



The Social Organization of Craft Production and Interregional Exchange at Teotihuacan

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ONE NEED ONLY GAZE UPON THE RUINS OF Teotihuacan to appreciate their magnitude and decidedly planned layout (Figure 5.1). These features of the ancient city bespeak a highly centralized government with an influence beyond the ceremonial core to the very residences its inhabitants occupied. But just how overarching was this influence? Although Teotihuacan served as a hub for the most robust economic system in Classic-period Mesoamerica, its organization remains a topic of spirited debate. While some propose that the Teotihuacano economy was tightly managed, with political and religious agents responsible for mobilizing most production and distribution, others suggest that it was strongly commercialized, with more significant roles for independent household crafting and market exchange (cf. Kurtz 1987; Manzanilla 1992; Millon 1992; Sanders and Santley 1983).

In this study, I model landscape usage between the city and areas of acquisition and distribution, and examine production contexts both at Teotihuacan and within adjacent regions in order to

assess potential interregional exchange routes and what dimensions of the Teotihuacano economy were more likely to have been commercially, rather than politically, motivated. Production and exchange should be considered as embedded within multiple, crosscutting social institutions such as household, market, temple, and state, which may be heuristically separated as domestic and institutional facets of a complex web of economic relations (see Hirth and Pillsbury, this volume). Economic opportunities attracted migrants to the city from throughout Mesoamerica, making it the most ethnically diverse and polyglot population of the Americas in its day (Figure 5.2), with more than one hundred thousand inhabitants speaking five or more languages (Cowgill 1997, 2008; Manzanilla 1999; Millon 1992). The macroregional scope of the economy is distilled here by considering four major commodities that circulated widely: obsidian, lime, cotton, and export ceramics. I evaluate potential exchange routes and mercantile activities involving these commodities after first outlining the economic base of the city.



figure 5.1
Teotihuacan viewed from Cerro Gordo in the early 1960s. (Photograph courtesy of William G. Mather III.)

figure 5.2
Teotihuacan
chronology.
(Chronology
by David M.
Carballo.)

Period	Date	Ceramic Phase	Cultural Attributes
Epi	700	Coyotlatelco	Still sizable populations live around former center
Late	600	Metepec	Political decentralization and demographic collapse
	500	Late Xolalpan	
	400	Early Xolalpan	Height of influence abroad
Early	300	Late Tlamimilolpa	Construction of: Apartment compounds Feathered Serpent Pyramid Moon Pyramid Sun Pyramid
	200	Early Tlamimilolpa Miccaotli	
	100	Tzacualli	
Terminal	AD	Patlachique	Urbanization
	BC		
	100	Tezoyuca	Possibly several competing centers in Teotihuacan Valley
Late	200	Late Cuanalan	
	300		

Economic Foundations

The immediate resource base that Teotihuacanos exploited was the semiarid highlands of Central Mexico (see McClung de Tapia 2009) (Figure 5.3). At 2,250 meters above sea level (masl), the small rivers of the Teotihuacan Valley drained into the lake system at the center of the Basin of Mexico. Although the valley receives less precipitation than do regions to the south, three of its characteristics were conducive to economic development. First, springs flowed at approximately five hundred to fifteen hundred liters of water per second, permitting permanent irrigation of more than three thousand hectares of farmland (Sanders et al. 1979:256–260, 386–389). This fertile land within an otherwise agriculturally

risky landscape encouraged the nucleation of early farming villages, while the digging and maintenance of canals may have stimulated larger-scale group coordination (Webster 1996). Second, the valley forms a natural opening in the basin, connecting with the adjacent Puebla-Tlaxcala region to provide the easiest route to the resources of the Gulf of Mexico as well as to all other points east and south. I refer to this route as the Tlaxcala Corridor, and build from a previous study (Carballo and Pluckhahn 2007) with new analyses here to assess its utility for exchange. Third, the eastern valley contains its own obsidian sources and has unimpeded passage to additional sources to the north (Charlton 1978). As metals were not used in Classic-period Central Mexico, these obsidian quarries

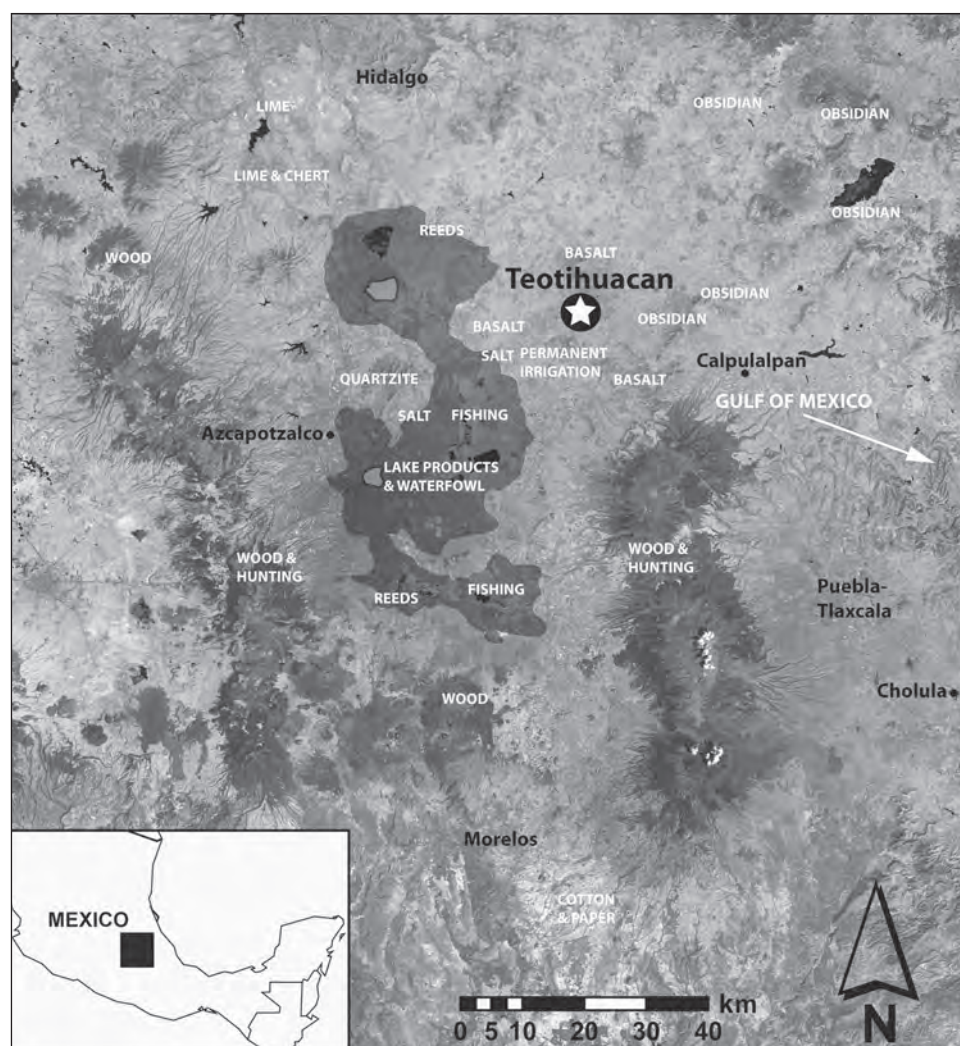


figure 5.3
Resources and
regions surrounding
Teotihuacan (after
Sanders et al.
1979:maps 24–25).
(LANDSAT ETM+ image
source: Global Land
Cover Facility [[http://
www.landcover.org](http://www.landcover.org)].)

provided Teotihuacanos with a highly desired trade commodity. Together with the lake resources and other highland products of the Basin of Mexico, this combination of springs, transportation corridors, and obsidian formed the city's economic foundation.

