Pottery Kilns of Ancient Ejutla, Oaxaca, Mexico

Andrew K. Balkansky

Gary M. Feinman

Linda M. Nicholas

University of Wisconsin-Madison
Madison, WI

In contemporary Mesoamerica, traditional methods of ceramic production are highly variable. Tracing this diversity to its prehispanic antecedents has been limited by a major empirical difficulty: the identification of production sites, especially kilns and other firing features, in archaeological contexts. As a consequence, Mesoamerican archaeologists have rarely recognized technological variation in firing methods, thereby limiting their capacity to discern spatio-temporal variation in ceramic production. The discovery and excavation of relatively ephemeral ceramic firing features at the Ejutla site in Oaxaca, Mexico, offers an archaeological perspective into the variability of pottery production techniques that were employed in ancient Mesoamerica. The excavated firing features and associated indicators of ceramic production at Ejutla are described and compared to similar features at other sites. An experimental study was conducted to understand how these firing features worked and the nature of the remains that they would have left. Our research suggests that impermanent methods of ceramic firing were more common in ancient Mesoamerica than previously supposed. The ephemeral nature of these firing procedures may contribute to the overall scarcity of excavated firing features to date. Consideration of ceramic firing technologies is argued to be a significant research concern since variation in firing methods may indicate prehispanic differences in the intensity of ceramic production.

Introduction

Variability in methods of ceramic production are characteristic of present-day Mesoamerica. The renowned ethnologist George M. Foster defined many aspects of this variability, describing the technologies employed, the ceramic products that were made, and the socio-organizational context of production (e.g., Foster 1948a, 1960, 1965). In a summary of this work, Foster (1967: 103) observed: "For variety in pottery-making techniques and in materials, forms, styles, and economic importance, few places in the world rival Mesoamerica and, particularly, Mexico." Similar variation is found (though to a lesser degree) in the modern Oaxaca Valley (Shepard 1963) (FIG. 1). The ethnographic perspective on ceramics presents an intriguing series of questions for the archaeologist. Did similar kinds of variability exist in the past? What factors accounted for this variability? Are ethnographic models appropriate measures of past variation? The excavation of ancient firing features at the Ejutla site in Oaxaca, Mexico (FIG. 2), provides a means to address these questions of prehispanic variability in methods of ceramic production. Before presenting the archaeological findings from Ejutla, we briefly consider traditional pottery making in contemporary Oaxaca.

Comparisons between the Oaxaca Valley's traditional pottery producing villages illustrate much of the diversity cited by Foster, and, in particular, highlight differences in the intensity of production, choice of firing methods, and patterns of distribution (see overviews in Flannery and Marcus 1994: 21–24; Shepard 1963). The villages of Santa María Atzompa, San Bartolo Coyotepec, San Marcos Tlapazola, and Ocotlán de Morelos have received uneven ethnographic attention (e.g., Foster 1955; Hendry 1992; Stolmaker 1976; van de Velde and van de Velde 1939), but each is characterized by household-based ceramic production that is carried out at different intensities of manufacture.

Atzompa, located at the commercial nexus of the

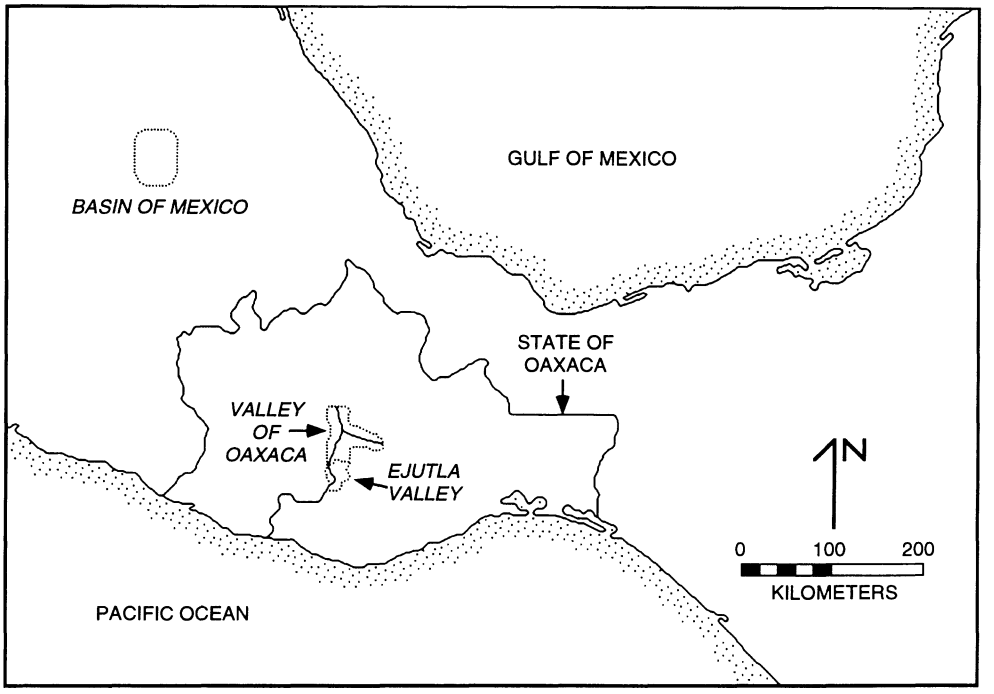


Figure 1. Southern Mexico, showing the location of the Oaxaca and Ejutla valleys.

Oaxaca Valley, less than 5 km from the region's largest market in the city of Oaxaca de Juárez (FIG. 2), represents one end of the production-intensity continuum. The Atzompa potters make large numbers of green-glazed vessels, unglazed ornamental vessels, and figurines for regional markets in Oaxaca and commercial venues far beyond (Hendry 1992; Stolmaker 1976). The pottery is fired in cylindrical updraft kilns, in which the fuel is placed in a shallow firebox excavated into the ground surface, below the pottery in the vessel chamber (see comparisons of firing methods in Rice 1987a; Rye 1981; Sinopoli 1991). The Atzompa kilns are relatively permanent facilities made from stone or adobes (as well as reused material from older kilns), and a mixture of two clays—different from those used to make pots—that serve as mortar and to coat the inner surfaces of the kilns (Mary S. Thieme, personal communication, 1994). These kilns are broadly analogous in design to those known from ancient Monte Albán (Winter and Payne 1976).

In contrast, the contemporary potters at still-remote San Marcos Tlapazola do not use formal kilns to fire their far smaller and less diverse inventory of plain brownwares. The San Marcos potters market most of their tortilla griddles (*comales*) and other utilitarian bowls and jars in the closest regional market in Tlacolula (and to a lesser degree in Oaxaca City). In San Marcos, there are no permanent firing facilities. The potters use an open, or bonfire, method in which the pottery and fuel are intermingled on the ground surface and burned in the open air. This relatively impermanent firing arrangement leaves few definitive traces for the archaeologist (Payne 1970, 1994). Despite the differences in firing technology between Atzompa and San Marcos, equivalent firing temperatures of around 700° Celsius have been recorded for the firing process in both villages (although sometimes at Atzompa, the temperature may exceed 900° Celsius for the second, glaze firing [Payne 1994; Shepard 1963]). From an archaeological point of view, it is interesting to note that the respective contexts of production are similar in the two communities—occurring in and around family houselots—despite the marked differences in firing methods, intensity of production, and spheres of distribution. Similar differences in production have been noted between two Tzeltal Maya pottery making villages studied by Deal (1983: table 17).

The contrast between Atzompa and San Marcos in the relative permanence of firing facilities has been observed across Mesoamerica. Open firings are known from Oaxaca, Veracruz, and Guatemala (Beals 1945; Krotser 1980; Reina and Hill 1978), while updraft kilns have been reported in Jalisco, Michoacán, Oaxaca, Puebla, and Yucatán (Foster 1948b: 88–90; Hendry 1992; Lackey 1981; Sayles 1955; Shepard 1963; Taylor 1933; Thompson 1958; van de Velde and van de Velde 1939). These studies under-

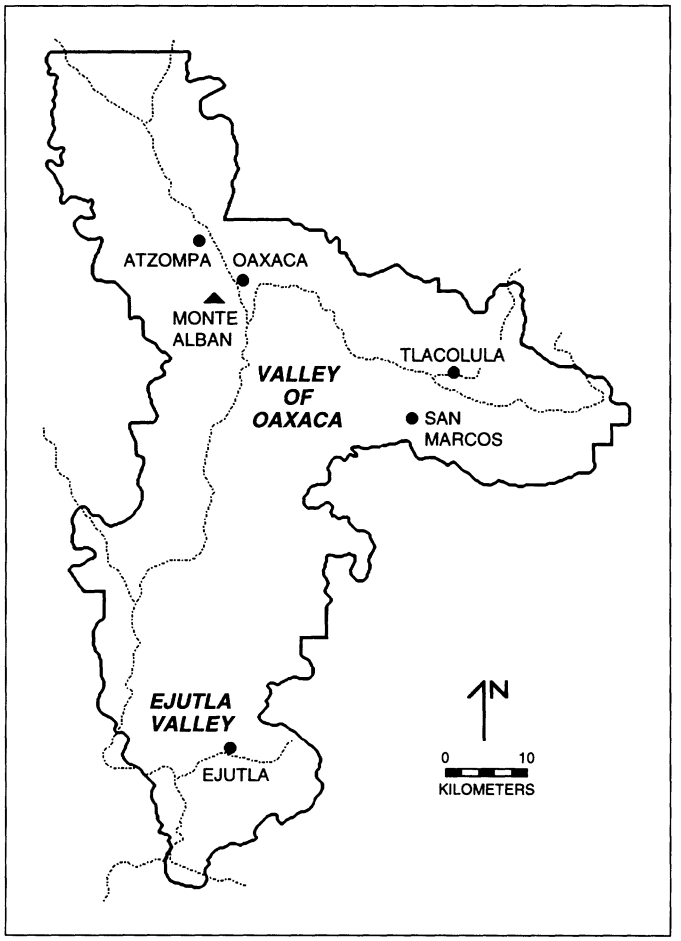


Figure 2. The Oaxaca and Ejutla valleys, with places mentioned in the text.

score the variation in ceramic production described by Foster, which he attributed to ethnicity, arguing that distinct social groups made pottery in diverse ways, according to their unique cultural institutions and histories. Foster concluded that the technological heterogeneity of modern potting communities had become especially pronounced with the introduction of the European updraft kiln into mestizo towns after the Spanish Conquest:

> The contemporary pottery of Mesoamerica represents, collectively, a product of Hispano-Indian acculturation. A typological spectrum can be defined, one end of which is represented by purely indigenous techniques, the other end, by purely Spanish techniques. The great bulk of production, however, represents a fusion of both Indian and European traits (Foster 1967: 103).

In a departure from the trait-based framework of culture history, Anna O. Shepard (1963), noting the variation in contemporary methods of production and patterns of marketing in the Oaxaca Valley, argued that some of the described variability was functionally related to socioeconomic differences between pottery-making communities. She added, moreover, that valuable economic information could be discerned by archaeologists from the study of ancient processes of ceramic manufacture and distribution.

In the years since Shepard's landmark paper, archaeologists have begun to record the kinds of data needed to place her argument on a stronger empirical footing. The discovery of updraft kilns at Monte Albán (Winter and Payne 1976) provided evidence that the more formal firing technology described by Foster had antecedents in the prehispanic era (also see Payne 1982; Santley, Arnold, and Pool 1989; Shimada 1989; Winter and Nardin 1982). Much recent archaeological discussion of prehispanic Mesoamerican ceramic manufacturing has focused on differences in the scale and intensity of production. These variables have been examined from diverse perspectives (see Rice 1981); examples include the study of regional survey data in the Oaxaca Valley (Feinman 1980, 1982; Feinman et al. 1989; Feinman et al. 1992), and the intensive site survey and test excavation at Matacapan, Veracruz, where the excavators reported numerous ceramic production contexts and double-chambered updraft kilns (Arnold et al. 1993; Arnold and Santley 1993; Santley, Arnold, and Pool 1989; Santley 1994). Variation in the scale and intensity of production has been attributed to an array of factors, including the environment (Arnold 1985; Pool and Santley 1992; Rice 1987b), demography and transport costs (Stark 1992), and an interplay of demographic factors and degrees of political control (Feinman 1980).

