the various groups, Mann Witney U tests were performed. The results indicate that, while those potters only using the parado technique exhibit the highest average production frequency, no difference between the groups exists at the .05 level of significance. In other words, while there is a tendency for parado production to associate with a higher production frequency, the relationship is not statistically significant.

Vessel Drying

Drying the ceramics is perhaps the least complex stage in production sequence. Drying requires little work on the part of the potter, save for physically moving the vessels and checking their progress over time. Ceramic producers in the Tuxtlas do not use drying racks and potters rarely attempt to accelerate drying rates by exposing the vessels to low heat over the hearth, a practice common in other tropical areas (e.g., D. Arnold 1985; Reina and Hill 1978).

(a)

(b)

Figure 7. Vessel formation using palmeado technique.

(c)

(d)

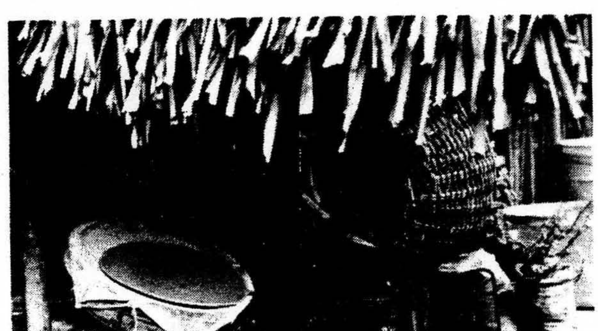

Figure 7. (Continued).

Table 7. Formation techniques and associated mean production frequencies.

Community	Parado	Mean Production Frequency	Palmeado	Mean Production Frequency	Combination	Mean Production Frequency
San Isidro	18	3.88	-	-	-	-
Bascascaltepec	-	-	2	1.62	-	-
Chuniapan de Abajo	3	2.16	6	2.66	8	2.00
Sehualaca	13	3.15	-	-	-	-
TOTAL	34	3.45	8	2.40	8	2.00

Despite the relative ease with which drying is conducted, these activities do have important implications for the organization of production. After the vessel has been formed, it is set outside on the patio to dry. Potters begin working in the morning and vessels are left outside until dusk. Vessel drying, therefore, generally lasts between 6 and 8 hours.

Pots in this *verde*, or "green," state are fragile. During this period, therefore, the space occupied by the pots cannot be used for other purposes. Children and animals are not permitted to get too close to the vessels, and play is discouraged in all areas of the patio.

After the pots have dried, the solid clay base left over from parado formation must be removed and the vessel walls shaved to the correct thickness. As noted earlier, potters perform this task with a raspador. In Chuniapan de Abajo, however, potters sometimes use a piece of jicara to conduct the same activity. Potters usually sit in the shade while thinning the vessels, staying either indoors or under a tree on the edge of the patio. The clay that is removed during this process is also recycled.

Vessel Firing

Open Firing

Firing vessels without the use of a facility to partially control atmospheric conditions is commonly referred to as open firing or mixed firing (D. Arnold 1985; Rye 1981). Among the Tuxtlas potters, open firing is the most common procedure for baking ceramics, with almost two-thirds of the producers (N=32) firing in this fashion.

To fire in the open, the potter begins by covering the ground with a layer of wood (Figure 8a). This bed of fuel (*cama*) actually serves three purposes: (a) it separates the pots from the wet ground, as the steam produced by heating the surface may break the ceramics; (b) it raises the pots off the ground so that air can circulate underneath, providing more complete oxidation; and (c) it serves to make the distribution of heat more even, by burning material both above and below the pottery. Other potters in Mesoamerica follow this procedure for similar reasons (e.g., Reina and Hill 1978).

Once the bottom layer of fuel has been laid down, a support is often placed in the center of the fuel. In some cases a brick was used, other producers used a large portion of a broken olla, and one potter used a metal stake. Pots are then laid against this support in an overlapping manner, slowly increasing the number of vessels as the pile grows larger (Figure 8b). Producers will take great care to place the vessels properly, because if one of the interior vessel should shift or collapse, the entire pile might fall inward and a number of pots will break. Potters who are firing several different vessel types will always place the comales on last -- these serve as a kind of insulation and help retain the heat. Between 20 and 30 comales are fired alone, or a group of five ollas, several tecualones and about 20 comales might be fired. Potters generally average about 25 vessels per open firing.

(a)

(b)

Figure 8. Vessel firing in the open.

When the pots have been properly arranged, the producer will ignite the fuel on the bottom and then lay the remaining wood against the pile, producing a tipi-like structure (Figure 8c). If the potter waited until the pile was finished before lighting the fuel, the bottom would have less oxygen and burn more slowly, causing an uneven distribution of heat. When she is finished adding the fuel, the potter carefully watches the fire, occasionally adjusting the fuel or even adding a small piece or two (Figure 8d). After the firing is completed, the potter will spread out the ceramics and allow them to cool. Firing usually takes about 2 hours, with another hour before the ceramics are cool.

Pyrometric readings were unavailable for the Tuxtlas firings, but visual estimates do present a consistent range of temperatures. Flame color is a common method by which pre-industrial potters gauge firing temperatures (Foster 1955; Lackey 1982; Reina and Hill 1978), and a system for estimating temperatures from the color of the fire has been developed. According to Fournier (Fournier 1973, cited in Lackey 1982:116) the correspondence of color to temperature is as follows: black heat = 400 degrees Centigrade; dull red heat = 500 degrees Centigrade; red heat = 700 degrees Centigrade; orange-red heat = 850 degrees Centigrade; yellow heat = 1100 degrees Centigrade; and white heat = 1350 degrees Centigrade. This system was verified by Lackey (1982) who, using a pyrometer, noted a close correspondence between these colors and temperatures during pottery firings in Acatlan, Mexico.

According to this chromatic system, the temperatures achieved during open firings in the Tuxtlas fall between 700 and 850 degrees Centigrade. Temperatures may have even been slightly higher during wind gusts. These estimates compare favorably with other known open-firing temperatures. Colton (1951) noted temperatures between 720 and 885 degrees Centigrade among the Hopi, while Shepard (1956:83) reports temperatures up to 890 degrees Centigrade for pottery fired by the Cochiti. These potters, however, were using fuels (such as sheep dung and cottonwood) that might burn hotter than the materials used in the Tuxtlas.

In terms of fuel, comparable data are available from various New Guinea potters. Irwin (1977, cited in Rye 1981) recorded maximum temperatures between 840 and 920 degrees Centigrade for Mailu Island potters who were using coconut fronds and husks to fire unglazed cooking jars. The ceramic producers of the Goodenough Islands, firing with sago fronds, attained temperatures between 680 and 880 degrees Centigrade. It would thus appear that the estimates for the Tuxtlas producers fall comfortably within the range of temperatures documented for other potters firing under similar conditions.

Kiln Firing

The use of kilns (*hornos*) has a very limited distribution in the Tuxtlas. Only the potters of San Isidro use kilns, and kiln firing is the only form of vessel firing conducted in that community. Hornos are located adjacent to the house on the edge of the patio and each

(c)

(d)

Figure 8. (Continued).

house averages one facility. In two instances this pattern was not followed. In one case the potter did not have a kiln and used a neighbor's horno to fire her ceramics. This woman stated that she did not work often enough to invest the time and effort into a kiln. In the second case there were two hornos in the household. The potter was in the process of moving the kiln closer to her house and had not yet dismantled the original facility. These two facilities were not used simultaneously, although the potter did fire in each of the kilns on separate occasions. When questioned about the continued use of the older kiln, the potter claimed that the new kiln was not quite ready (*ya no está listo*), even though it had been finished for about a week.