Like other traditional societies, the primary unit of production at Teotihuacan was the household; however, most Teotihuacanos lived in exceptionally large houses known as apartment compounds (Figure 5.4), within which dozens of individuals cohabitated (Cowgill 2007; Manzanilla 1996; Millon 1976). Craft production was primarily undertaken within apartment compounds or in the common spaces of neighborhoods (termed “barrios” in most of the literature on Teotihuacan), and the construction and maintenance of apartments themselves also involved specialists for

stuccoing walls and painting them with vibrant pigments. Under this residential system, domestic production became economies of scale in which labor tasks were divided for efficiency (Manzanilla 2009; Millon 1981). Such a system requires that its participants trust those with whom they cooperate (Blanton, this volume; Ostrom and Walker 2003). Household and barrio rituals cemented the bonds of this trust at Teotihuacan (Manzanilla 2002). The city's leaders also inculcated an ideology of work involving a corporate identity that did not celebrate particular ethnic groups or individuals (Kurtz and Nunley 1993). These integrative mechanisms provided some degree of cohesion for a cosmopolitan population that included immigrants from different regions of Mesoamerica, including west Mexico, the Gulf coast, Oaxaca, and the Maya region (Gómez Chávez 2002; Gómez Chávez

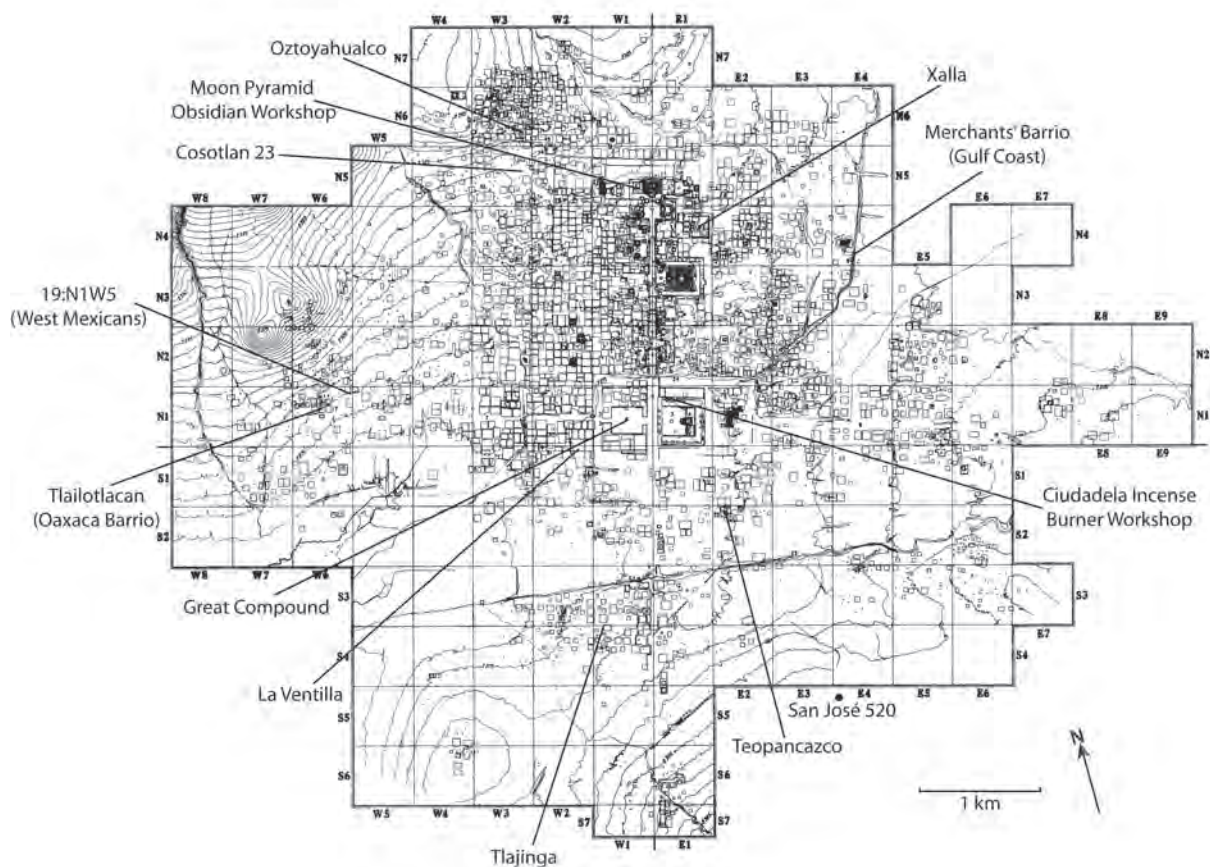


figure 5.4

Map of Teotihuacan with locations mentioned in text (after Millon 1973).

and Gazzola 2009; Price et al. 2000; Rattray 1990a; Spence et al. 2005; Taube 2003; White et al. 2004).

The art of Teotihuacan privileges religious and martial themes, flora and fauna, and geometric patterns, shedding little light on economic issues. Jorge Angulo (1995:113–133) made a noteworthy attempt to glean insights, but certain

reconstructions make considerable leaps from existing material evidence. Nonlocal resources, such as tropical feathers and shell, are emphasized in art, and some acquisition activities are depicted—such as individuals picking fruit trees, including lowland cacao, and divers collecting marine shells (Figure 5.5). Obsidian is represented

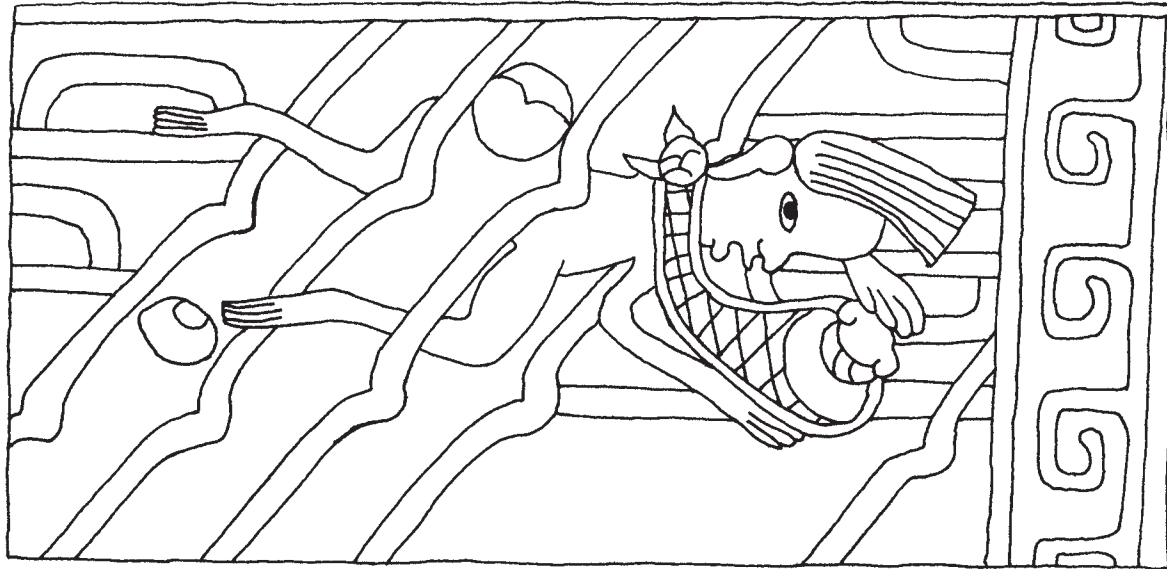


figure 5.5
Shell diver from Tetitla mural (redrawn from Fuente 1995b:fig. 19.24).