It is important, however, to make an analytical distinction between scale and intensity. We use these terms as defined by Costin (1991): scale refers to the setting or size of the production facilities, as well as the constitution of the work unit, while intensity is the relative time spent on production and the volume of goods produced. Scale ranges from kin-based domestic contexts to factory manufacture, while intensity may vary between part-time and full-time production. The volume of goods produced represents an additional measure of intensity. We agree with Costin that, although sometimes scale and intensity are linked, there is not a necessary or direct linear relationship between them; each may co-vary somewhat independently and should be investigated accordingly. In practice, this decoupling of scale from intensity has only recently been considered and rarely accomplished. In contrast to Costin's multidimensional approach, most discussions of craft specialization in the archaeology of Mesoamerica and elsewhere tend at least implicitly to follow more unilinear frameworks, such as those proposed by van der Leeuw

(1976) and Peacock (1982). These more evolutionary schemes (also see Rice 1984; Santley, Arnold, and Pool 1989) view craft specialization varying along a single continuum from small-scale household production to larger-scale or workshop manufacture. In this view, an underlying presumption is that if production takes place in a household-domestic context, then the intensity of that production is necessarily limited. Because intensity of production (as defined by Costin) is not easy for archaeologists to measure independently, scale becomes its proxy.

Despite the manifest interest in the ancient potter's craft, most of the earlier discussions have had to rely on indirect measures of ceramic production. The Monte Albán and Matacapan kilns are the seeming exception in the archaeological record of Mesoamerica, where kilns—the most direct evidence of the production context—are curiously rare. This empirical reality is perplexing, given the ubiquity of pottery in Mesoamerica, and the level of scholarly interest in the subject. It has been twenty-five years since William O. Payne wrote:

> Because references to ceramic technology in the records of archaeological field work tend to be sketchy, vague, and conjectural (if not entirely absent), we still lack understanding of the ways ancient Mesoamerican potters worked (Payne 1970: 1) . . . . Evidence of kilns is an illustration. At least two reasons for the paucity of such evidence in the literature are now plain: as all archaeologists have been noting for decades, there is a tendency to explore central areas of elite habitation and public buildings. Potters' houses and shops are not likely to be common there. But why has the conscious effort of archaeologists to get out of the elite areas not produced ancient kilns? (Payne 1970:5)

Much the same question might be asked today. Barbara L. Stark has written (1985: 172): "The sheer infrequency with which pottery production has been identified archaeologically suggests major problems with our approaches." Similar dismay has been expressed from the perspective of the southwestern United States (Sullivan 1988; but see Heacock 1995). Among other reasons given for the difficulty of locating firing areas is their distance from structures, the reuse of building material, and the ravages of time (e.g., Santley, Arnold, and Pool 1989; Stark 1984, 1985, 1989). In the absence of recognizable kilns, Mesoamerican archaeologists have relied on other material correlates of pottery production—principally, anomalous densities of potsherds and specific ceramic types, clay concretions, ash lenses, and wasters (e.g., Curet 1993; Feinman 1980; Krotser 1987; Redmond 1979; Stark 1985). Each class of data cannot, however, be taken alone as a definitive indicator of ceramic production (Santley, Arnold, and Pool 1989; Stark 1985, 1989). To present a convincing demonstration of ancient production, "a pattern of evidence must be examined" (Stark 1989: 104).

Both the scarcity of archaeological kilns and the past variability of ceramic production would be more explicable if production contexts were less formal than the kilns at Monte Albán and Atzompa, and instead were more like the open-firings of San Marcos (Payne 1970, 1994). The relative impermanence of some methods of prehispanic ceramic firing may help account for the scarcity of recognized kilns at many ancient production sites. Our review of the ceramic manufacturing evidence from ancient Mesoamerica indicates that such impermanent firing features may be more common than generally supposed. Relatively impermanent firing features have been noted at Lambityeco (Swezey 1975), Teotihuacan (Sheehy 1992), the Peñitas site in coastal Nayarit (Bordaz 1964), and several sites in the Puebla-Tlaxcala region (Abascal 1975, 1976). The recent discovery of pit kilns (see Rye and Evans 1976: 55–56, 165–166; Rye 1981: 98) in Peru (Russell 1994) suggests that ephemeral methods of ceramic production may have been more common in other New World regions as well. The excavation of similar features at the Ejutla site, and their relevance to these issues, is the focus for the remainder of this paper.

Background and Experimental Analysis

During the first season of extensive excavations at Ejutla in 1991, ample primary and secondary indications of ceramic production were recorded. Dense midden deposits with an abundance of figurines and figurine wasters, figurine molds, and hundreds of wasters from a variety of ceramic vessels were found to overlie shallow features that the prehispanic inhabitants had dug into the soft bedrock. Despite this evidence, the implication that these bedrock features were for ceramic firing did not fit our initial expectations, which were based on the familiar production methods of the potters at Atzompa and the formal kiln features excavated at Monte Albán.

In the proceeding discussions, we develop expectations for the Ejutla firing features from a broad interpretive context, which includes descriptions of the firing pits themselves, their associated ceramic products and by-products, the results of a pit-firing experiment, and available data on impermanent methods of production reported from other prehispanic sites in Mesoamerica. By so doing, these discussions recapitulate the learning curve that we followed and provide the full array of evidential clues and archaeological indicators that we found helpful in defining these features. Our aim in reviewing these multiple strands of evidence is to promote the more systematic recognition

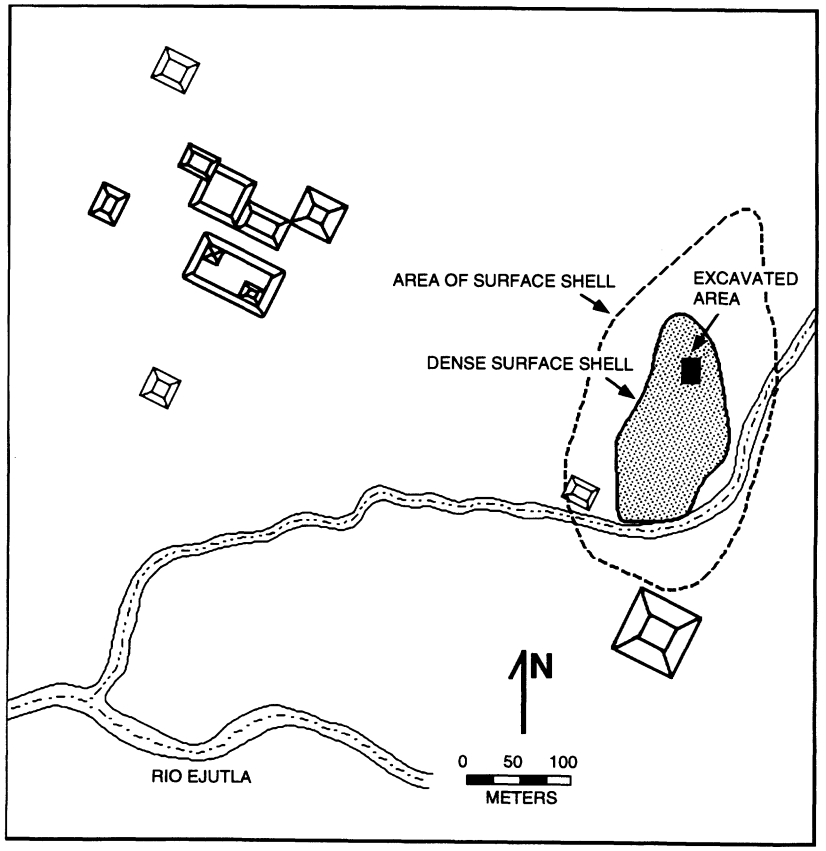
of ceramic production and firing contexts in the archaeological record of Mesoamerica and elsewhere.

The History of Research at the Ejutla Site

The ancient site that lies beneath the modern district capital of Ejutla de Crespo has been known since the turn of the century (Diguet 1905) and was recorded on Ignacio Bernal's (1965) reconnaissance of Oaxaca's central valleys. The site was not mapped systematically until 1984–1985, when a regional settlement survey of the Ejutla Valley was implemented by Feinman and Nicholas (Feinman 1985; Feinman and Nicholas 1988, 1990). The Ejutla site (FIG. 3), which had more than a dozen earthen mounds, was discovered to be one of the largest prehispanic settlements in the Ejutla Valley. In addition to its size and regional importance, the site was distinguished by a large and unusual concentration of surface marine shell at its eastern edge. Shell, although a valued trade item in prehispanic Mesoamerica (e.g., Pires-Ferreira 1976; Suárez 1991), was seldom encountered during the regional survey of the far larger Oaxaca Valley (Blanton et al. 1982; Kowalewski et al. 1989), or at other sites in the Ejutla Valley (Feinman and Nicholas 1992). With the unexpected discovery of marine shell, some 100 km from the Pacific coast, a program of more intensive research was undertaken in this sector of the Ejutla site (which also was endangered by the recent expansion of the contemporary community).

An exploratory field season of intensive surface collection and preliminary test excavations was conducted in 1990 (Feinman, Nicholas, and Fedick 1991a, 1991b). This field study documented that the Ejutla shell working was indeed prehispanic in date, and that despite the expansion of contemporary Ejutla, parts of the ancient site were still intact and undisturbed. Three seasons of more extensive excavations (1991–1993) and a summer of analysis (1994) followed (Feinman and Nicholas 1992, 1993, 1995; Feinman, Nicholas, and Middleton 1993). A contiguous 194 sq m area was excavated in order to examine a broad expanse of the site. The excavations exposed a number of features, including the stone foundations of a prehispanic structure, a sub-floor household tomb, several

Figure 3. The prehispanic site at Ejutla de Crespo, illustrating central mound complex, area of dense surface shell, and location of excavations.



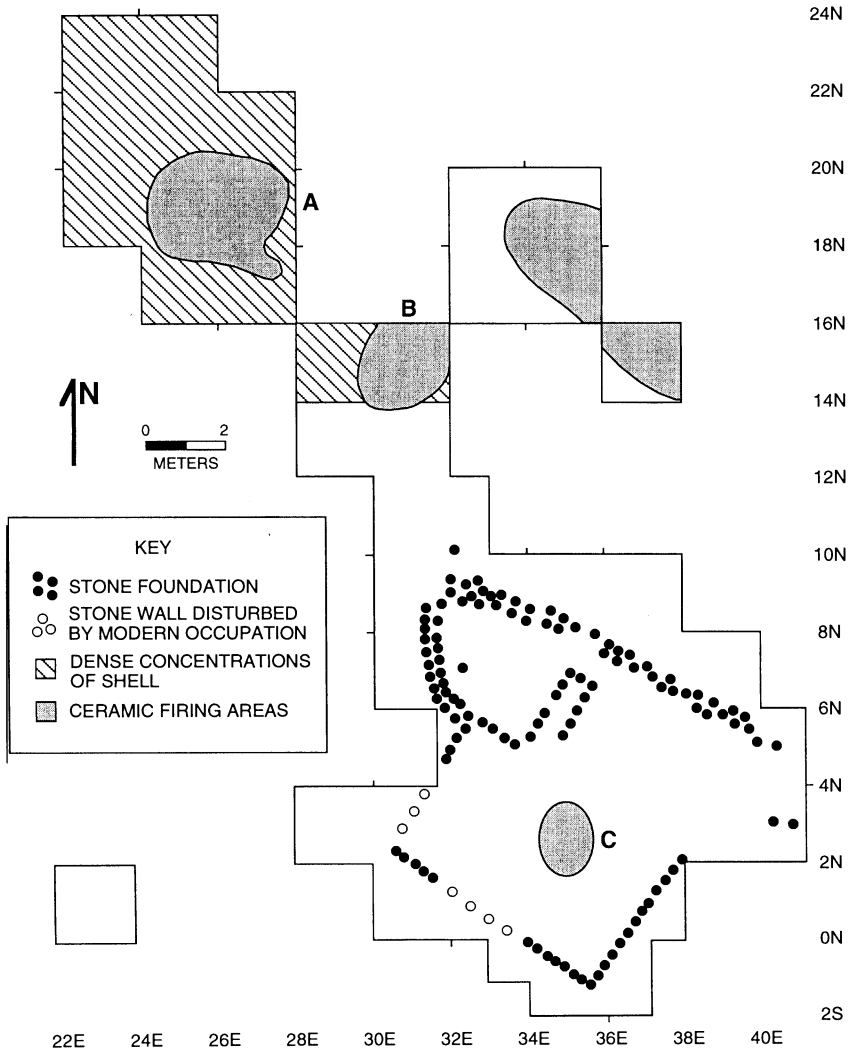


Figure 4. Area of excavation at the Ejutla site, illustrating the residential structure, firing features, and dense midden area.

shallow, oval-shaped pits dug into bedrock (the firing features), and a midden area that contained both the by-products of multiple craft activities and some domestic refuse (FIG. 4). Although the total span of occupation at Ejutla has an extended prehispanic history, the excavated features were dated to the Classic period (A.C. 200–800) (TABLE 1).