Kilns are above-ground, updraft facilities that are constructed out of adobe, clay, and a few stones. Measurements are available for 12 of the kilns in San Isidro. The average diameter, including the walls, was 103.75 centimeters (s.d. = 8.26 centimeters), and the average interior diameter was 84.83 centimeters (s.d. = 6.76 centimeters). The average height from ground surface was 69.91 centimeters (s.d. = 13.11 centimeters).

Kilns are divided into an upper (firing chamber) and lower (firebox) section by means of pieces of scrap metal that rest on a post in the center of the kiln. These pieces of metal were often taken from old cars, with chassis springs and leaf springs as the preferred parts. These metal bars rest on rocks that protrude from the interior wall of the horno and the pieces of metal extend from the sides to the center post. The use of a central post is this fashion is known from other parts of Mexico (Foster 1955), and archaeological data suggest it has considerable antiquity (Kneebone and Pool 1985; Winter and Payne 1976). In certain parts of Mexico this post is called the *macho* (Foster 1948, 1955) while in the Tuxtlas it is referred to as the *ombligo*. The firebox averages 27.16 centimeters in height (s.d. = 4.08 centimeters) while the firing chamber has an average height of 42.83 cm (s.d. = 11.66 centimeters). A small opening at the base of the kiln provides access to the firebox.

Prior to filling the kiln, the potter first removes any debris left over from the previous firing. This debris is often swept into the small streams adjacent to the households. The potter then re-arranges the metal pieces, insuring that they are securely positioned and will allow the heat to circulate properly. The potter may even place large pieces of broken vessels atop the pieces of metal for extra support against the weight of the pottery to be fired. Finally, she begins placing the ceramics in the horno (Figure 9a). Larger items, such as ollas and cazuelas are the first vessels to be loaded. These ceramics are placed mouth downward, to insure that the interiors are fired as well as the exteriors. Smaller vessels, including tecualones and *maseteras*, form the second layer of ceramics. In a procedure similar to open firing, the last items are the comales, again serving as a heat insulator. Large pieces of broken ceramics provide the final touch and an additional layer of insulation (Figure 9b).

The potter starts a small fire in the mouth of the firebox, often before the kiln is completely filled. This fire burns as the remaining vessels are loaded and slowly heats the con-

(a)

(b)

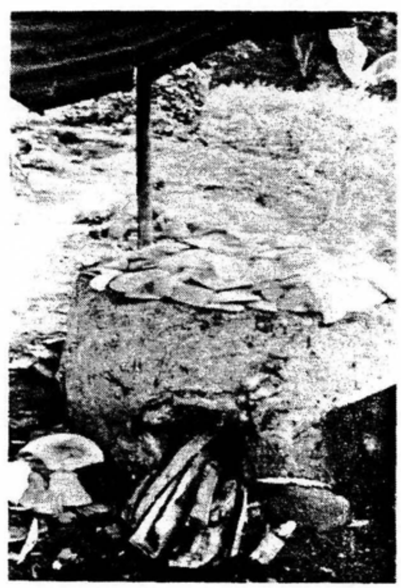

Figure 9. Vessel firing in kilns.

tents of the horno. This initial heating is termed "water smoking" by ceramic technologists, and refers to a period during which the last remnants of water are driven out of the clay (Shepard 1956).

Kilns are fired for a period of about 4 hours, with maximum temperature maintained for approximately 1.5 hours. Pots are often left in the kiln overnight and are removed the following morning when the kiln has completely cooled. Temperatures for kiln firing are estimated to fall within a range similar to open firing, although the maximum temperature does not appear to greatly exceed 800 degrees Centigrade. While it might seem unreasonable that kilns produce slightly lower temperatures than open firing, this assessment is also supported by ethnographic accounts of unglazed, utilitarian wares fired in simple updraft kilns. In Acatlan, potters fire to temperatures from 750 to 800 degrees Centigrade using cactus and rubber as fuel (Lackey 1982). The potters of Jaba'a, Palestine, using rubber and dung, fire to temperatures in the low 700 degrees Centigrade (Rye 1981). Diaz (1966) reports a temperature of 850 degrees Centigrade for firing *loza de olor* ceramics, with fuel consisting of wood and dung. Finally, refiring experiments, currently being conducted by the Matacapan Archaeological Project, have been used to estimate firing temperatures for both archaeological and ethnographic ceramics. Using clays from several Tuxtlas sources, including San Isidro, the tests have indicated that oxidizing temperatures between 750 and 800 degrees Centigrade produce colors similar to those from kiln-fired archaeological ceramics.

Depending on the items being fired, a kiln load usually consists of 30 to 50 vessels. Potters fire about once a week, generally on Thursday or Friday, so that ceramics can be taken to the weekend market. In a few instances, potters stockpile small quantities of vessels, especially at the end of the dry season. Producers say they are able to obtain a higher price per pot as wet season production falls sharply and fewer ceramics can be found in the market.

Breakage Rates

The percentage of vessels that break during a firing, or the "firing loss" (Rye 1981:118) is an important tool for comparing production efficiency among various potters. Consistent patterns of breakage may indicate problems in manufacture, as suggested in Guthe's (1925) comment that the entire base of vessels produced by the San Ildefonso potters often breaks off during firing. Evidence for a lack of atmospheric control while firing is manifested in bloating, warping, spalling, and dunting cracks (Rye 1981; Shepard 1956). Finally, the occurrence of misfired sherds is of interest to archaeologists wishing to reconstruct levels of production frequency and intensity (e.g., Feinman 1980, 1985; Redmond 1979; Santley et al. n.d.).

Patterns of breakage rates from the Tuxtlas are presented in Table 8. These data indicate that there is a distinct difference between kiln and open firing in terms of breakage

Table 8. Comparison of firing loss for kiln and open firing in the Tuxtlas.

	Firing Loss		Production Frequency[1]		Firing	
Community	Mean	Median	Manufacturing	Firing	Temperature	Length[2]
Kilns	21.0%	20.0%	3.00	1.00	700 - 800	4.00
Open Firing	31.5%	27.0%	2.50	1.00	750 - 850	2.09

[1] Median days per week.
[2] Median hours.

rates. Two factors appear to be primarily responsible for this difference. The first is the relationship between temperature and time -- open air firing achieves a slightly higher temperature in about half the time and the pots cool more quickly. As noted above, potters using kilns also water smoke their vessels, while potters firing in the open do not. The comparatively rapid heating and cooling associated with open firing certainly contributes to higher rates of breakage.

A second factor involves production frequency. Although most potters use similar clay/temper ratios and formation techniques, kiln-using potters work more frequently. Since firing periodicity is similar, it appears that potters manufacturing vessels less frequently are more likely to make critical errors that would result in firing loss. To test this relationship, a Spearman's correlation was performed on production frequency and firing loss for open firing only. A negative relationship ($r = -0.343$, $p > .05$) does indicate that firing loss and production frequency are inversely related. This relationship, however, is neither particularly strong nor is it significant.

One possible cause of this weak association is the fact that a third variable, producer's age, might also be affecting the relationship. Older potters work less frequently, but also have more production experience. These senior potters are thus represented at lower production frequencies, while at the same time they lose fewer vessels during firing. This situation is known to have occurred in two of the "aberrant" cases. If these two cases are removed from the calculation, a significant correlation coefficient of -0.55 results ($p < .05$). Conclusive evidence for this possible association must await further research.

III. CERAMIC CONSUMPTION IN LOS TUXTLAS

Vessel Frequencies

The number of vessels within the household assemblage of Tuxtlas potters is relatively consistent from one community to the next. Among the 50 households inventoried the average number of vessels was 6.58 with a median of 6.00 (Table 9). Households in Sehualaca have the highest overall mean number of vessels (7.53), while Bascascaltepec households contain the lowest average number of vessels (4.50). The figure for Bascascaltepec cannot be totally attributed to sample size; it appears that households in this community are replacing many of their ceramic vessels with plastic or metal alternatives (see below). The data from Sehualaca, on the other hand, include one household which contained 13 persons and a total of 19 vessels. When this outlier is removed and the Sehualaca average is recalculated, the mean number of vessels becomes 6.58 with a median of 6.00.