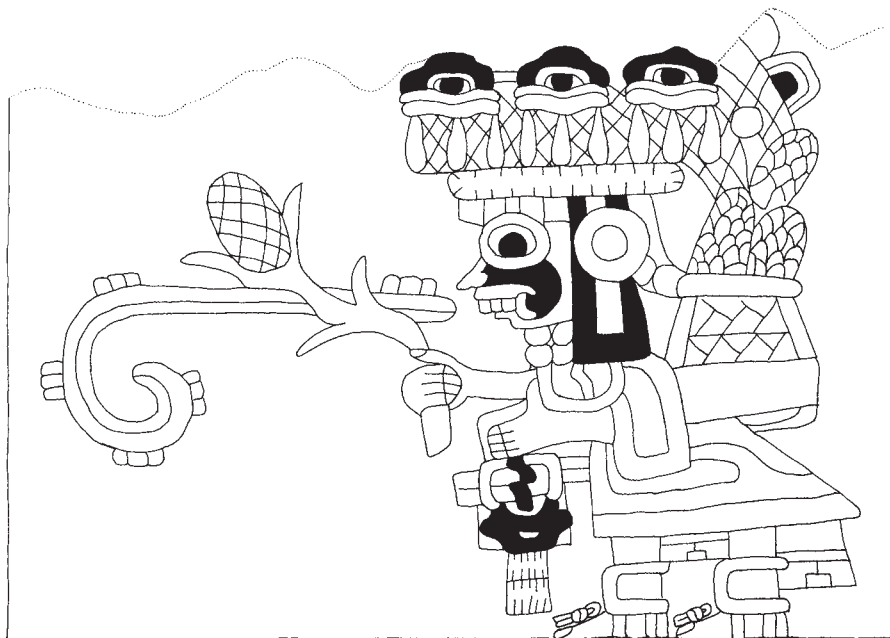


figure 5.6
Storm God with woven container carried on back from Zacuala mural (redrawn from Fuente 1995c:fig. 21.4).



figure 5.7

Exchange, either redistribution or trade, depicted on Temple of Agriculture mural (redrawn from Fuente 1995a:fig. 10.3 and lám. 5).

as weaponry, but the production and use of utilitarian tools or other types of craft production are not portrayed. Burdens carried on the back to transport goods, like those Aztec merchants used, are depicted (Figure 5.6), but the individuals carrying them are not iconographically designated as merchants (Von Winning 1987:153–154). While individuals are shown exchanging goods, it is unclear if the exchange is market based or redistributive. Most notably, a mural from the Temple of Agriculture includes a central scene in which individuals face each other as if involved in exchange (Figure 5.7) while others make offerings to figures that have been interpreted as deities or mortuary bundles. Linda Manzanilla (1992:328) suggests the image depicts redistribution, but the central figures could also be interpreted as engaged in trade (cf. Angulo 1995:99; Millon 1967).

The scale of market exchange at Teotihuacan remains a contested issue, and only limited excavations have been undertaken in the Great Compound—the most likely location for a central marketplace if one existed (Millon 1992). This chapter will not resolve the market-redistribution debate for Teotihuacan, which can only be addressed through multiscalar studies combining extensive investigations at the Great Compound, additional work on production and consumption

within apartment compounds, and similar research at contemporary communities within Central Mexico (see Feinman and Garraty 2010; Hirth 1998; Rodríguez García 1991). Scholars must also consider a broader spectrum of types of market exchange (e.g., Blanton, this volume; Isaac, this volume; Stanish and Coben, this volume), rather than framing the issue as an either/or question hinging on the operation of a large central marketplace akin to Tlatelolco during the Postclassic period. Progress in this direction is being made, and new information is available on how production and exchange were organized.

Transportation and Interregional Exchange

In reviewing the history of the railroad, historian John Coatsworth (1981:12) noted: “Mexico is a country where geography conspires against economy. Since the pre-rail transport system depended on overland movement using animal power or on foot, transportation costs were high.” Many scholars have similarly emphasized transportation possibilities in investigating Pre-Columbian economies, as these relied exclusively on human porters except for a few select instances of lacustrine or riverine transport (Drennan 1984; Hassig 1985; Hirth and



figure 5.8
Least-cost paths
calculated using SRTM
(90 m) satellite data
with Tobler (1993)
hiker function. Data
available from U.S.
Geological Survey,
EROS Data Center,
Sioux Falls, S. Dak.
(<http://seamless.usgs.gov/>). (Map by
David M. Carballo.)



figure 5.9
Least-cost paths
calculated using
ASTER (30 m)
satellite data with
Tobler (1993) hiker
function. ASTER
GDEM is a product
of METI and NASA
(<https://wist.echo.nasa.gov/>). (Map by
David M. Carballo.)

table 5.1

Distance and estimated travel time between Teotihuacan and selected resources and sites

	obsidian						
	Otumba	Pachuca	Tulancingo	Paredon	Oyameles	Zaragoza	
euclidian distance (km)	18	53	68	61	140	134	
travel time (hr, 4km/hr)	4.5	13.3	17.0	15.3	35.0	33.5	
path cost srtm (hr)	3.9	11.6	14.4	13.3	31.6	30.8	
path cost aster (hr)	5.4	17.4	16.9	12.8	38.3	38.3	

Notes: Travel time is estimated simply at a rate of four kilometers per hour over linear routes (Euclidian distance), whereas the relative costs of slope travel are registered in the different estimates using digital terrain models incorporating the Tobler (1993) hiker function for least-cost path. All travel times are calculated from Teotihuacan. The higher resolution ASTER data (thirty meters) results in routes that are more slope adverse than those produced using SRTM data (ninety meters). In most cases, this difference accounts for the longer time estimates with ASTER data, most of which are likely more accurate than are those based on SRTM data. The Basin of Mexico lake system was modeled as a barrier since this study focuses on foot travel outside of the basin. When not modeled as a barrier, only the Ucareo paths and Morelos cotton path based on ASTER data passed through the lakes.

Pillsbury, this volume; Sanders and Santley 1983). Analyses incorporating geographic information systems (GIS) further this line of inquiry by modeling possible routes across Mexico's mountainous landscape. The new analyses presented in this study build from an earlier one (Carballo and Pluckhahn 2007) to highlight some of the routes that Teotihuacanos may have taken for acquiring and exchanging raw materials and finished goods.

Two separate terrain models were derived from Shuttle Radar Topographic Mission (SRTM) elevation data with ninety-meter resolution (Figure 5.8) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) elevation data with thirty-meter resolution (Figure 5.9). The combination of two sources permits corroborative assessment of suggested least-cost paths over an anisotropic friction surface calculated using the hiker function developed by Tobler (1993) for modeling the time of travel through mountainous terrain. Destination points were chosen by virtue of being resource zones of established importance or

contemporary communities with documented ties to Teotihuacan. The Basin of Mexico lake system was modeled as a barrier because the destination points in the study all lay outside of the basin (but see Gorenflo and Gale 1990). Results of the analyses are summarized in Table 5.1.