The artifactual findings from the excavations suggest that Ejutla's prehispanic inhabitants manufactured ceramic figurines and vessels in addition to shell ornaments. Lapidary crafting also appears to have been carried out at lower intensities (Feinman, Nicholas, and Middleton 1993). The concurrence of such an array of craft activities at a single location contrasts with Oaxaca's ethnographically observed pattern of households (and villages) focused on a particular craft (e.g., Cook and Diskin 1976). To ensure the adequate recovery of the products and by-products of these craft activities, all deposits below the plow zone were screened in 1/8″ or 1/4″ mesh, depending on the nature of the soils and the cultural deposits.

No formal kiln features like those at modern Atzompa or ancient Monte Albán were found. Nevertheless, the recovery of large numbers of sherds from defective vessels, pottery by-products, and the frequent disposal of broken (but unused and complete) ceramic vessels suggested that the most abundant ceramic varieties—especially molded figurines, incense burners (*sahumadores*), tortilla griddles (*comales*), and certain types of reduced (gray) bowls—likely were made and fired in close proximity to the excavated structure. The unearthing of at least four pit features

Table 1. Prehispanic Chronology for the Oaxaca and Ejutla Valleys.

	Mesoamerica	Valley of Oaxaca	Ejutla Valley
1500	Late Postclassic	Monte Alban V	Monte Alban V
1000	Early Postclassic	Monte Alban IV	Monte Alban IV
	Late Classic	Monte Alban IIIB	
500	Early Classic	Monte Alban IIIA	Monte Alban IIIA
AC 0 BC	Terminal Formative	Monte Alban II	Monte Alban II
	Late Formative	Monte Alban Late I	Monte Alban Late I
500		Monte Alban Early I	Monte Alban Early I
	Middle Formative	Rosario	Rosario
		Guadalupe	
1000		San Jose	Early Formative
	Early Formative	Tierras Largas	
1500			

(centered in excavation units 18N24E, 14N30E, 16N34E, and 2N34E) led us to suspect the association of these features with the ceramic manufacturing process (FIG. 4). The pit features north of the structure had been carved into soft bedrock and were filled with dense layers of ash and potsherds. Considerable quantities of charcoal also were present, and sections of the bedrock at the base of these features were burned. The firing feature located in excavation unit 2N34E shared these characteristics, but was situated within the bounds of the structure and stratigraphically sealed beneath the house floor, clearly predating the construction of this residential unit. A possible fifth kiln was not completely excavated, but its upper levels showed many of the same indications of production as the others. Despite their overall similarities, there are individual differences among the features—in particular between the sub-floor feature and those outside the structure—that will be discussed below. Nevertheless, based on the nature of these features and their associated artifactual remains, all appear to have served as relatively impermanent and informal means to pit-fire pottery.

Review of the Ceramic Firing Literature

Careful study of the ceramic production literature for prehispanic Mesoamerica suggests that the Ejutla pit features and associated production process are more broadly typical than originally suspected. Semi-subterranean features like those at Ejutla have been found at a number of prehispanic sites in Mesoamerica (e.g., Abascal 1975, 1976; Sheehy 1992; Swezey 1975).

James Sheehy (1992: 755–756) identified indications of an ephemeral method of ceramic firing at the Tlajinga 33 apartment compound at Teotihuacan. He argued that two features (12 and 45) that were positioned directly adjacent to the residential compound and were associated with quantities of broken pottery, ash, wasters, and "burnt

adobe," may have served as pit kilns (Sheehy 1992: 768–769). Despite ample artifactual evidence for ceramic manufacturing at Tlajinga 33, the extensive excavations there did not expose any more substantial firing features. At prehispanic Lambityeco in the Oaxaca Valley, William Swezey (1975) also proposed the practice of similar pit-firing techniques based on the spatial association of a heavy ash layer, high density of potsherds, and other indicators of ceramic manufacture (also see Payne 1970). Because of its amorphous nature, the significance of this feature might easily have been overlooked had the associated remains not been found in situ. Swezey (1975: 183) concluded that "it would seem advisable for archaeologists to consider any thick ash layers they uncover with more circumspection than has generally been afforded in the past." Rafael Abascal (1975, 1976), working at sites in Puebla-Tlaxcala, found a number of similar prehispanic pits that he surmised were used for ceramic firing. In one instance, the concentration of residences with these features seemed to indicate village-level specialization in ceramic manufacture. The Puebla-Tlaxcala firing features are perhaps the most like those at Ejutla, since they had been excavated into the underlying *tepetate*—a soil that hardens like bedrock upon exposure to the air (Nimlos 1989; Williams 1972).

Dissertation research conducted by Jacques Bordaz (1964) at the Peñitas site in Nayarit, Mexico, is an important comparative case. Bordaz was the first Mesoamerican scholar to discuss ephemeral pit-firing methods vis-à-vis other indicators of ceramic production. Through a series of stratigraphic excavations, he distinguished three asymmetrical pit-firing features from overlying midden deposits. The best preserved of these prehispanic features was defined by a perimeter of cobblestones and was divided into a rectangular firebox and circular vessel chamber. Bordaz likened this arrangement to a horizontal updraft kiln, albeit one having several traits in common with less formally designed pit kilns. The associated deposits contained dense layers of ash and charcoal, wasters, figurines, and clay concretions. Bordaz inferred that the concretions—variously referred to as "amorphous clay lumps," or "numerous fire-hardened fragments of loam" (with grass imprints running in all directions)—were all that remained of an impermanent earthen cover or roof that was placed over the firing pits. The production setting of the Peñitas site is broadly similar to that at Ejutla, and provides another prehispanic Mesoamerican instance of domestically situated ceramic production carried out using a relatively informal firing technology.

Implications of the Firing Experiment

To broaden the interpretive perspective for the archaeological firing features at Ejutla, the senior author constructed and fired an experimental pit kiln at the outdoor archaeology laboratory of the University of Wisconsin in Madison. Since there is no contemporary analog to pit-firing in the Oaxaca Valley, the design of the experimental pit kiln was modeled after ethnographic descriptions of traditional potters in India, Pakistan, and the southwestern United States (see comparisons of firing methods in Hodges 1975: 36–39; Payne 1982: 190; Rice 1987a: 158; Rye 1981: 96–105; Rye and Evans 1976: 41; Shepard 1961; Sinopoli 1991: 31–41). A shallow depression was dug into the ground surface, and its contours defined by a layer of sand as a referent for the post-firing excavation. To improve the draft, the kiln floor was slightly inclined, with the open end or "mouth" at a greater depth than the rear of the firing chamber. The chamber was filled with a mixture of pottery (in this instance, various vessel forms, including comales and test tiles), kiln furniture (to separate the vessels and improve airflow), and fuel (cow dung, grasses, and fallen tree branches). The mixture of pottery and fuel was then covered with straw to form a matrix upon which to construct a mud plaster roof. The mud plaster provides structure to minimize the damage caused by the shifting of pots as the fuel is consumed, and insulation, to conserve fuel and better control temperature and atmosphere (FIG. 5). The atmospheric conditions can be modified throughout the firing. Openings in the mud-plaster dome maintain an oxidizing atmosphere; alternatively, smothering the fire yields reduced wares. Four thermocouples were placed at different locations inside and beneath this feature, and temperature readings were taken at 15-minute intervals over an eight-hour period.

Because pit kilns share certain traits with the open and updraft firing methods already described, it is tempting to place them along a technological continuum between open hearths and updraft kilns (Rye and Evans 1976: 165). Yet this would require a corpus of archaeological firing data that does not at present exist. Pit kilns, therefore, are not necessarily transitional in an evolutionary or historical sense as some scholars have argued (e.g., Hodges 1975: 38), but are better characterized as functionally intermediate between open firings and updraft kilns (Rice 1987a: 158; Rye 1981: 98). Our use of the term "pit kiln" is derived from ethnographic descriptions of potters in South Asia (Rye and Evans 1976: 165–166), but the term has been applied more broadly as well (e.g., Heacock 1995; Rice 1987a: 158). We recognize that pit kilns are not, in a literal sense (see Rhodes 1968: 11), true ceramic kilns in that they do not provide complete separation between the fuel and those ceramic vessels being fired. In pit-kiln firings, large sherds and rock cobbles are often placed within the bounds of the pit to help shield the

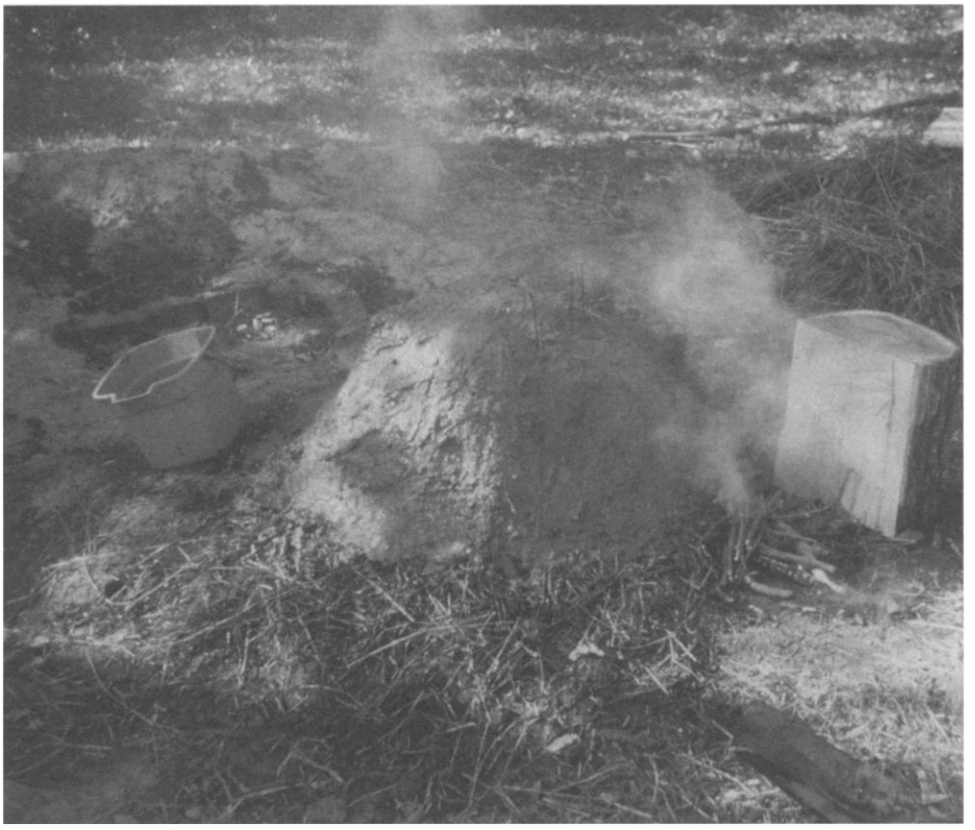


Figure 5. Experimental pit kiln being fired at the University of Wisconsin.

vessels from direct contact with the open fire (Peterson 1984: 140; Rice 1987a: 154).