The patterning displayed in Table 9 underscores several important components of the relationship between vessel occurrence (i.e., presence or absence) and frequency (i.e., total number): (a) the vessel's role in food preparation, (b) the multipurpose nature of the ves-

Table 9. Ceramic assemblage frequencies from sampled Tuxtlas households.

Vessel Type	Community San Isidro	 Bascas-caltepec	 Chuniapan de Abajo	 Sehualaca	 Total
Comal					
Mean	2.11	1.50	1.82	1.69	1.88
Median	2.00	1.50	2.00	2.00	2.00
Tecualon					
Mean	1.55	2.00	2.11	1.38	1.72
Median	2.00	2.00	2.00	1.00	2.00
Cazuela					
Mean	1.00	----	0.64	2.15	1.14
Median	1.00		0.00	2.00	1.00
Olla de Frijol					
Mean	1.22	0.50	0.76	1.23	1.04
Median	1.00	0.50	1.00	1.00	1.00
Olla de Maiz					
Mean	0.38	----	0.41	0.92	0.52
Median	0.00		0.00	1.00	0.00
Tostador					
Mean	0.22	0.50	0.41	0.16	0.28
Median	0.00	0.50	0.00	0.00	0.00
TOTAL					
Mean	6.50	4.50	6.17	7.53	6.58
Median	6.50	4.50	6.00	7.00	6.00

as well as a reduction in the proportion of households containing this vessel type. Given the importance of corn in the campesino diet, one might expect the same situation as that noted for bean jars -- that each house would have at least one jar for cooking corn. As Table 9 indicates, however, the average household has only 0.5 of these vessels, or stated another way, only about half of the households in the sample contain ollas de maiz. The actual number is 23 households, with three of the houses containing 2 such vessels and the remaining 20 houses possessing one olla each. Of these 23 houses, 11 were located in Sehualaca, six occurred in Chuniapan de Abajo, and the remaining six were encountered in San Isidro. In other words, not only are maize jars represented in less than half the total households, but almost half of these vessels were found in a single community.

The numerical difference between bean and corn ollas becomes more understandable when the technological system of food preparation is considered. The technological system involved in the preparation of food has been shown to affect both the number of vessel forms within the assemblage and the frequency of vessels within those forms (e.g., Braun 1983; Smith 1983). For example, Nelson (1985) provides a comparison of corn preparation technology between the Highland Maya and the Tarahumara. The Highland Maya employ a strategy in which the corn is soaked, boiled, ground while wet, and finally boiled again. The Tarahumara, on the other hand, parch their corn, grind it in a dry state, and then boil it. Nelson (1985) concludes that the intensive wet-grinding technology of the Highland Maya is more demanding in terms of assemblage size and diversity than the primarily dry-grinding carried out in the Tarahumara area.

When compared with corn, beans require a preparation technology that is considerably less intensive. Beans are washed, soaked overnight, and then boiled for several hours. When ready, beans are eaten whole or mashed. Corn, on the other hand, is first soaked in a lime solution, boiled, and then ground. The process of grinding corn is especially arduous and time consuming. Among one Zapotecan community in Oaxaca, for example, corn grinding is said to take between six to eight "woman-hours" per day for the average household (Chinas 1973, cited in Isaac 1986).

Data from other areas of Mexico likewise underscore the time-consuming nature of corn grinding (Foster 1967; Vogt 1970). Grinding corn by hand is conducted within the more traditional Tuxtlas households; more common, however, is the reliance on local, mechanized grinding "mills." The soaked and boiled corn is brought to these shops early in the morning, where it is ground into a corn dough. The women then return to the houses where they make tortillas from this dough.

The technological simplicity with which beans are prepared would suggest that the number of vessels associated with their preparation, and the frequency of those vessels, would be minimized. There is no technological reason to have more than one vessel (soaking and boiling is conducted in the same vessel), nor is there a behavioral reason (everyone is served from the same jar). When coupled with the almost ubiquitous observation that

food prepared in ceramics tastes superior to that prepared in metal containers (e.g., Foster 1965; Rice 1984), these facts would indicate a lack of incentive to alter the status quo food preparation technology. As a consequence, the frequency of vessels associated with bean preparation is likely to be small and is not expected to vary markedly from community to community.

As noted above, however, the number of maize jars within a community's assemblage does vary considerably. In this instance there is a definite incentive to alter the traditional food preparation technology. A main reason for this variability is the use of grinding mills noted above. It appears that there is an inverse relationship between the frequency of ollas de maiz and the patronage of these shops. This pattern is certainly the case at San Isidro where two-thirds of the visited households do not use ceramics for boiling corn and do not grind the corn by hand. A similar relationship was also indicated in Chuniapan de Abajo.

In both these communities metal pots are used in place of ceramics to boil corn. Because the corn is ground after it is cooked, it is not subject to the same culinary restrictions that surround the consumption of beans. In other words, concerns with food texture and color are not nearly as important for maize as they are for beans because the corn is further processed after boiling. Under these circumstances the use of metal pots is apparently more acceptable. It is interesting to note that a few informants mentioned that the taste of corn ground by machine was inferior to that of corn ground by hand. In this case, however, it may not be the use of the machine that affects the flavor as much as the use of metal pots to boil the corn. Despite their pronouncement, most of these same individuals feel that the difference in taste is not particularly significant.

The tostador is the least common vessel type encountered among the Tuxtlas households. The average household in the Tuxtlas sample contained 0.28 vessels, with a median value of 0.00. In reality, only 13 houses contained these vessels, which are primarily used for toasting coffee or less frequently corn. Tostadores are most common in Bascascaltepec and Chuniapan de Abajo. The emphasis on household-level coffee production in these communities is partially a function of access to local markets. As noted earlier, both these communities are located a considerable distance from markets and have poor access in terms of transportation. The majority of Tuxtlas households prefer to purchase coffee at the market, where they can obtain ground beans that have been mixed with sugar, a favorite drink throughout the region. Those households with limited access to the market, however, are more likely to produce their own coffee for personal consumption. It is not surprising, therefore, that the percentage of houses with tostadores is almost twice as high in Chuniapan and Bascascaltepec than in San Isidro and Sehualaca (36.84% vs. 19.35%), even though about the same percent of households produce the form in both groups (52.63% vs. 51.61%).

Vessel Frequencies and Replacement

Although data are available for ceramic consumption from both Africa (David 1971; David and Hennig 1972), and the Philippines (Longacre 1981, 1985), this comparison of assemblage size in the Tuxtlas with other groups focuses on ceramic consumers in the New World. As discussed previously, variation in diet and food processing technology have been identified as important factors conditioning the formal and numeric variability within a ceramic assemblage (Braun 1983; Nelson 1981, 1985; Smith 1983). Sorghum is the staple among the Fulani of Africa (David and Hennig 1972), while the Philippinos enjoyed a diet dominated by rice (Longacre 1985). Manioc is a major foodstuff among the Shipibo-Conibo, but corn is also a prominent component of their diet (DeBoer and Lathrap 1979). For this reason, the Shipibo-Conibo are included in the following discussion.

Overall, the average vessel assemblage among Tuxtlas potters contains a much smaller number of vessels than many cases observed for other ceramic producing groups in Mesoamerica. Recent studies carried out among the Highland Maya in Chiapas, Mexico, and Huehuetenango, Guatemala, indicate a significantly greater number of ceramic vessels within the assemblage (Deal 1983, 1986; Nelson 1981, 1985). From a sample of 51 households, Nelson (1985) notes that the average household in San Mateo Ixtatan contains 57 vessels. A comparable number of ceramic vessels was documented by Foster (Foster 1960), who recorded an average of 61.22 vessels from three households in Tzintzuntzan, Mexico. These two cases constitute the high extreme of vessel frequencies documented for New World groups.