It should be emphasized that cost-path analysis provides a measure of estimated optimal routes in energetic terms that must then be matched with archaeological indices of cultural interaction to be of analytical value. Accordingly, the analyses are tethered to recently documented studies of craft production and exchange within apartment compounds, barrio centers, and temples. Manzanilla (2009) provides a useful tripartite division of production within the city: 1) utilitarian goods often produced in the urban fringe; 2) elite dress and regalia often produced in barrio centers; and 3) implements of governance and rulership often produced at temple and palace precincts. Rossend Rovira Morgado (n.d.) gives an equally useful classification of exchange within Teotihuacan: 1) household

	obsidian			chingu lime	morelos cotton	thin orange	monte albán	gulf-cotton matapan
	Zacualtipan	Ucareo	Fuentezuelas					
	110	193	144	55	113	167	368	403
	27.5	48.3	36.0	13.8	28.3	41.8	92.0	100.8
	24.8	41.1	31.8	11.3	22.9	36.0	80.2	86.8
	32.2	50.2	36.9	10.8	27.0	38.5	88.7	78.2

barter, 2) institutionalized redistribution, 3) market exchange within barrio plazas or formal marketplaces, and 4) long-distance trade. To round out the city's economy we should add two forms of exchange that would have been organized by governing authorities: 5) tribute in goods and 6) temple labor obligations (for comparative frameworks, see Feinman and Garraty 2010; Hirth and Pillsbury, this volume).

Four Commodities

Obsidian, lime, cotton, and export pottery provide useful perspectives on economic activities at Teotihuacan because of their relatively well-defined places of origin and widespread consumption. These commodities also had the potential for labor-added value, as they could be made into quotidian items and sumptuary or ritual goods with restricted circulation based on the amount of labor involved in their transformation. Elaborate transformations included fashioning ceremonial artifacts from obsidian; maintaining the walls of elite residences with fresh coats of lime stucco painted with Teotihuacan's famous murals; fancy cotton vestments worn by social elites; and finely made ceramic vessels for food service and mortuary deposits. Additionally, these commodities had variable degrees of elasticity—meaning the

relationship between their value and demand (Wilk and Cliggett 2007:64–66). In the absence of metals, demand for obsidian was relatively inelastic, as it was essential to many daily tasks. The relative elasticity of lime depended on its usage. Stuccoing buildings with lime plaster was an entrenched cultural norm at Teotihuacan but was not a necessity for survival; yet treating maize with lime water (nixtamalization) was an important dietary practice in Mesoamerica. Cotton was used for clothing and other textiles, but its production occurred at a distance from Teotihuacan. Its value was more elastic, as woven cotton could have been substituted with cloth made from local maguey (*Agave* spp.) fiber. Export pottery likely had high elasticity: Teotihuacanos or societies with which they traded could simply manufacture pots from local clays. Consideration of relative labor-added value, degrees of elasticity, and possibilities of substitution is important as we turn to the production and exchange of these four commodities.

Obsidian

Based on the volume of literature on obsidian, a nonspecialist may be led to believe that either Teotihuacanos were obsessed with the material or that scholars are; neither is the case. Obsidian has been one of the primary materials used in explorations of Teotihuacan's economy because its place of origin can be easily traced (Cobean 2002)

table 5.2

Summary of three obsidian-sourcing studies for Teotihuacan

STUDY	SOURCE/NUMBER				
	o t u m b a	p a c h u c a	t u l a n c i n g o	p a r e d o n	
g a z z o l a (2009) i n a a & p i x e (n=85)	53 (62%)	12 (14%)		17 (20%)	
g l a s c o c k a n d n e f f (1993) i n a a (n=109)	79 (72%)	21 (19%)		5 (5%)	
c a r b a l l o e t a l . (2007) l a - i c p - m s (n=55)	26 (47%)	12 (22%)	14 (25%)	1 (2%)	

Note: Percentages are rounded.

and because it held importance in the absence of developed metallurgy. Its ubiquity and indelibility ensures that production, distribution, and consumption may be evaluated from a number of social contexts. For these reasons, obsidian has been emphasized at Teotihuacan and used as a proxy for inferring other less conspicuous economic activities.

Perspectives on the organization of obsidian industries range from those that hold Teotihuacanos monopolized all or most nearby sources, including state management of a large portion of production and distribution, to those that view these activities as having been mostly market driven and independent of political ties (cf. Andrews 2002; Charlton 1978; Clark 1986; Drennan et al. 1990; Santley 1983; Spence 1981, 1996). The initially proposed figure of four hundred obsidian workshops within Teotihuacan during its apogee is almost certainly too high (Spence 1996:30). Yet the position taken by John Clark (1986) for the scale of production in the city, extrapolating from only a superficial cover of debitage, has been shown to be just as unlikely by several excavations that have unearthed exceedingly dense subsurface deposits (Andrade Olvera and Arellano Álvarez 2011; Carballo 2011; Paredes Cetino 2000; Paz Bautista 1996; Trinidad Meléndez 1996). An accurate reconstruction lies somewhere in between, and the comprehensive excavation of an apartment compound inhabited by obsidian workers is needed to advance current understanding.

Literature on Teotihuacano obsidian exploitation has focused primarily on just two quarries within Central Mexico: the Pachuca source, with its valued green obsidian, and the nearby Otumba source of gray obsidian, located within a day's round-trip journey. Quarrying and production activities have only been well documented at the Pachuca mines, where Pastrana and Domínguez (2009) report on small Classic-period apartment compounds and campsites, which they attribute to Teotihuacano involvement in making preforms and tools for export back to the city and elsewhere. Chemical variability between different flows in the quarry has been defined (Ponamarenko 2004; Spence et al. 1984), but compositional analyses of artifacts found at Teotihuacan remain scarce. Obsidian sourcing studies for Teotihuacan artifacts of which I am aware include the analysis of samples from the Feathered Serpent Pyramid, dating to the midpoint of the city's occupation, by Michael Glascock and Hector Neff (1993); our analysis of samples from workshop dumps and construction fill next to the Moon Pyramid, which are later in the occupation (Carballo et al. 2007); and the analysis of samples from early construction episodes underneath the Ciudadela by Julie Gazzola (2009). It should be noted that though the three studies nicely span the city's primary occupation, they are all biased in originating in or next to major monuments. The results of these studies (summarized in Table 5.2) suggest that, while Otumba and Pachuca

	SOURCE/NUMBER				
	o y a m e l e s	z a r a g o z a	z a c u a l t i p a n	u c a r e o	f u e n t e z u e l a s
		1 (1%)	1 (1%)		
		2 (2%)		1 (1%)	1 (1%)
	2 (4%)				

obsidian were most important, material from the Tulancingo and Paredon sources made it to the city in significant amounts. These four sources are followed in much lower quantities by others along the Mexican Neovolcanic Belt.