The pit kiln combines the opportunism and simplicity of the bonfire or open-firing method with the structural support (and potential to stack vessels for a larger capacity per unit area) of updraft kilns. Yet, as compared to updraft kilns, vessels fired in pit kilns are more apt to come into direct contact with fuel or fire, thereby increasing the risk of miscolorations, uneven firing, and other forms of vessel wastage. These considerations suggest that, rather than a simple outcome of ethnic differences or unilinear evolution, the choice of firing technology may reflect the differing functional requirements potters had for their kilns and fired wares. For example, the pit kiln might have been a less costly option for intermittent producers than building and maintaining an updraft kiln. Another possibility stems from the enclosed nature of these kilns: compared to other firing methods, they allow potters a ready means to smother the fire (Rye 1981: 98). In the past, pit kilns would have been especially well suited to producing the reduced grayware vessels prominent in the prehispanic tradition of the Oaxaca Valley (Caso and Bernal 1965).

The experiment provided an independent perspective on the spatial patterns of the material remains, the condition of the underlying soil, firing temperatures, and other characteristics designed to examine the feasibility of a pit-firing model for the Ejutla features. The excavated experimental kiln section left few indications that an important step in ceramic manufacturing had occurred there. Evidence was limited to a number of broken vessels that had been damaged in the firing, a thin layer of ash mixed with charcoal, and a ground surface beneath the kiln that was discolored and partially baked to a depth of 1 cm (FIG. 6). In comparison, the Peñitas kilns, presumably fired numerous times, burned and discolored the underlying soil to a depth of 4 to 5 cm. Few of these residual materials from the experiment would likely survive intact on an exposed surface. On the other hand, if these deposits were rapidly sealed, they may have remained detectable as unusual concentrations of potsherds (anomalous quantities of particular forms and varieties), ash, and wasters. Most of the firing features at the Ejutla and Peñitas sites were covered by subsequent midden accumulation (or in the case of the southernmost Ejutla feature, by a house floor).

The most prominent remnant of the experimental firing was the pit kiln's mud plaster covering, now fired and

Figure 6. Experimental kiln after firing.

broken, that strongly resembled the clay concretions abundant at Ejutla, Peñitas, and other pottery-making sites in Mesoamerica (e.g., Bordaz 1964; Redmond 1979; Stark 1985). This class of residue also might resemble the "fired adobes" so prevalent at Tlajinga 33 (Sheehy 1992). Although other processes might result in similar concretion-like materials, their presence in contexts where numerous other indicators of ceramic production (including the pit kilns) have been recovered implies that these artifacts are all that remain from impermanent roofing.

Temperature data from the experimental firing provides an additional perspective on the archaeological features at Ejutla. The maximum recorded temperature was 768° Celsius—adequate to fire the vast majority of pottery known from prehispanic Mesoamerica—and consistent with other experimental and ethnoarchaeological studies of impermanent firing methods (e.g., Payne 1994; Rye 1981). In addition, this reading falls within 100° Celsius of experimentally refired potsherds from the Ejutla and Oaxaca Valleys (Feinman et al. 1989; Feinman et al. 1992), the survey collections from the production site of La Mixtequilla, Veracruz (Curet 1993), and excavated production sites in Nayarit and Central Mexico (Bordaz 1964; Sheehy 1992). Since the controlled refiring of ceramics provides an estimate of the maximum temperature to which the pottery was originally subjected, the complementarity of these temperature data might indicate that similar methods of production were employed, that the fired wares had similar functional requirements, or both. Yet the experimental temperature index alone cannot serve as definitive evidence of pit-kiln firing. The range of temperature variation from open through updraft firing methods is continuous (Gosselain 1992), a point made for modern potters in the Oaxaca Valley (Payne 1994; Shepard 1963). Nevertheless, the experimental firing does illustrate that ancient Mesoamerican potters could have used a pit-firing technology for the specialized production of ceramics, while leaving relatively few traces of the ceramic firing process.

The Archaeological Features

Most of Ejutla's pit-firing features (like those at Peñitas) were overlain with dense midden deposits that contained a wide variety of artifacts. Even so, the levels below the midden deposits that were in direct association with the bedrock pits held a more restricted artifact complex. These deposits were limited to ash, wasters, clay concretions, a

Figure 7. Profile of prehispanic pit kiln (18N24E, Feature A in Figure 4), with mass of potsherds and ash layers at base.

few rock cobbles, burnt bedrock, and potsherds—all consistent with a ceramic firing context (FIG. 7). The basal levels of these units held almost pure ash, often mixed with several large potsherds that may have insulated the vessel chamber from the bedrock surface, or served as spacers or other types of kiln furniture to shield the manufactured vessels from the fuel (FIG. 8) (Peterson 1984: 175). The surficial bedrock of the pit-firing features was blackened as if from burning, while decomposing pieces of bedrock (also burnt) were found in association. In at least two instances, the bedrock appeared to have been modified after its initial use. The feature in excavation unit 14N30E was dug to a second, deeper level (FIG. 9), while the "cigar-shaped" feature in units 16N34E and 14N36E may represent two separate, partially overlapping pit kilns.

The associated ceramic collections provide independent corroborative evidence that production took place in the vicinity of the structure. These collections are basically similar to the pottery found in other contexts at the site. In addition, petrographic analyses currently underway suggest that the archaeological ceramics were made with local clays. The distribution of production-related ceramic artifacts, moreover, is localized in and adjacent to the pit-firing features. The 2 × 2 m excavation squares that include these bedrock depressions had high densities of ceramic artifacts, wasters, and clay concretions relative to the other 2 × 2 m units that were excavated (FIG. 10).

The best preserved of the pit-firing features (at 18N24E and 2N34E) were slightly asymmetrical, with dimensions ranging from 2–4 m across and 40–70 cm deep (FIGS. 8, 11). The irregular shape of these pit kilns was due in part to a narrowing of the bedrock depression into what might have served as a stoke pit, or mouth, to add fuel and ventilate the kiln. Each of the extensions was oriented to the south—the direction of the prevailing afternoon wind—which presumably enhanced performance with the increased airflow into the kiln. Similar orientations toward local prevailing winds have been reported ethnographically (e.g., Krotser 1980) and noted at other archaeological sites (Abascal 1975; Bordaz 1964; Rice 1994; Russell 1994).

The sub-floor kiln feature varied in certain respects from the pit kilns north of the structure. In part, this variation can be attributed to the different use-lives of these features and their relative states of preservation; however, other kinds of variation may relate to slight differences in kiln design. The sub-floor feature, like the others at the Ejutla site, was carved in the prehispanic period from a natural depression in the underlying bedrock and had high densities of ash, wasters, and potsherds. Nevertheless, in contrast to the other firing features, the sub-floor kiln had the

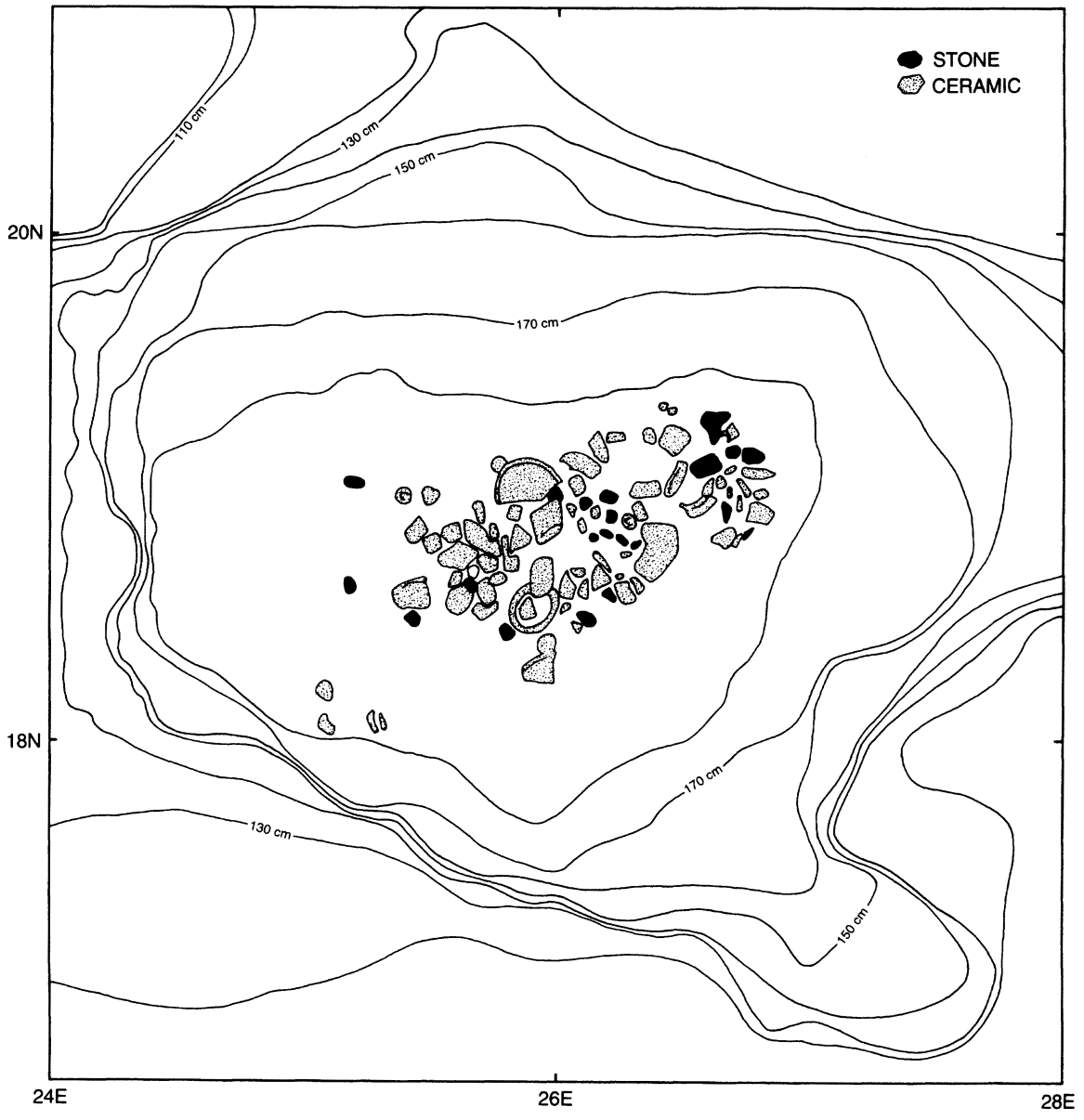


Figure 8. Contour drawing of the pit kiln in 18N24E (Feature A in Figure 4), illustrating kiln furniture and other debris near base of kiln. Grid is defined in 2-meter intervals; contour interval is 10 cm.

best defined and most distinctive bedrock fire pit, greater numbers of cobble-sized basalt stones, and unusually large pieces of charcoal (FIG. 12). Many of the cobblestones were spalled, covered in soot, and otherwise discolored from burning. Some of these, moreover, had been purposefully inserted into low spots in the bedrock, defining the edge of the pit-firing depression (in much the same way as at Peñitas). Although it seems likely that the sub-floor feature was built partly of stone, it would be premature to suggest that it operated in any way other than the rest of the pit kilns. It may, however, have been a more formally designed, or a better preserved, pit kiln. The installation of the house floor may have protected and better preserved this feature relative to the other Ejutla pit kilns. In contrast, the shallow, subsurface fireboxes of updraft kilns, like those at Monte Albán and Atzompa, are deeper and more regular in shape than any of the firing features at Ejutla (FIG. 13). This is a key point, since it appears that these otherwise distinct firing methods would be distinguishable archaeologically even when standing walls and other superstructural features did not survive.