Somewhat lower vessel frequencies, but still higher than those recorded in the study region, were observed among the Shipibo-Conibo of central Peru (DeBoer 1974; DeBoer and Lathrap 1979). During an early study, DeBoer (1974) reported an average of 17.14 vessels from a sample of 7 households. Further research and a larger sample reduced this number to a mean of slightly over 15 complete vessels from each of 18 households (DeBoer and Lathrap 1979). The Tarahumara of northern Mexico exhibit a smaller inventory (Pastron 1974). Based on a sample of 10 households, one can use Pastron's data (1974) to estimate an average assemblage size between 9 and 12 vessels. These examples fall within the middle range of documented New World ceramic assemblages.

There is only one study to date which presents an average assemblage size that resembles that found within the Tuxtlas. Hagstrum (1985, 1987) has recently reported some of the results of her investigations among ceramic producers and consumers in the highlands of Peru. A total of 200 households were inventoried, resulting in an average assemblage size of 8.40 vessels per household. These potters, like those in the Tuxtlas, were increasingly incorporating metal containers into their assemblages, thereby reducing the number of ceramic vessels in use (Hagstrum 1987).

The broad range of variability that characterizes these assemblage frequencies denotes a complex relationship between number of vessels, number of individuals, and

access to ceramics. One of the more common questions concerning assemblage size is the relationship between the number of vessels within a household and the number of individuals using those ceramics (e.g., Kramer 1985; Nelson 1981). Data from the majority of cases noted above indicate that such a relationship is weak at best. Nelson (1985) demonstrates that, despite the overall difference in vessel numbers, figures for household populations are relatively consistent from one group to the next. The numbers range from a low of approximately 4 persons per household among the Tarahumara to a high of 6.5 persons from the Highland Maya. To this account we add the figure of 5.7 persons per household noted by Hagstrum (1987) and the mean household size of 6.28 persons in the Tuxtlas sample. As Nelson (1985) argues, the variability in assemblage size is not matched by variability in average populations figures from the studied communities.

Another way to investigate the relationship between household population and assemblage size is by a correlation analysis. For the Tuxtlas data a Spearman's correlation between vessel frequencies and population produced a coefficient of 0.26, indicating that approximately seven percent of the variability in one variable is "explained" by the other. When taken as a whole, therefore, data from the Tuxtlas also suggests a weak relationship between household population and assemblage size.

When the same relationship is investigated for individual communities, however, a much different picture is produced. In two instances the correlations produced values notably higher than the regional figure. The Spearman's coefficient for assemblage size and household population in San Isidro is 0.68, accounting for almost seven times as much variability. In Sehualaca the relationship produces a coefficient of 0.39, explaining about twice as much variability as the regional figure. When combined, these two communities attain a coefficient of 0.54. While not overwhelming, they suggest that the relationship between household population and assemblage size varies from community to community.

In both Chuniapan de Abajo and Bascascaltepec, on the other hand, a much different pattern was observed. The Spearman's correlation for Chuniapan de Abajo is -0.008, indicating a slight inverse relationship between population size and number of vessels. This negative relationship is also apparent in Bascascaltepec, where the two cases produced a coefficient of -1.00. The perfect correlation is a function of the sample size ($N=2$), but the negative value is not a necessary result. When combined, these communities produce a correlation coefficient of -0.12. Ignoring the strength of these relationships for the moment, it still appears that there are important differences between the former group of production communities as compared to the latter.

The fact that household size and number of ceramic vessels are related is further suggested by a chi-square analysis of the two variables. Table 10 presents a contingency table comparing high and low household population figures with high and low assemblage sizes. In both cases groups were separated based on the median value for all 50 cases. As the contingency table demonstrates, there is distinct variability among the groupings, with small

ASSEMBLAGE SIZE	HOUSEHOLD POPULATION: LOW ≤5	HOUSEHOLD POPULATION: HIGH >5	Total
LOW ≤6	18 (14)	10 (14)	28
HIGH >6	7 (11)	15 (11)	22
	25	25	50

$X^2 = 5.18$, $p < .05$, df. 1

Table 10. Contingency table of household population by assemblage size.

household populations more likely to have fewer vessels than large household populations. The chi-square statistics of 5.18 is significant at the .05 probability level.

These findings indicate that, despite the low overall correlation between household size and ceramic assemblage for the entire sample, important inter-community relationships between these two variables do exist. However, the analyses suggest that it is only when certain conditions are met that a significant relationship can be expected. Many of these conditions can be grouped under the concept of replacement ease, or the degree to which new ceramic vessels can be obtained after a vessel has worn out or is broken.

Available data from the Tuxtlas and other New World cases suggest that the ease with which a new vessel is obtained to replace an old or broken vessel is a critical factor in household assemblage size (DeBoer and Lathrap 1979; Hagstrum 1987; Nelson 1985). One variable affecting ease of replacement is the number of potters within a community. This relationship is exhibited among the households studied by Nelson (1985). In this case households average 57 vessels per household and most of the households do not have their own potter. Ceramics must be obtained from the market, usually with cash. Nelson (1985) attributes the high number of vessels in part to "stockpiling," or the accumulation of new ceramics while older vessels are still in use. This necessity is brought about by the relatively short use life of the vessels and the fact that it is often difficult to obtain replacement vessels. As a result, households keep a number of extra vessels on hand so that the normal operation of household activities will not be unnecessarily interrupted. Under these circumstances, vessels numbers vary not as a direct function of household population, but as a function of available cash and the schedule of market attendance. Households thus accumulate ceramics according to a less predictable (in terms of family size) and more irregular strategy. Over the longer periods usually reflected in the archaeological record, vessel "stockpiling" may artificially inflate assemblage size and produce an erroneous assessment of household population.

Activities such as "stockpiling" may also be necessary even though the household contains ceramic producers. In this case, either production frequencies are very low, or the technology of production limits production output. Among the Shipibo-Conibo, for example:

> ...the frequency of ceramic vessels is not directly governed by immediate households needs. In the Conibo village of Iparia...fully half of the complete vessels were stored in the rafters as future replacements for broken vessels or as 'special occasion' ware immediately available for serving guests [DeBoer and Lathrap 1979:124].

The reason that these potters might wish to store half of the assemblage is in part a response to the specific cultural tradition of these Indians; that is, their custom of serving household visitors beer in a newly-made ceramic mug. This possibility, however, only accounts for a small portion of the household assemblage. In fact, beer mugs constitute only about 10.5 percent of the complete vessels within the domestic Shipibo-Conibo

ceramic inventory (DeBoer and Lathrap 1979). A more likely explanation for the need to store extra vessels is the ceramic production technique in which pots are usually fired singly (DeBoer and Lathrap 1979). Under these circumstances, it would be more efficient to have a number of vessel on hand, rather than performing the entire production process for a single vessel. Thus, although these households contain potters, the production technology limits the rate at which new vessels are available. Again, it would not be reasonable to expect a good relationship between household population and assemblage size.

The Tuxtlas data are in agreement with this expectation. In this instance, replacement ease can be monitored in terms of production frequency, access to market, and proportion of households engaged in manufacturing a given pottery type. Accordingly, both San Isidro and Sehualaca should replace vessels more rapidly, while Chuniapan de Abajo and Bascascaltepec should be more limited in their ability to obtain new ceramics. San Isidro and Sehualaca potters operate at significantly higher levels of production frequency than potters in Chuniapan de Abajo, a relationship which is not significantly altered if Bascascaltepec producers are included with Chuniapan de Abajo. Thus, households in San Isidro and Sehualaca produce goods more frequently and can obtain new ceramics with considerably more ease than those of the other communities. In addition, San Isidro and Sehualaca enjoy a more favorable position in terms of proximity to major markets. This position is a function of both linear distance and available transportation networks.