Potential routes to the primary obsidian sources may be inferred by the cost-path analyses and compared with contemporary roads, for which a distinction between divided highways and undivided highways is relevant, as the construction of the former often involved dynamiting through slopes while the latter more often follow natural topography. The route suggested by the ASTER terrain model to Pachuca quickly forks from the route to Tulancingo and Paredon, with the modern divided highway running between these two possibilities, whereas the route to Tulancingo nearly mirrors the undivided highway between Teotihuacan and that city. The routes suggested by the SRTM terrain model to the four most utilized sources are similar but straighter. The high exploitation of these sources and their accessibility within four to seventeen hours, suggested by the Tobler hiker function, lend additional support and resolution to Charlton's (1978) pioneering work on trade routes. Charlton noted the importance of sites near Calpulalpan, in northwestern Tlaxcala, for the transshipment of obsidian and other goods that Teotihuacanos would have traded in easterly and southerly directions. More recent work near Calpulalpan affirms that communities there were part of Teotihuacan's

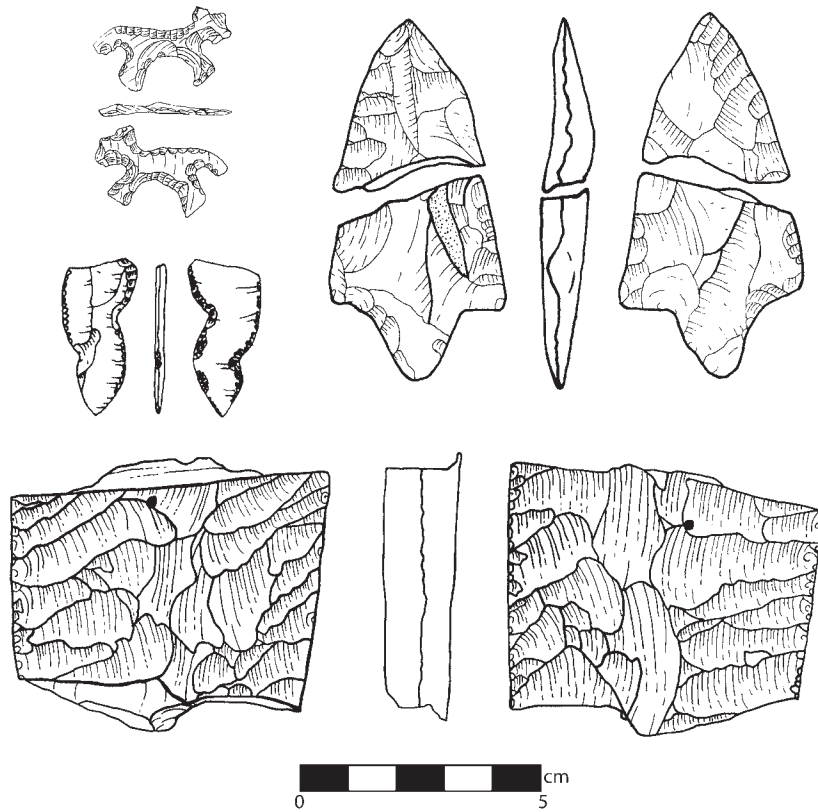
immediate core zone (Martínez Vargas and Jarquín Pacheco 1998). It is, therefore, likely that Calpulalpan's modern identity as a gateway community has roots extending back two millennia.

The geochemical studies indicate that other obsidian sources are uncommon at Teotihuacan, but the least-cost analyses are illustrative of potential exchange at lower scales in obsidian or other goods. The routes to the eastern sources run through the Tlaxcala Corridor in the ASTER-based model, largely following Mexico's first railroad, linking Mexico City and Veracruz, as well as the undivided highway passing through Apizaco. Following the SRTM-based model, these eastern routes originate in the Tlaxcala Corridor as well, but then they traverse part of Sierra de Ixtacamaxtitlan. Such a course is inconsistent with settlement and artifact inventories in northern Tlaxcala (Carballo and Pluckhahn 2007; García Cook and Merino Carrión 1996), which instead support the route from the ASTER analysis.

Once procured, the obsidian from these sources was reduced into varied artifact types at Teotihuacan. Our excavations next to the Moon Pyramid demonstrate that artisans engaged in large-scale but episodic production of dart points, large knives, and eccentrics depicting martial symbols (Carballo 2007, 2011) (Figure 5.10). The high quantities of by-products attest to the intensity of these activities. In the most completely excavated deposit, more than 170 kilograms of debris was recovered from an estimated third to sixth of the

figure 5.10

Obsidian debris
from Moon
Pyramid workshop
deposits, including
canid and serpent
eccentric, refitting
dart-point preform,
and fragment
of large knife.
(Drawing by
David M. Carballo.)



original dump. We encountered millions of waste flakes, along with pieces of dart points and eccentrics broken during manufacture. The episodic nature of the activity is apparent from the depositional contexts of the three deposits, which were discarded within depressions in compacted, sterile substrate (*tepetate*) during remodeling episodes at the pyramid. Artisans were well supplied with raw obsidian and could be characterized as having been wasteful in its reduction. This is particularly apparent in the large biface production activities: blocks and large pieces broken during production could have been recycled into other tools but were not. Such wastefulness within specialized and symbolically charged production activities is more consistent—in this one particular case—with centralized provisioning of raw material and/or ritual production rather than with commercially oriented, household production (see Schortman and Urban 2004).

Domestic production of obsidian tools was likely much more common than was temple production, but further study is needed. Excavations

at the La Ventilla Barrio recovered abundant green obsidian, likely associated with the manufacture of prismatic blades (Cabrera Castro and Gómez Chávez 2008; Trinidad Meléndez 1996). Further, a technological reanalysis conducted by Brad Andrews (2002) for the San Martín complex and new excavations by David Andrade support domestically organized production intended for exchange (Andrade Olvera and Arellano Álvarez 2011). Consumption patterns also suggest that production was more likely to have been independently, rather than politically, organized. For instance, in a study of 284 burials containing grave offerings, Martha Sempowski (1994:130, 154–155, 252) tallies approximately 20 percent having blades, 6 percent having points, and less than 1 percent having eccentrics. These data imply that blades and other utilitarian items circulated relatively freely in the Teotihuacano economy, while the movement of eccentrics was more restricted. Yet eccentric production was not confined to temple contexts, such as the Moon Pyramid, as Andrews (2002) has demonstrated.



figure 5.11

Lime-plastered mural fragment from Temple of the Feathered Shells. (Photograph by David M. Carballo.)

Lime

A second major industry at Teotihuacan centered on lime, which would have been consumed in staggering quantities for basic food processing and for making plaster or stucco to cover walls (Figure 5.11) and certain ceramics (Barba Pingarrón and Córdova Frunz 1999, 2010; Murakami 2010). Limestone deposits are scarce within the Basin of Mexico but can be found in the Zumpango region of the northern basin and in adjacent areas of Hidalgo, Puebla, and Morelos. The chemical analyses of Luis Barba and associates have been at the forefront of understanding this industry. They suggest that elevated levels of carbonates within the floor of a room at Azcapotzalco may indicate the draining of water associated with the nixtamalization (Barba et al. 1999). Higher carbonate levels were also detected in certain rooms of the Oztoyahualco compound at

Teotihuacan, but in this case production activities appear to be associated with plaster making, since excavations also recovered large quantities of stone smoothers used for applying plaster to walls, floors, and other surfaces (Lizárraga and Ortiz Butrón 1993; Ortiz Butrón and Barba 1993). These authors propose that plastering would have been one of the trades in which inhabitants of the compound specialized. A similar group of artisans likely occupied the Oaxaca Barrio (Rattray 1995:71), but here Zapotecs appear to have migrated from their homeland to work on construction projects at Teotihuacan.