The nature of the excavated ceramic assemblage from

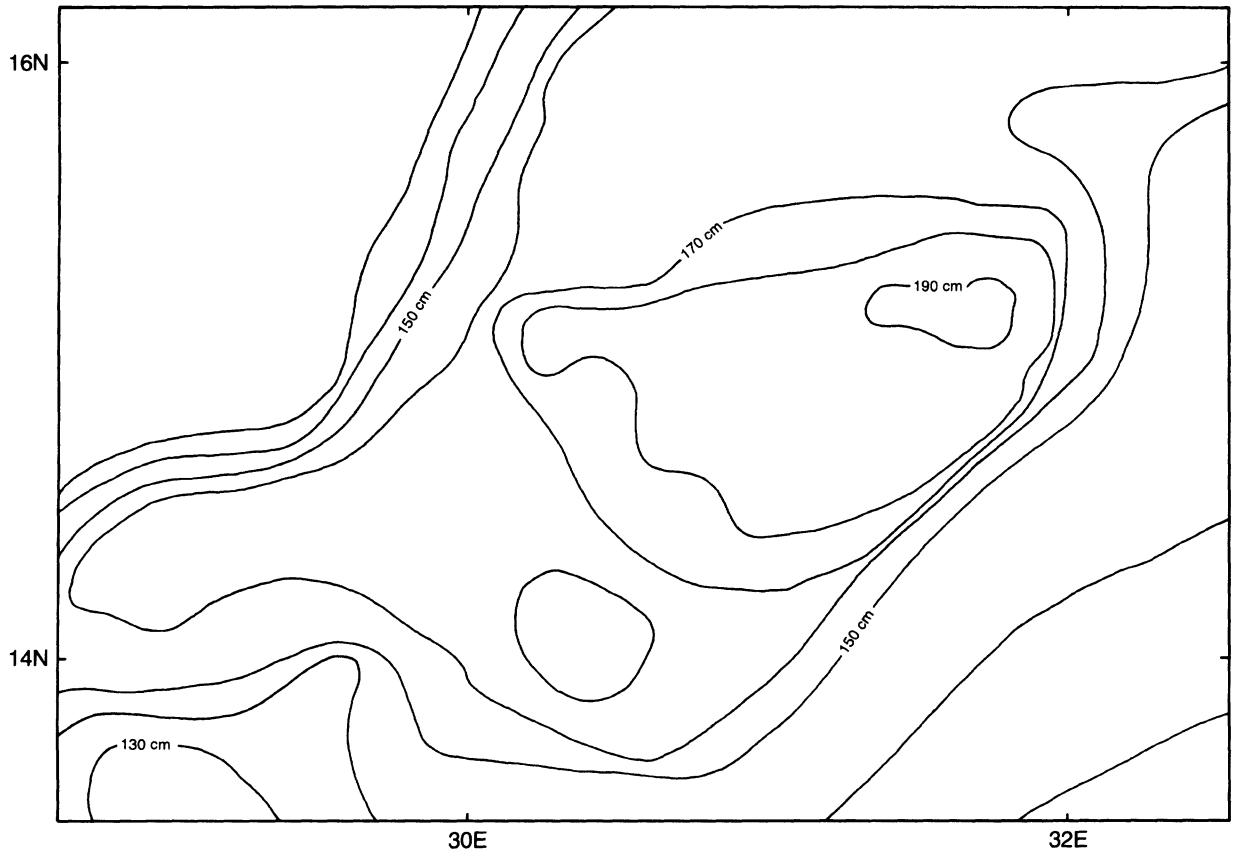


Figure 9. Contour drawing of pit kiln in 14N30E (Feature B in Figure 4).

Ejutla also suggests that the site's potters did not have the control over firing that would be expected if updraft kilns were employed. Conservative standards were used by this project in the definition of defective vessels or wasters. Yet nearly 0.5% of the ceramic assemblage from the Ejutla excavations was classified as such. The percentages for those forms that clearly were made at the site (for example, figurines for which molds have been recovered) were even higher. Roughly 8% of the figurine assemblage was defined as wasters. In addition to the misformed, vitrified, and exploded vessels that were categorized as wasters, misfired sherds also were common. For example, most figurines were oxidized brown, but a small number appear to have been accidently reduced. Similar inconsistencies in coloration were noted for most of the forms produced by the Ejutla potters. Multi-toned and fire-clouded vessels also were found with some regularity. Frequent firing errors of these sorts are the likely consequence of direct-fuel firings, where fuel and vessels are not entirely separated (Vitelli 1993: 207).

A final consideration is the spatial arrangement of the Ejutla kilns. The presence of multiple firing features in the vicinity of the structure suggests the frequent movement of specific firing location, or the simultaneous use of multiple kilns. Contemporary pottery-making families at Atzompa move kilns around their houselots as older kilns fall into ruin and the spatial needs of the household change (Mary Thieme, personal communication, 1994; also see Arnold 1991: 54; Rye and Evans 1976: 41, 54, 165–166). The time frame of these changing configurations is typically from 5 to 30 years, too short a span in most cases to be distinguished archaeologically. Whether the Ejutla kilns were contemporaneous or sequential, it is likely that our sample underrepresents the total number of such features in the vicinity of the structure, and perhaps in this sector of the Ejutla site. Bordaz also thought there were more kilns at Peñitas [1964: 44], while Abascal showed a total of 17 kilns at one locality in Puebla-Tlaxcala (1976: fig. 3).

Discussion

Ephemeral firing procedures like those at the Ejutla site do not leave a distinct or easily discernible record. The

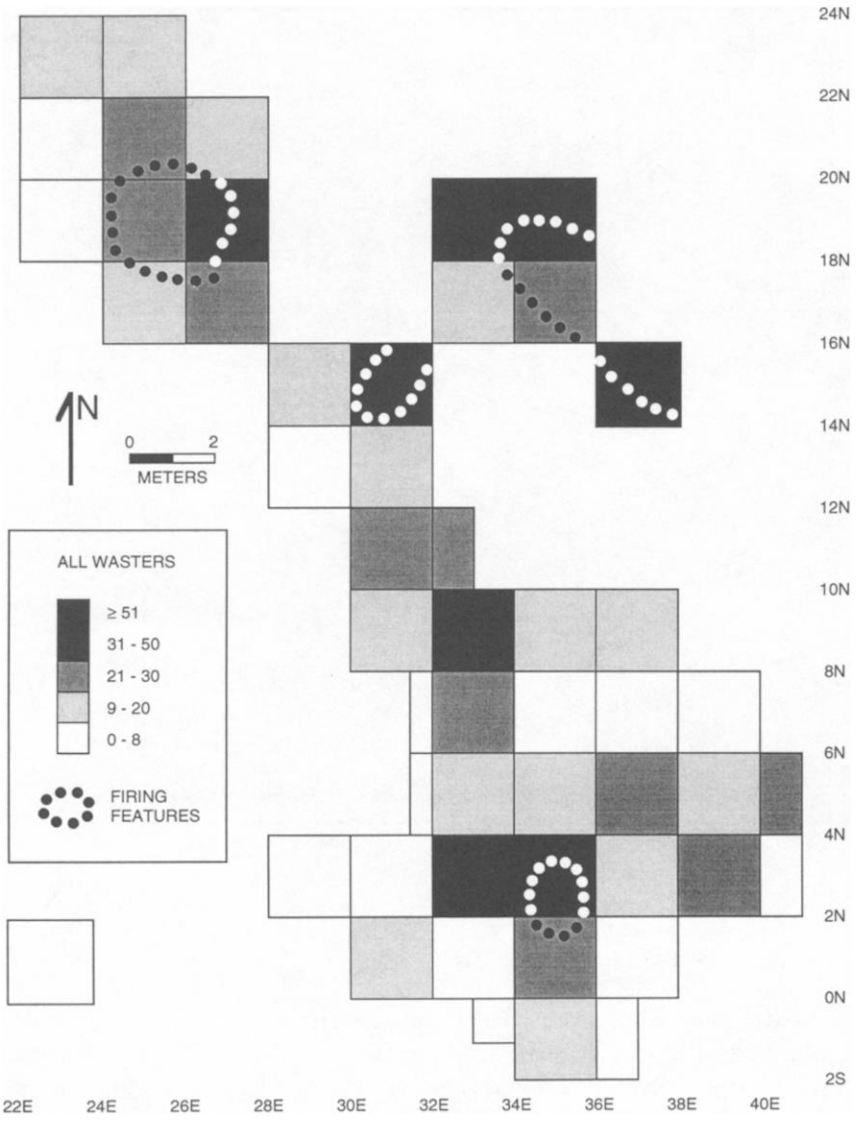


Figure 10. Density of ceramic wasters in the excavated area at the Ejutla site.

nature of the archaeological pit kilns at Ejutla, having been carved in the high bedrock below the site, made it far easier to recognize them. Nevertheless, the ashy gray and carbon-laden soils, the heavy densities of potsherds, the anomalous abundance of specific ceramic forms, and the various other residues and by-products associated with ceramic manufacture confirmed the production of appreciable quantities of ceramics. With these contextual data, the commonly cited alternatives—that these kinds of remains only imply the heavy consumption of ceramics or some depositional anomaly (e.g., Costin 1991: 31; Stark 1985: 177)—seem far less satisfactory. Each class of evidence used in the analysis of the Ejutla kilns—the excavated ceramics and pit-firing contexts, the experiment, and the comparative cases—taken alone, provides a suggestive though incomplete statement on the nature of ceramic production at Ejutla. Taken together, this suite of data supports an argument that ceramic production occurred at the Ejutla site and that an informal firing technology was employed.

We are unaware of any contemporary Mesoamerican examples of pit-kiln firing. Perhaps for this reason, Mesoamerican archaeologists have not consistently recognized informal firing features in the vain expectation that more formal updraft kilns were generally employed. These preconceived notions notwithstanding, the findings presented