Figure 10 presents a graph indicating the percentage of households producing the six main vessel forms, contrasting production in San Isidro and Sehualaca with that in Chuniapan de Abajo and Bascascaltepec. As the graph demonstrates, there is important variability between the two groups. In only one case, that of the tostador, are the communities of Chuniapan de Abajo and Bascascaltepec similar to San Isidro and Sehualaca. Comales are produced in all sampled households, and the manufacture of ollas de maiz is only slightly less in Chuniapan de Abajo and Bascascaltepec than in San Isidro and Sehualaca. Among the remaining three vessel types, tecualones, cazuelas, and ollas de frijol, dramatic differences are in evidence. The greatest difference involves the production of cazuelas. Eighty-seven percent of the sampled households in San Isidro and Sehualaca manufacture cazuelas, as compared with 21 percent of the households in Chuniapan de Abajo and Bascascaltepec.

A second factor includes the number of households which use a given vessel type but do not manufacture that type. It would be meaningless to argue for differences in ease of replacement if all households only use those vessels they are producing. Table 11 provides data on the percentage of households that use a given vessel type but do not manufacture that type. These figures provide a general measure of one facet of the difficulty in replacing ceramics. As the data indicate, there are striking differences between the use and production of vessels among the Tuxtlas communities.

All households make and use their own comales, so this vessel type is not affected by replacement ease. Among the remaining vessel forms, however, differences are apparent.

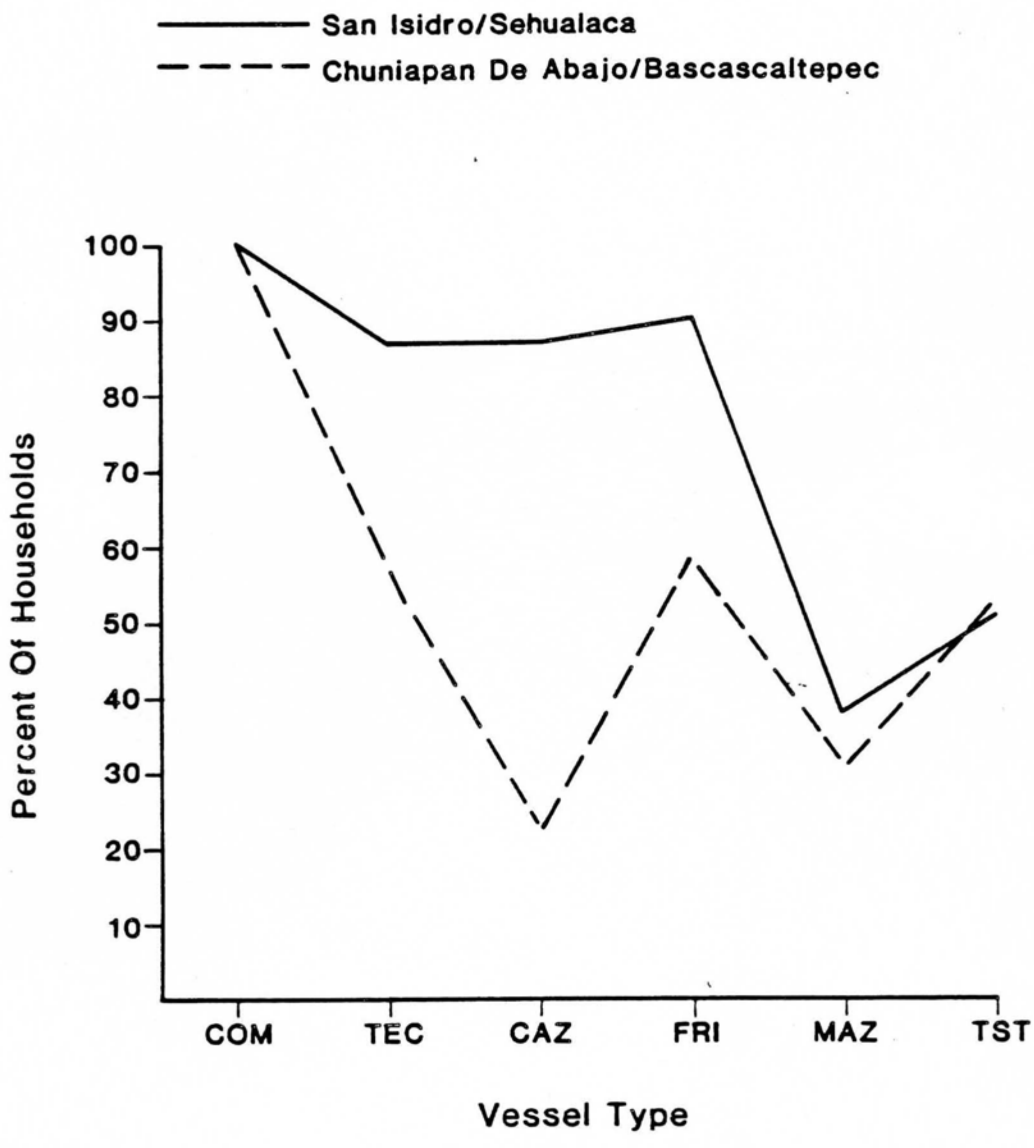

Figure 10. Percent of producer households manufacturing six main vessel forms.

Table 11. Percentage of households using a given vessel form but not producing that form.

	VESSEL FORM					
Community	Comal	Tecualon	Cazuela	Olla de Frijol	Olla de Maiz	Tostador
San Isidro/ Sehualaca	0.00	4.76	8.69	10.00	47.05	33.33
Chuniapan de Abajo/ Bascascaltepec	0.00	43.75	62.50	38.46	0.00	57.14

Less than five percent of the San Isidro and Sehualaca potters who have tecualones must purchase these vessels, while more than forty percent of tecualon-using households in Chuniapan de Abajo and Bascascaltepec do not manufacture bowls. Similarly, access to cazuelas in San Isidro and Sehualaca is considerably greater than for households in Chuniapan de Abajo and Bascascaltepec. Only when maize jars are considered is this pattern reversed. Of the six households in Chuniapan de Abajo and Bascascaltepec using ollas de maiz, all produced this vessel type. In four of this six main vessel types, therefore, households in San Isidro and Sehualaca can more easily replace a given ceramic form than the producers in Chuniapan de Abajo and Bascascaltepec.

Given these distinctions, the Tuxtlas data conform to the expected role of replacement ease in determining household size/assemblage size variability. In San Isidro and Sehualaca, where access to ceramics is greater, the strategy of "stockpiling" is not required. Potters replace vessels as they are broken: not from a ceramic reserve, but from the load of pottery that has recently been produced. As one indication of this strategy, the pottery of many ceramic manufacturing households throughout the Tuxtlas often consisted of the production "seconds"; that is, those vessels that, although perfectly functional, were in some way blemished, thereby reducing their overall value. Potters kept these vessels for personal use, rather than attempting to sell them at reduced cost in the market.

In Chuniapan de Abajo and Bascascaltepec, where replacement ease is inhibited, the relationship between household size and assemblage numbers becomes much weaker. This poor relationship is not a function of a larger than necessary assemblage, however. In this case there is a tendency for these households to have fewer ceramic vessels. Because of the difficulty involved in acquiring some of the vessel types (e.g., tecualon, cazuelas) these households are beginning to adopt nonceramic alternatives. Many of these potters feel that this is a more cost-effective strategy, and even though these modern wares cost more, they usually last longer (cf. Hagstrum 1987).

These same producers, however, continue to practice a manufacturing strategy that enables them to replace a vessel without the difficulty noted among the Maya and Shipibo-Conibo. Potters firing in the open in the Tuxtlas produce approximately 25 vessels per episode, as opposed to the single vessel often representing Shipibo-Conibo output (DeBoer and Lathrap 1979). In contrast to the Highland Maya and Shipibo-Conibo, the households in Chuniapan de Abajo and Bascascaltepec are "streamlining" their assemblages, rather than "stockpiling."