The vast quantities of lime used in stuccoing Teotihuacan would have necessitated coordinated acquisition networks and large amounts of fuel to convert limestone into powdered quicklime. Barba Pingarrón and Córdova Frunz (2010:147) estimate that some six hundred thousand tons of lime would

have been necessary to plaster the temples, plazas, and apartment compounds of the city. They extrapolate that such an amount necessitated one hundred forty porters daily in order to move lime between a quarry and the city during its height. Burning this much limestone would have required tens of thousands of tons of fuel per year (Barba Pingarrón and Córdova Frunz 2010:114–117). Nevertheless, Carmen Adriano-Morán and Emily McClung de Tapia (2008) suggest that Teotihuacanos successfully managed forest resources throughout the Classic period. Although these authors register significant landscape modification, including the retreat of nearby forests at the expense of agricultural fields, their study does not support deforestation as a primary factor in Teotihuacan's collapse, even with such intensive lime processing (see also McClung de Tapia 2009).

Barba and colleagues (2009) combined compositional analyses with petrographic characterization in determining that the lime used to plaster the main courtyard at Teopanazco originated from the Chingú region of southern Hidalgo, as opposed to other possible sources in the states of Puebla and Morelos. The authors reason that the transformation of limestone to quicklime would have occurred near the source, a proximity that would have been energetically sensible and consistent with Adriano-Morán and McClung de Tapia's (2008) documentation of sustained wood resources near Teotihuacan. The source region is near the eventual Toltec capital of Tula; therefore, it appears that Classic-period contacts with Teotihuacan stimulated population growth and increased social complexity during the Postclassic period, as was suggested by Clara Díaz Oyarzábal (1981). The least-cost path to the Chingú region lime source proceeds in a fairly straight line northwest from Teotihuacan. An estimated travel time of eleven hours implies that the trip could be made in a single day.

It is interesting to note that the least-cost routes match the distribution of documented sixteenth-century communities involved in lime exchange much more accurately than do contemporary roads, which are oriented toward Mexico City for historical reasons (see Barba Pingarrón and Córdova

Frunz 1999:fig. 1). They also pass directly through the Zumpango region, which Tatsuya Murakami (2010:191–192) notes may have been a second important source of lime for Teotihuacan at half the distance, but source material from this region was not included in the study by Barba and colleagues (2009). In either case, the least-cost path distribution raises the possibility that the demand Teotihuacan exerted for lime created a sort of “lime corridor” of production communities that persisted along this route into the Postclassic period.

Cotton

Cotton represents another nonlocal resource. It was grown in the more humid, adjacent state of Morelos or in more distant lowland regions. Drawing comparisons to the Mexica strategy of early expansion, Hirth (1978) suggested that significant reorganization of settlement between the Terminal Formative and Early Classic periods in eastern Morelos was stimulated by the intensification of cotton production related to Teotihuacan. While it is likely that cotton arrived to Teotihuacan from greater distances, particularly due to its low weight and ease of packing (see Hirth, this volume), eastern Morelos would have been the most accessible source. It was also the nearest source for more temperate fruits, including avocados. The least-cost paths derived from both terrain models follow a similar route south of the city, exiting the basin through the Amecameca pass and mimicking the undivided highway to Cuautla. As with other cases, the SRTM-derived path is straighter because subtle changes in slope are obscured by the coarser resolution of the data.

Although Morelos is closer to Teotihuacan, manufacture of cotton textiles is better documented at two barrios that exhibit greater ties to the Gulf coast. Manzanilla (2007, 2009) recovered abundant remains associated with the tailoring of elaborate costumes at Teopanazco. Cotton *mantas* appear to have been imported along with Gulf of Mexico fauna, and the small eyes on needles suggest that raw cotton thread was also imported and used for sewing decorative elements onto costumes (Manzanilla 2009:32). The sex and strontium ratios of six individuals buried in the barrio center lead Manzanilla



figure 5.12
Priest wearing an elaborate cotton garment in a mural from Tepantitla (reconstruction, Museo Nacional de Antropología, Mexico City). (Photograph by David M. Carballo.)

to conclude that the tailors were men who migrated from the Gulf coast, possibly originating from the Nautla region in northern Veracruz (Manzanilla 2011). In a related case that is interesting for contrast, Spence and colleagues (2005:163) suggest that textile working at the Merchants' Barrio was performed by women and that their role in this socially valued labor contributed to their relatively high status. Men in the Merchants' Barrio appear to have been the long-distance traders, moving between their Gulf-coast homeland and Teotihuacan, while local-born Teotihuacanas maintained a matrilocal household, a pattern seen in urban merchant enclaves elsewhere in the world (Spence et al. 2005:179). The potentially divergent exchange and production practices in these two barrios provide insights into possible gender and ethnic variability in mercantile activities. The cotton-weaving women of the Merchants' Barrio may have enjoyed an elevated

status relative to that of women involved in crafting with local resources, such as maguey fiber or clay, but the textiles that the women of the Merchants' Barrio produced appear to have been utilitarian and geared toward general consumption. More ornate costumes were made at Teopancazco (Figure 5.12).

At the macroregional scale, intensified Gulf-coast cotton industries, possibly associated with demand from Teotihuacan, have been documented in the Mixtequilla (Stark et al. 1998) and Tuxtla (Hall 1997) regions. Trade routes to these areas may be inferred through the least-cost analyses between Teotihuacan and Matacapán, building from our previous study plotting three equidistant destinations along the gulf (Carballo and Pluckhahn 2007). Matacapán is also appropriate as a destination because it is centrally located along the Gulf coast and has been proposed as a Teotihuacan colony with a small resident population of ethnic Teotihuacanos

involved in coastal–highland exchange (Santley 2007). People from other areas of the Gulf coast certainly exchanged with Teotihuacanos (Ruiz Gallut and Pascual Soto 2004), and energetically optimal routes for them would likely pass through the Sierra Madre Oriental closer to Xalapa (north) or to Orizaba (south), based on their final destination.

The ASTER-derived route to Matacapán passes through the Tlaxcala Corridor and crosses the Sierra Madre south of the Cofre de Perote volcano before hugging the coast. The SRTM route passes through the Tlaxcala Corridor, Oriental Valley, and Maltrata Valley, following the Mexico City–Veracruz rail line. Recent archaeology in the Oriental Valley and Maltrata region suggests that the Maltrata route was of greater importance to Teotihuacan. Survey and excavations by Yamile Lira López (2010) have demonstrated settlement disruption in the region during the Formative–Classic transition, followed by the appearance of Teotihuacano materials. Further, the corpus of radiocarbon assays presented by Ángel García Cook (2004, 2009) for Cantona shows that the city was a large contemporary of Teotihuacan. If Cantonecos challenged Teotihuacano passage through the northern Oriental Valley, the Maltrata route likely would have been a less contested option for merchants. Yet if Manzanilla’s (2011) postulated ties between inhabitants of Teopanazco and the Nautla region are correct, then this northerly route or another around Cantona may have also been used. In any case, the journey between Teotihuacan and the central Gulf coast would have taken approximately ten days and would have represented a portion of farther-flung exchange relations and hegemonic alliances with certain Maya kingdoms (see Freidel et al. 2007).