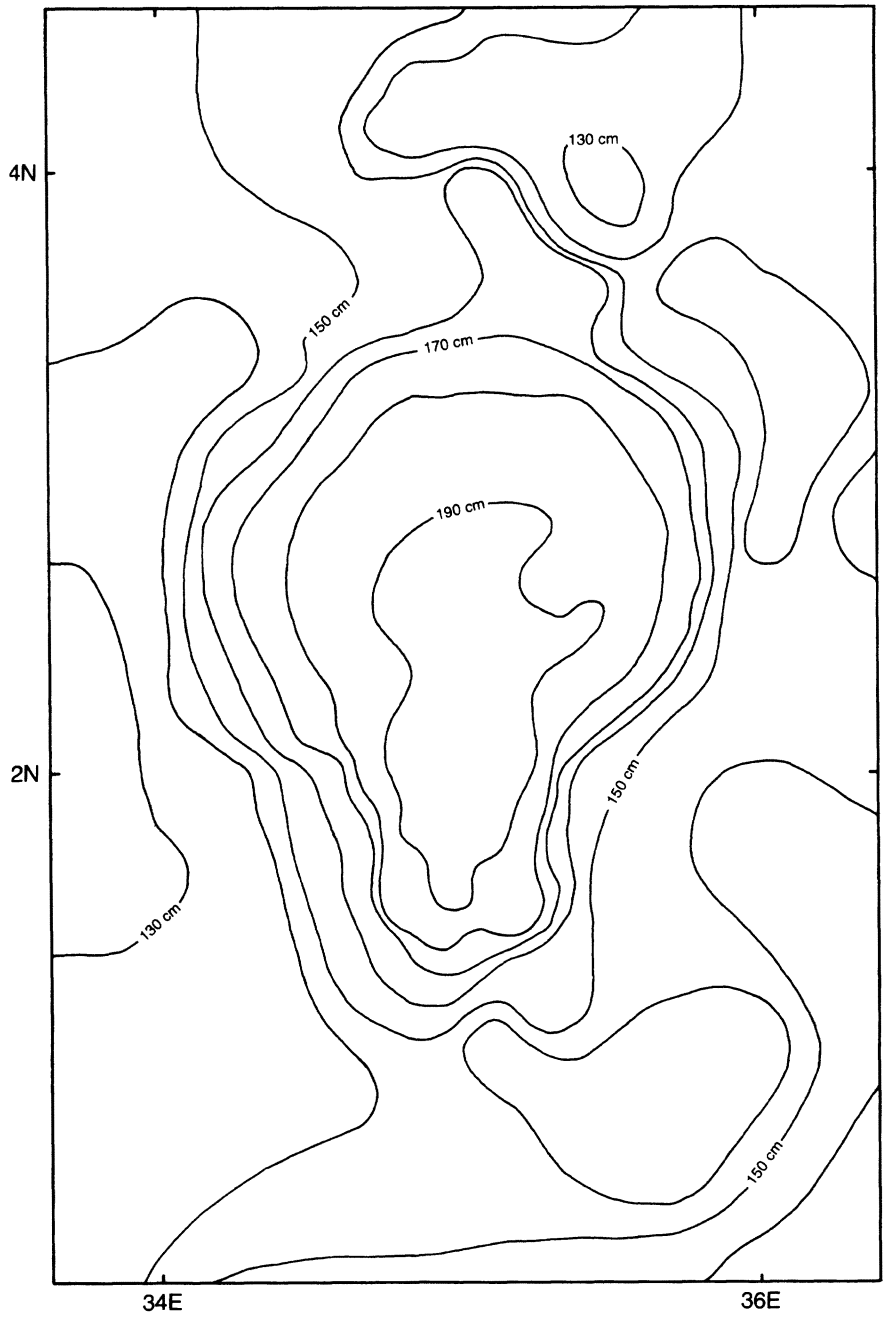


Figure 11. Contour drawing of the sub-floor pit kiln in 2N34E (Feature C in Figure 4).

here suggest that in prehispanic Mesoamerica significant quantities of pottery were fired in pit kilns and other less permanent facilities. We hypothesize that more ephemeral means of ceramic firing likely were employed at various ancient Mesoamerican sites where ample evidence for ceramic production has been noted, but no formal kilns have been recovered (e.g., Krotser 1987; Rattray 1990). Mesoamerican archaeologists should no longer be predisposed to encounter formal updraft kilns alone.

The problem of identifying prehispanic ceramic production is not simply a product of the "tyranny of ethnographic analogy," but may be compounded by the implementation of field methodologies that are not always adequate to recover impermanent exterior features. Excavation strategies limited to narrow test trenches or the isolated exposure of 2 × 2 m units are unlikely to yield unequivocal archaeological indicators of ephemeral firing. Inattention to midden deposits undoubtedly also has led

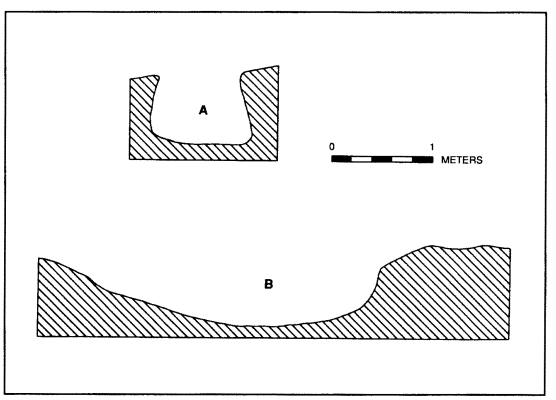
Figure 12. Rock cobbles and ceramic debris in sub-floor pit kiln in 2N34E (Feature C in Figure 4).

archaeologists to define firing features (such as those identified at Ejutla) that were later filled with trash as "burnt areas within middens," or the ubiquitous "ash-filled pit." Without careful horizontal excavations of exterior contexts that immediately surround non-elite domestic residences, the systematic recognition of impermanent firing features will remain elusive (an argument given broader attention in Flannery and Marcus 1994: 25–37).

Despite these methodological limitations, the available evidence indicates that diverse firing strategies have been practiced in Mesoamerica since the Formative period. The known distribution of relatively permanent updraft kilns (like those at Monte Albán) varies widely over time—from the Late Formative through the Late Postclassic periods, and across space—in Oaxaca, Tehuacán, the state of Mexico, Veracruz, and Honduras (Cabrera Castro 1988; Flannery and Marcus 1983: 299; Redmond 1979; Santley, Arnold, and Pool 1989; Stone and Turnbull 1941; Whalen 1981: 88–105; Winter and Payne 1976). This distribution is matched by the reported sample of impermanent, open, or pit-firing facilities from a markedly diverse range of sites—village occupations in Middle and Late Formative Puebla-Tlaxcala (Abascal 1975, 1976), Classic period Teotihuacan (Sheehy 1992), and Postclassic sites in Nayarit (Bordaz 1964) and Oaxaca (Swezey 1975). The Classic period Ejutla pit kilns apparently were used at the same time as the more formal kilns at Monte Albán, but varied in size, design, and degree of permanence. In highland Oaxaca, therefore, technologically diverse ceramic-firing methods were practiced at contemporaneous sites fewer than 75 km apart.

The research presented here suggests that the modern

Figure 13. Profile comparison of (A) updraft kiln at Monte Albán and (B) Ejutla pit kiln.



diversity of the potters' craft described by Foster has antecedents in the prehispanic era. But how might we account for these variable production methods over so long a time span? If ethnicity were the key factor, one might expect differences between informal pit-firing and formal updraft kiln sites in vessel forms and decorative attributes, as well as method of production. Contrary to these expectations, the ceramic complex from Ejutla was highly similar on stylistic grounds to Classic period occupations in the Oaxaca Valley (although the Ejutla collections were generally less decorated as one might expect in a peripheral region). If ethnicity explains the recognized differences in firing technologies, then clearer geographic and temporal distinctions also might be expected. Yet this view is not supported for the cases cited here, which clearly do not vary along a single spatio-temporal trajectory. We adhere to an approach closer to that advocated by Shepard, one that seeks an active relationship between the organization of ceramic producers, their technology, and multi-scale patterns of consumption. A full accounting of the past variation and change in ancient Mesoamerica's ceramic production complex must include socioeconomic and demographic factors in the analysis.

The analysis of ceramic firing may help Mesoamerican archaeologists disentangle the measures of scale and intensity (see Costin 1991). Although, as we have argued elsewhere, much of ancient Mesoamerica's ceramic (and other craft) production was situated domestically, there are clear differences in the volumes of pottery produced (the intensity of manufacture) by different ceramic-making households. If variation in firing technology is related to intensity, then Mesoamerican archaeologists might find intensity a more accessible measure of ceramic production.

In a cross-cultural review of 55 modern potting communities, Sheehy (1992: 73–102, table 3.1) compares resources, social organization, technology, and other aspects of production to construct a multi-level model of ceramic-production intensity. Although Sheehy (1992: 133–140, table 4.6) recognized the difficulty of drawing generalizations from such a wide-ranging sample, he noted a proportionate increase between the frequency of ceramic firing and the formality of the production facilities. The lowest-volume producers fire their pottery in open hearths or pit kilns. Levels of productive intensity increase with the use of updraft kilns and still more complex downdraft and multi-chambered kiln arrangements (changes that Sheehy attributes to demand). Even within the category of pit-firing groups, there is a trend toward the increasing diameter and depth of the firing facility with greater levels of production. The strong correlation between the intensity of ceramic production and firing technology identified by Sheehy provides a well-founded cross-cultural basis for the proposition that the choice of firing technology is intensity related (also see Deal 1988: 124).

The comparisons between the modern Oaxacan potting communities of Atzompa and San Marcos seem to bear out many of these points. Both villages operate on a household scale, yet work at markedly different productive intensities and use variable firing technologies in response to different external marketing options. The nature of ceramic firing is independent of scale and appears to be intensity related in that both the Atzompa and San Marcos potters work out of their domestic houselots but produce markedly different quantities of pottery. Similar observations can be made about the Coyotepec and Ocotlán potters, yet these cases are suggestive for other reasons. Although firing at these villages is done in true kilns, they are housed underground, a practice that might be considered continuous with pit-firing from the prehispanic era. Moreover, the black pottery of Coyotepec is possibly continuous with Oaxaca's reduced fired grayware tradition. As proposed earlier, pit kilns are ideally suited to produce this reduced ware.

These observations notwithstanding, we recognize, as Arnold (1991: 109–110) has persuasively argued, that multiple factors govern technological choices in ceramic firing, so that the use of updraft kilns as opposed to open firing cannot be reduced to the intensity of manufacture alone. Still, following Sheehy, we suspect that intensity of production may be one of the critical factors that influence firing decisions. Working in the Tuxtlas mountains of southern Veracruz, where he completed a comparative ethnoarchaeological study, Arnold (1991) attributes firing variability primarily to differences in houselot space. He demonstrates that potters at San Isidro—the only community in the study region to use updraft kilns—had the smallest houselots. Nevertheless, of the four pottery making communities examined, San Isidro did have the highest productive intensity as measured in the frequency of manufacture (Arnold 1991: table 17). Likewise, an informant who did not have a kiln of her own stated that she did not work often enough to invest the time and effort into building one (Arnold 1991: 54).

Of all the Tuxtlas potting communities studied, San Isidro is located nearest to the region's major demographic center at San Andres Tuxtlas, whose population is nearly twice that of the region's next largest town (Arnold 1991: 12–13). San Isidro potters, living in the most densely settled part of the region, may have had the opportunity to produce more ceramics to meet a potentially larger market. The use of updraft kilns by these potters might reflect the

greater volume of production relative to other potters in the Tuxtlas region, although alternative factors, such as houselot arrangement, may have been a consideration. San Isidro's location in this more densely settled area also could have been a key factor in the greater spatial constraints that were placed on the use and organization of the houselot (Santley and Hirth 1993: 7–8).

We have suggested that the nature of ceramic firing may be a somewhat independent measure of productive intensity. But what of the scale of that production? Although there are clear differences in the volumes of ceramic and other craft goods produced at ancient Mesoamerican sites, careful archaeological investigations repeatedly situate craft production in a domestic context (e.g., Charlton, Nichols, and Charlton 1991). The apparent contrast in the scale and intensity of production, as Costin (1991) has argued, requires that these two dimensions or parameters of specialization be kept analytically separate. In practice this has been difficult to achieve. The analysis by Santley and colleagues (Arnold et al. 1993; Santley 1994; Santley, Arnold, and Pool 1989) of multiple contexts and modes of ceramic production at the Classic period site of Matacapan, Veracruz, is one such example. They employed intensive site-survey methods to identify variation in the intensity of ceramic production both across the site and over time, and in conjunction with inferences drawn from other artifact categories, concluded that Matacapan's scale of production varied from household to workshop to industrial settings. This interpretation, however, is predicated on indirect measures of context (Santley, Arnold, and Pool 1989: 119–120) that, rather than providing independent referents, are guided by unilinear evolutionary presumptions (Peacock 1982; van der Leeuw 1976) that equate the degree of intensity with productive scale. The identified workshop and industrial-scale production areas at Matacapan may instead reflect an unusual concentration of producing households in a particular residential zone—an issue of analytical scale rather than scale of production (Costin 1991: 29–30; cf. Arnold et al. 1993: 185; Santley 1994: 258). Although we concur that the intensity of ceramic production may have varied as they describe in their study region, it is misleading for them to equate intensity with productive scale in the absence of unambiguous contextual information. If, as proposed, there were indeed non-domestic ceramic workshops or factories at Matacapan, then it would be important to describe such contexts in detail, as we lack adequate descriptions for them anywhere in prehispanic Mesoamerica.