Vessel Use Life

Intra-Assemblage Variability

Given the different roles of ceramics within the Tuxtlas assemblage, one would expect to encounter of good deal of intra-assemblage use-life variability. Intra-assemblage as used

here refers to the differences among the vessel forms within the overall assemblage. Ceramics that are moved frequently run a higher risk of being dropped and broken than vessels remaining in out-of-the-way corners. Pottery used in cooking will suffer the effects of thermal stress, while vessels used for serving or dry/wet storage are rarely exposed to high temperatures. The way in which ceramics function within the behavioral system, therefore, is a critical element in the life span of a given vessel form.

As Table 12 indicates, this kind of formal/functional variability is very much in evidence for the common ceramic forms used within the Tuxtlas. Certain vessel types are characterized by a relatively short use life, while other forms last a considerably longer period. Comales exhibit the shortest average life span, lasting for little more than two and one-half months. Tecualones have the second shortest longevity, with an average use life of ust over eight months. The four large cooking vessels all display considerably longer life spans. Cazuelas have a mean longevity of 15.56 months, followed closely by the olla de frijol with a use life of 15.83 months. The fifth longest life span is displayed by the tostador, with an average of just over one and one-half years. The final vessel type is the olla de maiz whose mean use life is almost 20 months. Overall, vessel forms in the sampled Tuxtlas households range from a low of seven weeks for comales in San Isidro to a high of two and three-quarter years for ollas de maiz in Chuniapan de Abajo.

To understand this wide variability in the life span of vessel forms, one must consider the various factors affecting ceramic breakage and curation. One of the most important of these conditions is use frequency (e.g., DeBoer 1985; Longacre 1981). As the term implies, use frequency is a general measure of the number of times a vessel is employed in task performance. Overall, an inverse relationship is expected between use life and use frequency (DeBoer 1985; Foster 1960; Longacre 1981).

For the purposes of this discussion, use frequency will be based on the average number of times per week the vessel is utilized. Use was monitored in this fashion because the function of certain vessels is tied into the agricultural cycle, resulting in short periods of intensive use. Averaging was deemed to be a valid method for "smoothing" this variation.

The second consideration involved in vessel use life is replacement cost. Replacement cost is a combination of several variables, including procurement cost and manufacturing cost (DeBoer 1985). Replacement cost as used here is based on five categories: (a) production time, the amount of time required to manufacture the item; (b) producer skill, the experience and expertise necessary to successfully produce a vessel type; (c) raw material, the amount of clay and temper (by weight) used to make a single vessel; (d) access restriction, the percentage of producers within the sample who do not make the vessel type; and (e) price, based on the average cost of the item according to the producer. A positive relationship is expected between replacement costs and vessel longevity.

Table 13 provides rankings for use frequency and replacement costs for the Tuxtlas assemblage. Final rankings for replacement cost are derived by averaging the ranks for

Table 12. Use-life values for six main vessel types within sampled Tuxtlas household assemblages.[1]

Vessel Type	San Isidro	Bascas-caltepec	Chuniapan de Abajo	Sehualaca	Total
		Community			
Comal					
Mean	1.89	2.00	3.37	2.76	2.61
Median	1.75	2.00	3.00	2.50	2.50
Tecualon					
Mean	4.01	2.45	14.78	4.50	8.09
Median	2.50	2.45	6.00	4.50	4.50
Cazuela					
Mean	7.69	----	22.06	20.60	15.56
Median	7.00		18.00	12.00	12.00
Olla de Frijol					
Mean	9.58	12.00	19.66	20.00	15.83
Median	8.00	12.00	12.00	12.00	12.00
Olla de Maiz					
Mean	8.85	----	33.00	19.09	19.97
Median	10.00		33.00	12.00	12.00
Tostador					
Mean	9.25	4.00	23.33	30.00	18.53
Median	11.00	4.00	18.00	30.00	12.00
TOTAL					
Mean	6.01	3.48	14.54	14.55	11.03
Median	6.31	3.48	13.40	10.20	7.90

[1] Use-life figures are presented in months.

each category and then ranking the averages. In cases where there was significant overlap among the values for a given category the ranked scores were tied.

Overall, the negative relationship between use frequency and use life and the positive relationship between replacement costs and use life are indicated for the Tuxtlas data. Figure 11 presents three graphs depicting this relationship. In Figure 11a the ranks for use frequency are plotted against the ranks of mean vessel use life. It is readily apparent that the predicted negative relationship is achieved. In Figure 11b ranks of procurement cost are plotted against average vessel use life. This time the proposed positive relationship is indicated. Finally, in Figure 11c ranks of use frequency are plotted against replacement costs, with the plotted value indicating the use life rank for that vessel type.

Two patterns are important here. The first relationship involves the linearity between the two axis, indicating the strength to which the variables are negatively associated. The second pattern concerns the order of use life ranks as they appear on the graph. As the figure indicates, this order is maintained with minimal deviations. In other words, vessel life spans continue to adhere to the predicted relationship. Comales, with the shortest use life, are characterized by the highest use frequency and the lowest replacement costs. Tecualones have the second shortest longevity, are ranked second in replacement cost and fifth in use frequency. Starting with ollas de maiz some variability is introduced and a perfect relationship is not maintained. This divergence is not severe, however, especially given that the median use life of these remaining four vessels is exactly the same for the entire sample.

It is important to note that two factors do not appear to condition average assemblage use life. The first of these is production frequency. There is no strong relationship between production frequency and assemblage use life, taken either as a whole or considered on a community by community basis. The Spearman's correlation coefficient for the entire sample is -0.108, indicating a weak negative relationship. Figure 12 presents a scatterplot of this correlation. Plotted letters refer to the community from which the case was obtained. It can be seen from the figure that the values for San Isidro actually covary in a positive manner ($r=0.167$), while the correlation for the remaining communities is negative ($r=-0.014$). In no instance were these coefficients significant at the .05 level. Overall, the pattern reflects little relationship between average assemblage use life and production frequency.

The second variable which does not affect use life is the degree to which individuals using the vessel also made the vessel. In other words, does the fact that households are consuming their own ceramics provide any influence on overall pottery life spans. Chi-square analyses were conducted in order to investigate this possibility.

Analyses were performed on four vessel types: (a) tecualones, (b) cazuelas, (c) ollas de frijol, and (d) ollas de maiz. Comales were not considered, because all households manufactured this form, and tostadores were not analyzed due to the comparatively small

Table 13. Rankings of vessel acquisition for six main vessel types in sampled Tuxtlas household assemblages.