Ceramic Trade Wares

Unlike obsidian, lime, and cotton, most pottery was not conducive to long-distance trade since it was bulky and fragile and since most people could find suitable potting clay close to home. Nonetheless, Teotihuacan is notable for two ceramic types that circulated widely throughout its sphere of interaction and reached more distant parts of Mesoamerica:

Thin Orange ware and theater-style incense burners. Thin Orange, produced in southern Puebla, is one of the best studied and most widely distributed ceramic types from Mesoamerica (Kolb 1977, 1986; Rattray 1990b, 2001). Its defining attributes—thin vessel walls of orange paste—appear to have been desirable for Central Mexicans in the Late Formative period, but the ware became standardized due to the volume of demand from Teotihuacan and its economic networks (Plunket and Uruñuela 2012; Uruñuela and Plunket 2010).

Thin Orange is more commonly found in burials than in fill contexts, suggesting that vessels were reserved for ritual consumption events, passed along as heirlooms, and taken out of circulation by mortuary rites and limited accidental breakage (Kolb 1986; Uruñuela and Plunket 2010). An example is provided by a tomb from Los Teteles de Ocotitlán that contained thirteen Thin Orange vessels mixed with 291 vessels of other, mostly local, types (Vega Sosa 1981). Given the positioning of the site along the Tlaxcala Corridor, the presence of these vessels suggests that locals engaged in trade relations with wider networks involving southern Puebla and Teotihuacan. Thin Orange wares are found as far away as Honduras (Sharer 2003), demonstrating that their social value as an index of contacts with Central Mexico—and likely Teotihuacan in particular—outweighed the challenges inherent in moving vessels long distances. Charles Kolb (1986:190–191) has noted that the standardized dimensions and open form of one of the most commonly traded Thin Orange vessels—annular-based hemispherical bowls—permitted them to be stacked for efficient packaging (Figure 5.13). Based on a survey of Thin Orange deposits throughout Central Mexico, Hirth (this volume) contends that the decreasing frequency from the Río Carnero manufacturing region toward Teotihuacan is more suggestive of commercially based exchange than of tribute, which should result in discrete concentrations at some distance from where the pottery was produced.

Both least-cost path analyses for Thin Orange support a route between the production zone and Teotihuacan that passes east into the Tlaxcala



figure 5.13
Stacked annular-based Thin
Orange bowls. (Photograph
by David M. Carballo.)

Corridor before descending south through the Puebla-Tlaxcala Valley. The ASTER route runs directly through the sites of Cholula and Cacaxtla-Xochitecatl, while the SRTM route passes slightly east of the former and through the latter. Both routes' general paths nicely match Kolb's (1986:178–179) favored possibility. They also initially parallel those between Teotihuacan and Monte Albán, which then branch through the Tehuacan Valley following the modern undivided highway. Other than Thin Orange, ceramics from the Gulf coast and Oaxaca are two of the more common foreign wares in the city. The sourcing study of George Cowgill and Hector Neff (2004) documents imported ceramics from the southern Gulf coast and suggests possible origins of one group in the vicinity of Matacapan; the other is more to the east near Tabasco. Kolb (1986:193–194) noted that the Calpulalpan region would have served as a gateway for Thin Orange exchange, to which we may add ceramics from the Gulf coast and Oaxaca.

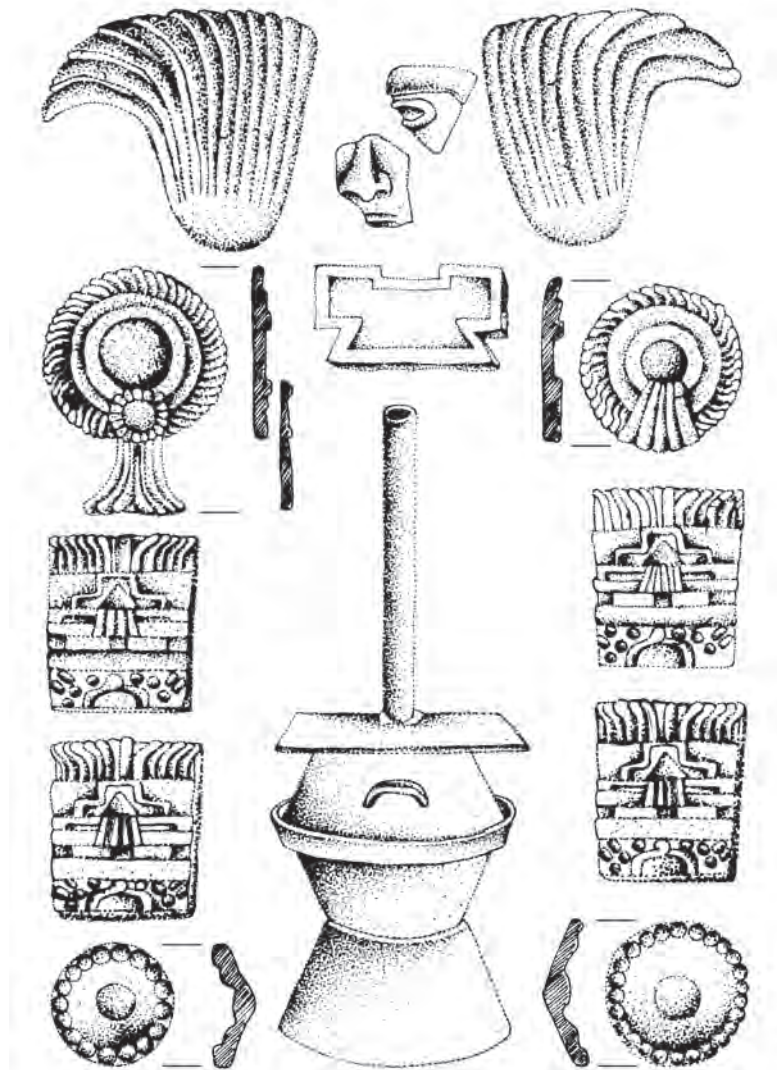
The composite ceramic incense burners called “theater-style”—for their resemblance to a stage (likely a temple) with a human face or figure (Figure 5.14)—emphasize iconographic themes related to Teotihuacan's state and religious hierarchy (Sugiyama 2002). These burners are found not only

in most apartment compounds at Teotihuacan but also in distant communities, such as the potential colony of Montana along the Pacific coast of Guatemala (Berlo 1984; Bove and Medrano Busto 2003). Associated production debris has been encountered within certain apartments at Teotihuacan (Sullivan 2007), but it was also abundant at a workshop attached to the northern facade of the Ciudadela. Here, Carlos Múnica Bermúdez (1985) recovered a complete production sequence including molds, broken decorative plaques, polishers, wasters, sheet-mica, and pigment grinders used in the process of adorning burners. Accordingly, the manufacture of theater-style incense burners appears to have been organized both at the domestic and state/temple levels. Although these items were predominantly destined for use in domestic rituals, their iconography, exportation abroad, and temple workshop suggest that the politico-religious hierarchy of the Teotihuacan state oversaw a significant portion of their production.

Ceramic manufacture within the city that likely operated independently from its institutional economies has been investigated recently at several apartment compounds. Kristin Sullivan's (2006) analysis of San Martín Orange pottery from the Tlajinga Barrio suggests that this utility ware from

figure 5.14

Components of a theater-style incense burner, showing mold-made adornments (redrawn from Ségourné [1966:fig. 24]).



the Xolalpan-Metepec phase was produced by individual households working cooperatively as part of larger neighborhood collectives, as does her analysis of figurine and censer production at Cosotlan 23 (Sullivan 2005, 2007). Site 520, located just southeast of the mapped portions of the city, has been explored by Oralia Cabrera Cortés (2006), who documents domestic potting by a low-ranking household occupying residences made of more modest materials than those of the apartment compounds. Yet burial offerings suggest that the inhabitants of Site 520 were integrated into Teotihuacan's urban economy, likely by exchanging the ceramics they manufactured. Lastly, the production strategies

of potters who fashioned elegant cylinder tripods have been studied by Cynthia Conides (1997). She proposes that the increased frequency of stuccoing and painting relative to more labor-intensive excising during the late occupation of Teotihuacan may be attributed to potters attempting to increase output and reach more consumers.