In our comparison of ceramic production in Oaxaca, it is revealing that, despite the contrasting firing technologies used by potters at Monte Albán and Ejutla, the firing features at both sites were associated with domestic contexts. Compared to Ejutla, however, ceramic manufacturing at Monte Albán may have been conducted more continuously and at greater intensities, making the construction and maintenance of more formal and permanent firing facilities a reasonable if not necessary investment. Even in much of rural Mesoamerica today, full-time specialists, producing large volumes of craft goods for outside consumption and markets, often work in domestic settings, not factories. Indeed, simply because ancient (and much modern) Mesoamerican craftwork is situated domestically does not imply that such manufacture was either part-time or economically insignificant. To understand prehispanic Mesoamerican craft specialization and the nature of these ancient economies, existing presumptions concerning the scale and intensity of that production must be decoupled.

To conclude, we have argued that Mesoamerica's ethnographic record, while an indispensable source of archaeological insight, cannot be applied uncritically to the prehispanic past of the region. There appears to have been greater variability in ceramic firing practices in ancient than in modern times. Archaeological methods may play a role in the underrepresentation of this variability. What is needed are more excavated production contexts that are not limited to isolated features, but include households and the lateral space beyond structures. We also have proposed that differences in the technology of ceramic firing may provide an indicator of the intensity of ceramic manufacture, independent of the scale of that production. Archaeologists may find this consideration useful to disentangle the complex and varied relationship between scale and intensity. Finally, the research at Ejutla suggests that in ancient Mesoamerica, ceramic production was often implemented through the deceptively simple technology of the pit kiln.

Acknowledgments

Earlier versions of this paper were presented at the 1994 Midwest Mesoamericanists Meeting and the 1994 Annual Meeting of the American Anthropological Association. Philip J. Arnold III, Charles C. Kolb, and Louana M. Lackey provided those opportunities, and we are grateful. The firing experiment was completed in conjunction with a graduate seminar at the University of Wisconsin-Madison on ancient technology directed by J. Mark Kenoyer. We thank Mary S. Thieme and Ronald Spores, both of whom visited the Ejutla excavations and contributed to the analysis in the field. Thieme introduced the senior author to the potters of Atzompa, while Spores commented on a previous draft of this paper. We also appreciate the construc-

tive comments of Barbara L. Stark, Karen D. Vitelli, Marcus C. Winter, and Ricardo J. Elia during the review process.

The Ejutla excavations were funded by grants to the second author by the National Science Foundation (BNS 89-19164, BNS 91-05780, and SBR 9304258), the National Geographic Society, the H. John Heinz Foundation, the Graduate School and the Nave Foundation at the University of Wisconsin-Madison, and Arvin Weinstein. The Instituto Nacional de Antropología e Historia provided essential permissions and support. We acknowledge the invaluable help of Eduardo López Calzada, Angel García Cook, Ernesto González Licón, Alejandro Martínez Muriel, Lorena Mirambell Silva, Mari Carmen Serra Puche, John Yellen, the archaeological and curatorial staffs at the Centro Regional de Oaxaca, our hard-working field and laboratory crews, and the municipal authorities and people of Ejutla.

Andrew K. Balkansky is a Ph.D. candidate in Anthropology at the University of Wisconsin in Madison. The focus of his dissertation is a regional settlement pattern survey of the Sola Valley, Oaxaca. He has worked on archaeological projects in Minnesota, Wisconsin, and the Huamelulpan Valley, Oaxaca, and was a field assistant for two seasons of excavation at the Ejutla site. Mailing address: Department of Anthropology, University of Wisconsin, Madison, WI 53706. e-mail: andrewb@macc.wisc.edu

Gary M. Feinman (Ph.D. City University of New York-Graduate Center, 1980) is a Professor of Anthropology at the University of Wisconsin in Madison. He was principal investigator and co-director of both the Ejutla Valley Settlement Pattern Project and the University of Wisconsin Ejutla Shell Project. e-mail: gfeinman@macc.wisc.edu

Linda M. Nicholas (M.A. Arizona State University, 1981) is Honorary Fellow of the Department of Anthropology at the University of Wisconsin in Madison. She was co-director of both the Ejutla Valley Settlement Pattern Project and the University of Wisconsin Ejutla Shell Project.

Abascal, Rafael
1975 "Los Hornos Prehispánicos en la Región de Tlaxcala," *XIII Mesa Redonda de la Sociedad Mexicana de Antropología,* tomo I. Mexico, 189–198.

1976 "Los Primeros Pueblos Alfareros Prehispánicos," *Comunicaciones, Suplemento*, Vol. III, *Proyecto Puebla-Tlaxcala.* Fundación Alemana para la Investigación Científica, 49–52.

Arnold, Dean E.
1985 *Ceramic Theory and Cultural Process.* Cambridge: Cambridge University Press.

Arnold, Philip J., III
1991 *Domestic Ceramic Production and Spatial Organization: A Mexican Case Study in Ethnoarchaeology.* Cambridge: Cambridge University Press.

Arnold, Philip J., III, Christopher A. Pool, Ronald R. Kneebone, and Robert S. Santley
1993 "Intensive Ceramic Production and Classic-Period Political Economy in the Sierra de Los Tuxtlas, Veracruz, Mexico," *Ancient Mesoamerica* 4: 175–191.

Arnold, Philip J., III, and Robert S. Santley
1993 "Household Ceramics Production at Middle Classic Period Matacapan," in Robert S. Santley and Kenneth G. Hirth, eds., *Prehispanic Domestic Units in Western Mesoamerica: Studies of Household, Compound, and Residence.* Boca Raton, Florida: CRC Press, 227–248.

Beals, Ralph L.
1945 *Ethnology of the Western Mixe. University of California Publications in American Archaeology and Ethnology* 42. Berkeley: University of California.

Bernal, Ignacio
1965 "Archaeological Synthesis of Oaxaca," in Robert Wauchope and Gordon R. Willey, eds., *Handbook of Middle American Indians*, Vol. 3: *Archaeology of Southern Mesoamerica*, pt. 2. Austin: Universiy of Texas Press, 788–813.

Blanton, Richard E., Stephen A. Kowalewski, Gary M. Feinman, and Jill Appel, eds.
1982 *Monte Albán's Hinterland, Part I: The Prehispanic Settlement Patterns of the Central and Southern Parts of the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 15. Ann Arbor: University of Michigan.

Bordaz, Jacques
1964 "Pre-Columbian Ceramic Kilns at Peñitas, a Post-Classic Site in Coastal Nayarit, Mexico," unpublished Ph.D. dissertation, Columbia University, New York.

Cabrera Castro, Rubén
1988 "Horno Cerámico Posteotihuacano en el Palacio de Atetelco," *Arqueología* 4: 47–75.

Caso, Alfonso, and Ignacio Bernal
1965 "Ceramics of Oaxaca," in Robert Wauchope and Gordon R. Willey, eds., *Handbook of Middle American Indians*, Vol. 3: *Archaeology of Southern Mesoamerica,* pt. 2. Austin: Universiy of Texas Press, 871–895.

Charlton, Thomas H., Deborah L. Nichols, and Cynthia Otis Charlton
1991 "Aztec Craft Production and Specialization: Archaeological Evidence from the City-State of Otumba, Mexico," *World Archaeology* 23: 98–114.

Cook, Scott, and Martin Diskin, eds.
1976 *Markets in Oaxaca.* Austin: University of Texas Press.

Costin, Cathy L.
1991 "Craft Specialization: Issues in Defining, Documenting, and Explaining the Organization of Production," *Archaeological Method and Theory* 3: 1–56.

Curet, Antonio
1993 "Regional Studies and Ceramic Production Areas: An Example from La Mixtequilla, Veracruz, Mexico," *Journal of Field Archaeology* 20: 427–440.

Deal, Michael
1983 "Pottery Ethnoarchaeology among the Tzeltal Maya," unpublished Ph.D. dissertation, Simon Fraser University, Burnaby, British Columbia.

1988 "An Ethnoarchaeological Approach to the Identification of Maya Domestic Pottery Production," in Charles C. Kolb, ed., *Ceramic Ecology Revisited, 1987: The Technology and Socioeconomics of Pottery. BAR International Series* 436 (ii). Oxford: British Archaeological Reports, 111–142.

Diguet, M. Leon
1905 "Notes D'Archéologie Mixteco-Zapotéque," *Journal de la Société des Américanistes de Paris, Nouvelle Série,* tome II: 109–116.

Feinman, Gary M.
1980 *The Relationship between Administrative Organization and Ceramic Production in the Valley of Oaxaca, Mexico.* Ph.D. dissertation, City University of New York. Ann Arbor: University Microfilms.

1982 "Patterns of Ceramic Production and Distribution, Periods Early I through V," in Richard E. Blanton, Stephen A. Kowalewski, Gary M. Feinman, and Jill Appel, eds., *Monte Albán's Hinterland, Part I: The Prehispanic Settlement Patterns of the Central and Southern Parts of the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 15. Ann Arbor: University of Michigan, 181–206.

1985 "Investigations in a Near-Periphery: Regional Settlement Pattern Survey in the Ejutla Valley, Oaxaca, Mexico," *Mexicon* 7: 60–68.

Feinman, Gary M., Sherman Banker, Reid F. Cooper, Glen B. Cook, and Linda M. Nicholas
1989 "A Technological Perspective on Changes in the Ancient Oaxacan Grayware Ceramic Tradition: Preliminary Results," *Journal of Field Archaeology* 16: 331–344.

Feinman, Gary M., Stephen A. Kowalewski, Sherman Banker, and Linda M. Nicholas
1992 "Ceramic Production and Distribution in Late Postclassic Oaxaca: Stylistic and Petrographic Perspectives," in George J. Bey, III, and Christopher A. Pool, eds., *Ceramic Production and Distribution: An Integrated Approach.* Boulder, CO: Westview Press, 235–260.

Feinman, Gary M., and Linda M. Nicholas
1988 "The Prehispanic Settlement History of the Ejutla Valley, Mexico: A Preliminary Perspective," *Mexicon* 10: 5–13.

1990 "At the Margins of the Monte Albán State: Settlement Patterns in the Ejutla Valley, Oaxaca, Mexico," *Latin American Antiquity* 1(3): 216–246.

1992 "Pre-Hispanic Interregional Interaction in Southern Mexico: The Valley of Oaxaca and the Ejutla Valley," in Edward M. Schortman and Patricia A. Urban, eds., *Resources, Power, and Interregional Interaction.* New York: Plenum Press, 75–116.

1993 "Shell Ornament Production in Ejutla: Implications for Highland-Coastal Interaction in Ancient Oaxaca," *Ancient Mesoamerica* 4: 103–119.

1995 "Household Craft Specialization and Shell Ornament Manufacture in Ejutla, Mexico," *Expedition* 37: 14–25.

Feinman, Gary M., Linda M. Nicholas, and Scott Fedick
1991a "Shell Working in Prehispanic Ejutla, Oaxaca (Mexico): Findings from an Exploratory Field Season," *Mexicon* 13: 69–77.

1991b "La Industria de Concha en Ejutla Prehispánico: Un Análisis Arqueológico," *Boletín del Consejo de Arqueología 1990.* México: Instituto Nacional de Antropología e Historia, 106–111.

Feinman, Gary M., Linda M. Nicholas, and William D. Middleton
1993 "Craft Activities at the Prehispanic Ejutla Site, Oaxaca, Mexico," *Mexicon* 15: 33–41.

Flannery, Kent V., and Joyce Marcus
1983 "Urban Mitla and its Rural Hinterland," in Kent V. Flannery and Joyce Marcus, eds., *The Cloud People: Divergent Evolution of the Zapotec and Mixtec Civilizations.* New York: Academic Press, 295–300.

1994 *Early Formative Pottery of the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 27. Ann Arbor: University of Michigan.

Foster, George M.
1948a "Some Implications of Modern Mexican Mold-Made Pottery," *Southwestern Journal of Anthropology* 4: 356–370.