Category	Comal	Tecualon	Cazuela	Olla Frijol	Olla Maiz	Tostador
USE FREQUENCY RANK	6	5	4	3	2	1
REPLACEMENT COST						
Production Time	1	2	4	5.5	5.5	3
Production Skill	1	2	4	5.5	5.5	3
Raw Material	1	2	4	5.5	5.5	3
Avail-ability	1	3	4	2	6	5
Price	1	2	3	4.5	4.5	6
REPLACEMENT COST RANK	1	2	3	5	6	4

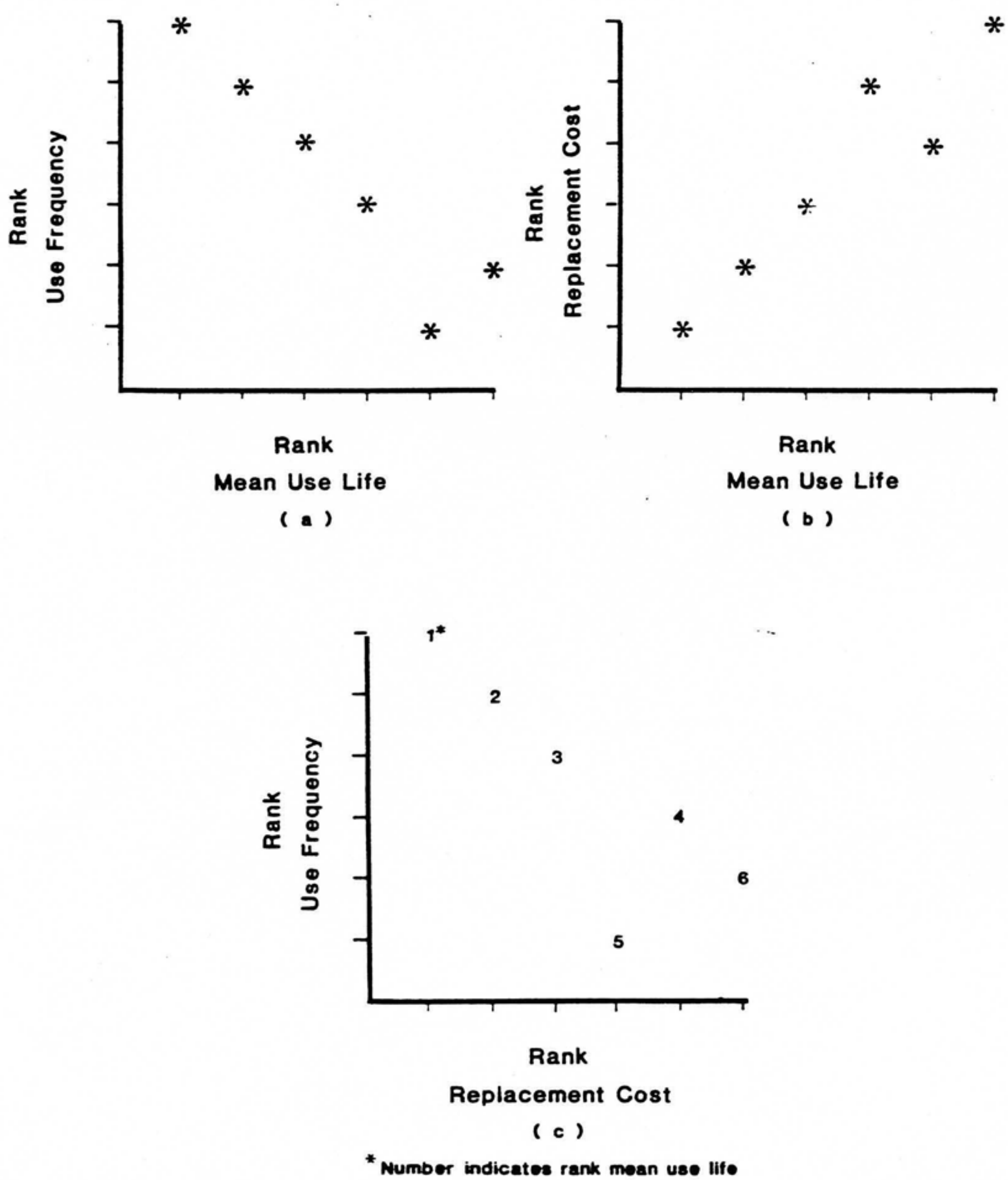

Figure 11. Relationship between use frequency, replacement costs, and use life for six main vessel forms.

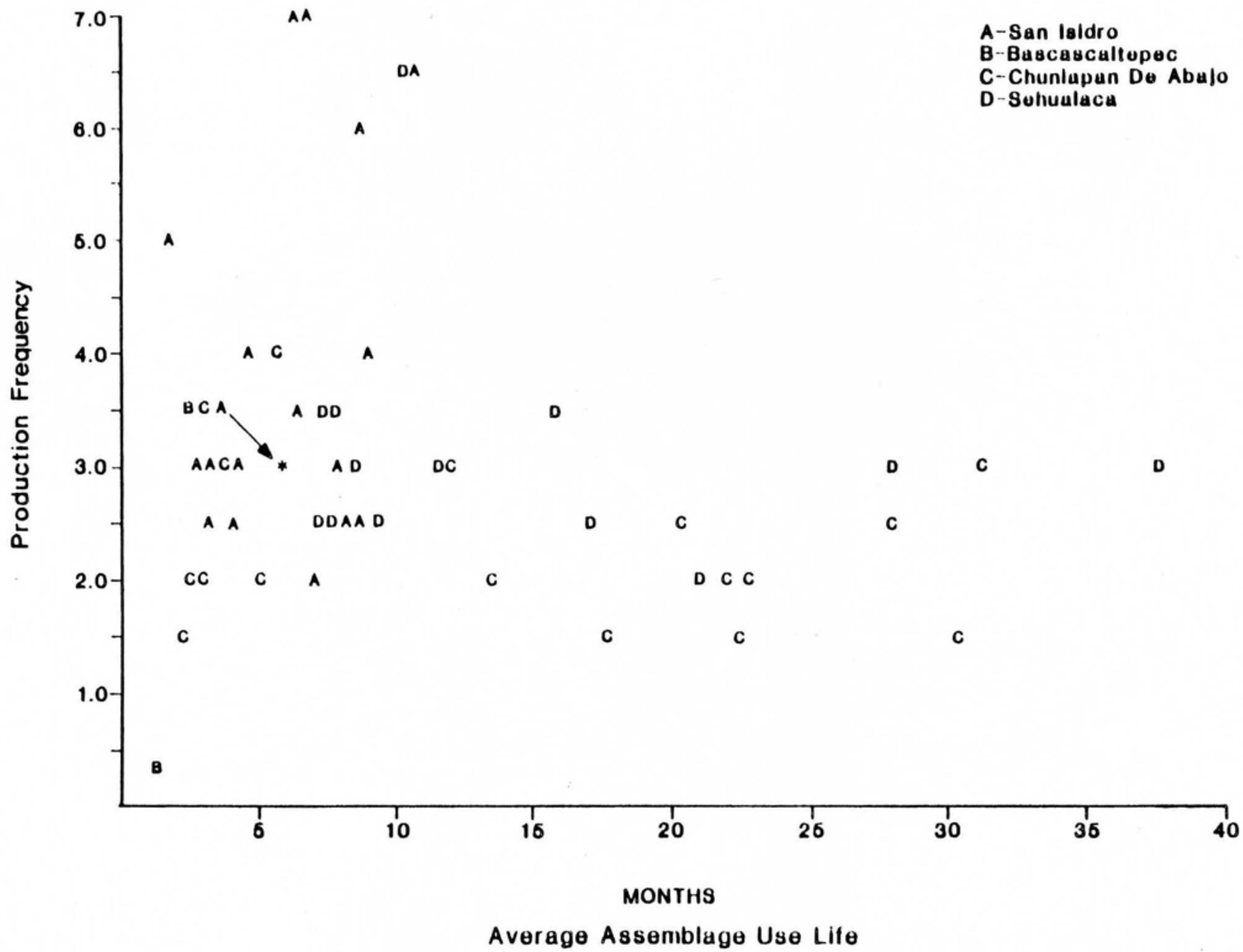

Figure 12. Scatterplot of production frequency by vessel use life for production communities.

number of use life cases involving this type.

The results of this analysis indicate that the life span of the ceramics is not significantly affected by variability in production patterns. Chi-square results are as follows: tecualones -- $X^2=0.505$, $p>.05$, df. = 1; cazuelas -- $X^2=0.177$, $p>.05$, df = 1; ollas de frijol -- $X^2=1.44$, $p>.05$, df. = 1; ollas de maiz -- $X^2=3.02$, $p>.05$, df. = 1. In none of the cases were the results significant at the .05 level. These results suggest that the manufacture and use of a given vessel type is not associated with significant differences in that vessel's use life.