1948b *Empire's Children: The People of Tzintzuntzan. Institute of Social Anthropology Publication* 6. Washington, D.C.: Smithsonian Institution.

1955 *Contemporary Pottery Techniques in Southern and Central Mexico. Middle American Research Institute, Tulane University, Publication* 22. New Orleans: Tulane University, 1–48.

1959 "The Coyotepec Molde and Some Associated Problems of the Potter's Wheel," *Southwestern Journal of Anthropology* 15: 53–63.

1960 "Life Expectancy of Utilitarian Pottery in Tzintzuntzan, Michoacán, Mexico," *American Antiquity* 25(4): 606–609.

1965 "The Sociology of Pottery: Questions and Hypotheses Arising from Contemporary Mexican Work," in Frederick R. Matson, ed., *Ceramics and Man.* Aldine: University of Chicago Press, 43–61.

1967 "Contemporary Pottery and Basketry," in Manning Nash, ed. (Robert Wauchope, general editor), *Handbook of Middle American Indians,* Vol. 6: *Social Anthropology.* Austin: University of Texas Press, 103–124.

Gosselain, Olivier P.
1992 "Bonfire of the Enquiries. Pottery Firing Temperatures in Archaeology: What For?," *Journal of Archaeological Science* 19: 243–259.

Heacock, Laura A.
1995 "Archaeological Investigations of Three Mesa Verde Anasazi Pit Kilns," *Kiva* 60: 391–410.

Hendry, Jean Clare
1992 *Atzompa: A Pottery Producing Village of Southern Mexico in the Mid-1950s. Vanderbilt University Publications in Anthropology* 40. Nashville: Vanderbilt University.

Hodges, Henry
1975 *Artifacts: An Introduction to Early Materials and Technology.* London: John Baker.

Kowalewski, Stephen A., Gary M. Feinman, Richard E. Blanton, Laura Finsten, and Linda M. Nicholas
1989 *Monte Albán's Hinterland, Part II: The Prehispanic Settlement Patterns in Tlacolula, Etla, and Ocotlán, the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 23. Ann Arbor: University of Michigan.

Krotser, Paula
1980 "Potters in the Land of the Olmec," in Michael D. Coe and Richard A. Diehl, eds., *In the Land of the Olmec*, Vol. 2: *The People of the River.* Austin: University of Texas Press, 128–138.

1987 "Levels of Specialization Among Potters of Teotihuacan," in Emily McClung de Tapia and Evelyn Childs Rattray, eds., *Teotihuacan: Nuevos Datos, Nuevas Síntesis, Nuevos Problemas.* México: Universidad Nacional Autónoma de México, 417–427.

Lackey, Louana M.
1981 *The Pottery of Acatlán: A Changing Mexican Tradition.* Norman: University of Oklahoma Press.

Nimlos, Thomas
1989 "The Density and Strength of Mexican Tepetate," *Soil Science* 147: 23–27.

Payne, William O.
1970 "A Potter's Analysis of the Pottery from Lambityeco Tomb 2," *Boletín de Estudios Oaxaqueños* 29: 1–8.

1982 "Kilns and Ceramic Technology of Ancient Mesoamerica," in Jacqueline S. Olin and Alan D. Franklin, eds., *Archaeological Ceramics.* Washington, D.C.: Smithsonian Institution Press, 47–56.

1994 "The Raw Materials and Pottery-Making Techniques of Early Formative Oaxaca: An Introduction," in Kent V. Flannery and Joyce Marcus, *Early Formative Pottery of the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 27. Ann Arbor: University of Michigan, 7–20.

Peacock, David P. S.
1982 *Pottery in the Roman World: An Ethnoarchaeological Approach.* London: Longman.

Peterson, Susan
1984 *Lucy M. Lewis: American Indian Potter.* Tokyo: Kodansha International.

Pires-Ferreira, Jane W.
1976 "Shell and Iron-Ore Mirror Exchange in Formative Mesoamerica, with Comments on Other Commodities," in Kent V. Flannery, ed., *The Early Mesoamerican Village.* New York: Academic Press, 311–328.

Pool, Christopher A., and Robert S. Santley
1992 "Middle Classic Pottery Economics in the Tuxtla Mountains, Southern Veracruz, Mexico," in George J. Bey, III, and Christopher A. Pool, eds., *Ceramic Production and Distribution: An Integrated Approach.* Boulder, CO.: Westview Press, 205–234.

Rattray, Evelyn Childs
1990 "New Findings on the Origins of Thin Orange Ceramics," *Ancient Mesoamerica* 1: 181–195.

Redmond, Elsa M.
1979 "A Terminal Formative Ceramic Workshop in the Tehuacán Valley," in Robert D. Drennan, ed., *Prehistoric Social, Political, and Economic Development in the Area of the Tehuacán Valley: Some Results of the Palo Blanco Project. Technical Reports, Museum of Anthropology, University of Michigan* 11. Ann Arbor: University of Michigan, 111–125.

Reina, Reuben E., and Robert M. Hill, II
1978 *The Traditional Pottery of Guatemala.* Austin: University of Texas Press.

Rhodes, Daniel
1968 *Kilns: Design, Construction, and Operation.* Philadelphia: Chilton Book Company.

Rice, Prudence M.
1981 "Evolution of Specialized Pottery Production: A Trial Model," *Current Anthropology* 22(3): 219–240.

1984 "The Archaeological Study of Specialized Pottery Production: Some Aspects of Method and Theory," in Prudence M. Rice, ed., *Pots and Potters: Current Approaches in Ceramic Archaeology. Monograph, UCLA Institute of Archaeology* 24. Los Angeles: University of California Press, 45–54.

1987a *Pottery Analysis: A Sourcebook.* Chicago: The University of Chicago Press.

1987b "Lowland Maya Pottery Production in the Late Classic Period," in Prudence M. Rice and Robert J. Sharer, eds., *Maya Ceramics: Papers from the 1985 Maya Ceramic Conference. BAR International Series* 384 (ii). Oxford: British Archaeological Reports, 525–561.

1994 "The Kilns of Moquegua, Peru: Technology, Excavations, and Functions," *Journal of Field Archaeology* 21: 325–344.

Russell, Glenn S.
1994 "Cerro Mayal, Peru: Moche Ceramic Workshop Excavated," *Backdirt* (Spring): 6–7.

Rye, Owen S.
1981 *Pottery Technology: Principles and Reconstruction. Manuals on Archaeology* 4. Washington, D.C.: Taraxacum.

Rye, Owen S., and Clifford Evans
1976 *Traditional Pottery Techniques of Pakistan: Field and Laboratory Studies. Smithsonian Contributions to Anthropology* 21. Washington, D.C.: Smithsonian Institution.

Santley, Robert S.
1994 "The Economy of Ancient Matacapan," *Ancient Mesoamerica* 5: 243–266.

Santley, Robert S., Philip J. Arnold, III, and Christopher A. Pool
1989 "The Ceramics Production System at Matacapan, Veracruz, Mexico," *Journal of Field Archaeology* 16: 107–132.

Santley, Robert S., and Kenneth G. Hirth
1993 "Household Studies in Western Mesoamerica," in Robert S. Santley and Kenneth G. Hirth, eds., *Prehispanic Domestic Units in Western Mesoamerica: Studies of the Household,*

Compound, and Residence. Boca Raton, FL: CRC Press, 3–17.

Sayles, E. B.
1955 "Three Mexican Crafts," *American Anthropologist* 57: 953–973.

Sheehy, James J.
1992 "Ceramic Production in Ancient Teotihuacan, Mexico: A Case Study of Tlajinga 33," unpublished Ph.D. dissertation, The Pennsylvania State University, University Park.

Shepard, Anna O.
1961 *Ceramics for the Archaeologist.* Washington, D.C.: Carnegie Institution of Washington, Publication 609.

1963 "Beginnings of Ceramic Industrialization: An Example from the Oaxaca Valley," in Anna O. Shepard, *Notes from a Ceramic Laboratory* 2. Washington, D.C.: Carnegie Institution, 1–24.

Shimada, Izumi
1989 "Excavation and Experimental Firing of Formative Kilns in Batan Grande, North Coast, Peru, July–September, 1989," unpublished manuscript on file, Peabody Museum, Harvard University.

Sinopoli, Carla M.
1991 *Approaches to Archaeological Ceramics.* New York: Plenum Press.

Stark, Barbara L.
1984 "An Ethnoarchaeological Study of a Mexican Pottery Industry," *Journal of New World Archaeology* 6: 4–14.

1985 "Archaeological Identification of Pottery Production Locations: Ethnoarchaeological and Archaeological Data in Mesoamerica," in Ben A. Nelson, ed., *Decoding Prehistoric Ceramics.* Carbondale, Illinois: Southern Illinois University Press, 158–194.

1989 *Patarata Pottery: Classic Period Ceramics of the South-Central Gulf Coast, Veracruz, Mexico. Anthropological Papers of the University of Arizona* 51. Tucson: The University of Arizona Press.

1992 "Ceramic Production and Exchange in Prehistoric La Mixtequilla, South-Central Veracruz, Mexico," in George J. Bey, III, and Christopher A. Pool, eds., *Ceramic Production and Distribution: An Integrated Approach.* Boulder: Westview Press, 175–204.

Stolmaker, Charlotte
1976 "Examples of Stability and Change from Santa María Atzompa," in Scott Cook and Martin Diskin, eds., *Markets in Oaxaca.* Austin: University of Texas Press, 189–207.

Stone, Doris, and Conchita Turnbull
1941 "A Sula-Ulúa Pottery Kiln," *American Antiquity* (1): 39–47.

Suárez Díez, Lourdes
1991 *Conchas y Caracoles: Ese Universo Maravilloso.* México, D.F.: Banpais.

Sullivan, Alan P., III
1988 "Prehistoric Southwestern Ceramic Manufacture: The Limitations of Ancient Evidence," *American Antiquity* 53: 23–35.

Swezey, William R.
1975 "Mound 91, Lambityeco, a Description of an Ancient Kiln," *XIII Mesa Redonda de la Sociedad Mexicana de Antropología*, tomo II. Mexico, 179–184.

Taylor, Paul
1933 "Making Cántaros at San José Tateposco, Jalisco, Mexico," *American Anthropologist* 35(4): 745–751.

Thompson, Raymond H.
1958 *Modern Yucatecan Maya Pottery Making. Memoirs, Society for American Archaeology* 23. Salt Lake City: The Society for American Archaeology.

van de Velde, Paul, and Henriette R. van de Velde
1939 *The Black Pottery of Coyotopec, Oaxaca, Mexico. Southwest Museum Papers* 13. Los Angeles: Southwest Museum.

van der Leeuw, Sander E.
1976 *Studies in the Technology of Ancient Pottery.* Amsterdam: Organization for the Advancement of Pure Research.

Vitelli, Karen D.
1993 *Franchthi Neolithic Pottery.* Vol. 1, *Classification and Ceramic Phases 1 and 2.* Bloomington: Indiana University Press.

Whalen, Michael E.
1981 *Excavations at Santo Domingo Tomaltepec: Evolution of a Formative Community in the Valley of Oaxaca, Mexico. Memoirs, Museum of Anthropology, University of Michigan* 12. Ann Arbor: University of Michigan.

Williams, Barbara J.
1972 "Tepetate in the Valley of Mexico," *Annals of the Association of American Geographers* 62: 618–626.

Winter, Marcus C., and Valérie Nardin
1982 "Rescate Arqueológico en Loma del Trapiche Guadalupe Hidalgo, Etla, Oaxaca," in *Estudios de Antropología e Historia* No. 30. Oaxaca: Instituto Nacional de Antropología e Historia (Centro Regional de Oaxaca), 1–14.

Winter, Marcus C., and William O. Payne
1976 "Hornos Para Cerámica Hallados en Monte Albán," *Boletín del Instituto Nacional de Antropología e Historia* 16. México: Instituto Nacional de Antropología e Historia, 37–40.