In sum, it does appear that many of the factors conditioning intra-assemblage use life noted for other New World communities are in evidence for the Tuxtlas assemblage. The use frequency of a vessel type is negatively related to its longevity, while the cost of replacing the vessel appears to be positively related to its life span. As has been noted, however, there continues to be significant differences for the use life of the same vessel form between communities. This variability is discussed below.

Inter-Assemblage Variability

An unexpected product of the use-life data is the amount of inter-assemblage variability that is indicated. In other words, communities using the same vessel type are exhibiting significant differences in the life spans of those ceramics. Obviously, these differences should not be the result of functional variability, in as much as the vessel forms are used consistently from community to community. It would seem, therefore, that in addition to the variables noted above, vessel use life also varies as a function of conditions that are specific to the individual communities.

To facilitate this discussion, data from Bascascaltepec are excluded. The two households sampled in this community did not contain one-third of the vessel types, and use-life data for several of the remaining pottery types were collected from only one household. The size of this sample effectively ensures that no statistically significant difference would be obtainable when compared with the other communities.

Returning to the data presented in Table 12, it is apparent that the average household assemblage use life can be divided into two groups: one containing values for San Isidro and the other including pottery use-life data from Sehualaca and Chuniapan de Abajo. Upon closer inspection, however, not all vessel types conform to this dichotomy. Comales, for example, exhibit a life span that is relatively consistent from community to community. Tecualones, on the other hand, have similar patterns of longevity between San Isidro and Sehualaca, but average use-life values are considerably higher in Chuniapan de Abajo. This difference is not so pronounced when median figures are considered. Finally, the life span of larger cooking vessels, including cazuelas, both olla forms, and the tostador, is much higher in Sehualaca and Chuniapan de Abajo than in San Isidro. The data suggest a complex pattern, with larger cooking vessels making the largest contribution to overall variability, although additional differences are indicated.

One of the factors influencing inter-assemblage variability is the different temper types used in Los Tuxtlas. As discussed earlier, San Isidro potters used a sand temper, while the potters of the remaining communities added volcanic ash to their clay. Differences in temper are especially crucial for cooking vessels, for which thermal stress is a primary concern. Thermal stress refers to the negative effects of heat on the fired clay body (D. Arnold 1985; Rye 1976, 1981), and is produced in two ways: (a) thermal expansion, or the volumetric increase in size of the various paste constituents; and (b) thermal shock, or the reduction in tensile strength as a function of unequal temperature increases along different portions of the vessel (Steponaitis 1984). All things being equal, the greater the similarity between the thermal expansion characteristics of the temper and the fired clay matrix, the greater the vessel's resistance to thermal shock (Rye 1981).

According to Rye (1976), quartz, a common mineral found in sand deposits, has a rate of thermal expansion that is much higher than minerals associated with volcanic activity, such as plagioclase and olivine. In other words, a reliance on quartz-bearing temper would be more likely to produce ceramics with lower resistance to thermal stress than pottery manufactured with temper such as volcanic ash.

In addition to quartz, sand deposits usually contain moderate amounts of sea shell, of which calcium carbonates are a major constituent. Experiments on the effects of shell temper on fired ceramics have demonstrated that calcite decomposes to calcium oxide during firing, combines with water vapor during cooling, and results in calcium hydroxide (Rye 1976). Calcium hydroxide occupies a larger volume in the ceramic than the original calcite, resulting in internal pressure within the fired clay body. Depending on the severity, this internal pressure can result in spalling, cracking, or crumbling (D. Arnold 1985; Rye 1976, 1981).

The use of sand temper by the potters of San Isidro should significantly affect the durability and thus the use life of their ceramics. Mann Witney U tests, comparing the difference in vessel longevity between San Isidro (by itself) and Sehualaca and Chuniapan de Abajo (as a group) produced significant results for all but two ceramic types. Comales, cazuelas and both bean and maize ollas were all significantly different at the .05 probability level ($U=389.5$, $Z=2.54$, $p<.05$; $U=236.5$, $Z=3.19$, $p<.05$; $U=316.5$, $Z=2.66$, $p<.05$; and $U=198$, $Z=3.64$, $p<.05$, respectively). A comparison of tostadores failed to produce a significant difference ($U=24$, $Z=1.27$, $p>.05$), primarily as a function of the small sample size ($N=4$ and 8, respectively). Tecualones were also not significantly different ($U=203$, $Z=1.86$, $p>.05$). The patterning displayed in Table 12, however, continues to indicate a considerable degree of variability within these vessel types.

These results are certainly in keeping with the expectations derived from the above discussion of tempering materials. It appears, therefore, that the presence of quartz in the temper of San Isidro pottery is a major contributor to variability in vessel use life. The inclusion of quartz in the clay body is more likely to have a detrimental affect when vessel

function involves cooking. Of secondary importance is the occurrence of some shell in the temper, which will produce spalling and cracking without exposure to heat. This effect is apparent in the tendency for San Isidro tecualones to display shorter use-life values than those in Sehualaca and Chuniapan de Abajo.

IV. CONCLUSION

Ceramic producers in the Sierra de los Tuxtlas work on a part-time basis, organizing their efforts around the seasonal variability in rainfall and the labor demands of subsistence agriculture. These female potters manufacture a relatively restricted suite of vessels and emphasize utilitarian ceramics. Ceramics are produced for both household use and for sale at local markets. Given their utilitarian nature the vessels are rarely decorated. Demand for ceramics comes from within the Tuxtlas, and there is no tourist market affecting either the intensity of production efforts or the kinds of vessels that are manufactured.

Despite this overall similarity, there is a surprising degree of variability exhibited within the study region. This variability occurs at both the inter- and intra-community level. For example, the potters of each community emphasize a different source of clay and temper, and may employ different types of fuel as well. In three of the four communities, however, two sources of clay were exploited. Moreover, the decision of which deposit to use was not always based on preference. While the potters were aware of the various properties of the raw material, additional factors conditioned the selection process. In San Isidro, for example, some producers did not utilize the negro clay because of the access fee. Distance to clay deposits was an important concern for potters in Sehualaca and Chuniapan de Abajo. Some potters even altered their pattern of procurement based on the weather or the availability of labor.

Production techniques also varied from community to community. Parado construction was more common than palmeado formation, but potters within the same community often practiced both techniques. The most obvious distinction occurred with vessel firing -- kiln firing was only practiced by the San Isidro potters, while the producers in the remaining communities all fired in the open. This difference could not be attributed to variability in production frequency, as both San Isidro and Sehualaca potters were characterized by similar values. Pressure on the available fuel resources could be one factor conditioning the use of kilns in San Isidro. A second possibility, discussed elsewhere, is that the smaller houselots in San Isidro are not well suited for open firing (P. Arnold 1987). In either case, it would appear the production techniques can and do change independently of differences in production frequency and scale.

The frequency and use life of vessels also displayed interesting patterns. As vessels became more difficult to acquire there was a tendency for households to begin "streamlining" their ceramic assemblages. As a result, these households often exhibited an emphasis

on the least expensive (i.e., most easily made) pottery. The frequency of a specific vessel, the olla de maiz, was also shown to be inversely related to the use of mechanical mills to grind nixtamal.

The most noticeable difference in vessel use life occurred in San Isidro. In this case it appears that the use of sand temper in the pottery is the causal factor. Because of the chemical properties of the sand, San Isidro vessels are more susceptible to the effects of thermal stress and calcium hydration. This possibility was reflected in the significantly lower use-life values for all the major cooking vessels within the San Isidro assemblage.

In sum, the production and consumption of ceramics in Los Tuxtlas is affected by a complex interaction of social, environmental, and physical forces. Because these relationships ultimately produce the material record, it is crucial that archaeologists begin to understand how and why they occur. This study has attempted to make a small contribution to that important goal.

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