Discussion

Viewed through four commodities, the heterogeneity in Teotihuacan's economy and the organization of different production and exchange activities

are apparent. Given our incomplete record, it is not surprising that little consensus exists on the degree to which economic institutions were organized by political-religious authorities as opposed to a more commercial system; yet recent investigations have moved the debate beyond polarizing positions. In fact, the anthropological focus of Teotihuacan studies has led to sophisticated explorations of a scale of economic activity that economists often ignore: those social arrangements that mediate between the household and state or market, such as corporate kin groups and guildlike trade organizations. In an article titled “Neither Markets nor States,” the economist Elinor Ostrom and colleagues (1997) emphasize precisely these types of institutions and call attention to the importance of face-to-face interactions, mutual monitoring, and sanctioning in organizing collective economic relations of an intermediate scale. Scholars of Teotihuacan largely agree on this fundamental scale of economic organization within the city but debate the relative importance of other institutions (cf. Manzanilla 1992, 2009; Millon 1992).

In considering production near the Moon Pyramid and Ciudadela, I argue that ethnohistoric analogy to the Mexica best matches the production contexts and remains. It is clear in both cases that these craft activities were not undertaken at temples exclusively; obsidian points and eccentrics as well as theater-style incense burners were also produced within households. Nevertheless, the symbolic themes, specialized distribution networks, and large-scale manufacture at temples connect these activities to the state religious system, and historical documents from the Aztec period may reveal the mechanism by which such production was organized. Mexica labor duties involving work as part of a collectivity were termed *tequitl*, and are detailed by Pedro Carrasco (1978) and Teresa Rojas Rabiela (1977, 1986). A similar institution may have organized production among the social units that occupied the apartment compounds and barrios of Teotihuacan. Mexica political or religious labor obligations were usually designated *coatequitl* (“public works”), which were a form of rotating, obligatory labor tribute in duties such as digging irrigation

canals or making crafts next to temples (Molina 2008 [1571]:23). One form of Mexica *coatequitl* was directed at the manufacture of arms for state armories called *tlacochcalco* (“house of darts”) (Díaz del Castillo 1956 [1568]:211–212). Claudia García-Des Lauriers (2008) has identified iconographic elements suggestive of the presence of armories at Teotihuacan and, based on the scale of dart-point production at the Moon Pyramid, one of the structures within the Moon Precinct would certainly seem to be the best candidate for such a building. In the case of public labor duties and state armories, therefore, the analogy between Teotihuacan and the Mexica seems appropriate, and such production was likely rendered as part of the labor tribute required of households within the city itself (see Millon 1992:377).

The organization of other mercantile activities at Teotihuacan depends largely on the robustness of market exchange within the city and its sphere, and the characteristics of the goods and resources that were exchanged. Useful frameworks have been developed by Randolph Widmer (1996) and Linda Manzanilla (2009). Widmer begins by noting that a nonelite compound at Maquixco Bajo, located outside of the city but within the Teotihuacan Valley, possessed one of the densest concentrations of imported *Spondylus* shell excavated in highland Mesoamerica (see also Kolb 1987). He contrasts this pattern with pottery production using local clays at the Tlajinga Barrio at Teotihuacan. Unlike mined resources, shell is less easily monopolized since it is widely dispersed along coasts. Shell was used for adornment at Teotihuacan and, therefore, had relatively high elasticity as a commodity. Widmer (1996) proposes that a material like shell would have moved through several exchange nodes before arriving to Teotihuacan, where traders would have distributed some portion as a tax to ruling elites and others as a market commodity. Manzanilla’s (2009) synthetic reconstruction elaborates further, suggesting a division between the production of utilitarian goods in the urban fringe, the production of elite vestments and adornments often in barrio centers, and the production of items relating to governance and rulership within temple and palace precincts.

Extrapolating from the potential exchange routes and production contexts reviewed in this study, the organization of mercantile activities relating to many utilitarian obsidian tools, lime used for treating maize, simpler cotton garments, and most pottery appears to have been organized at an intermediate, corporate-kin scale, rather than by the noble heads of barrios or by temple or state institutions. These goods would have likely circulated as commercial commodities within periodic, barrio-centered markets as Manzanilla (2009) proposes and may also have been exchanged in a centralized market within the Great Compound (Millon 1992). Plastering temples, palaces, and other civic-ceremonial structures certainly would have been a form of production related to governance and rulership, consistent with Manzanilla's model, and lime was a relatively circumscribed resource that would be easy to monopolize, consistent with Widmer's model. Why Teotihuacano rulers would manage the plastering of houses is less clear, however, unless we consider the highly planned apartments of Teotihuacan to have been a massive public housing project. Most convincing in this regard is René Millon's (1981:209) observation that, like Pachuca obsidian and theater-style incense burners, apartment compounds do not survive the collapse of the state. Central Mexicans continued to live in relatively large quadrangular residences after Teotihuacan, but not at the scale and level of orthogonal precision seen during the Classic period. Centralized oversight of the construction and maintenance of apartment compounds may have been an effective way for Teotihuacano rulers to have organized labor tribute and taxed goods (Kurtz and Nunley 1993; Millon 1976, 1981), and lime plaster was one part of these more involved relationships. But lime-plaster production was likely another activity organized by independent households along the lime corridor as well as by state/temple tribute demands, as it was for the Mexica (Rojas Rabiela 1986:142).

Both Michael Spence (1986:95) and Ian Robertson (2001:225–227) have noted that the construction of apartment compounds in a massive urban-planning project during the middle of the city's

history would have required state oversight for leveling most existing residences to raise new ones, but the building program also may have allowed households to relocate to parts of the city that better suited their needs. This possibility could help explain a pattern to emerge from the least-cost path analysis presented here: that certain compounds appear to be conveniently positioned with respect to trade routes associated with the economies of those compounds. Examples include the western location of Oztoyahualco and the Zapotec Barrio, near the route to lime; the eastern location of the Merchants' Barrio and Teopanacazco, near the route to the Gulf coast; and the greater number of potential obsidian workshops in northern sectors of the city, closer to the four primary sources (Spence 1981, 1986). Alternatively or additionally, households may have adopted economic strategies based partially on their proximity to the terminus of certain exchange routes.

At the macroregional scale, the cost-path analyses demonstrates the profound impact that the Teotihuacano economy had on neighboring areas, as hypothesized optimal routes coincide with major settlement shifts and changes in material culture more often than not. The analyses underscore the importance of the Puebla-Tlaxcala region for Teotihuacan contacts to the east and south: the Tlaxcala Corridor to the east/southeast and the Puebla-Tlaxcala Valley to the south. Obsidian routes to the northeast cover the four quarries of greatest importance, and the Calpulalpan region appears an enduring node for transshipment. Northwest of the city, a possible linear network of sites may represent a route of lime processing that was a Classic-period legacy of the Teotihuacan economy still operational a millennium later when the Spanish arrived.

The political and mercantile activities of Teotihuacanos in other regions of Mesoamerica would have stimulated and maintained the ethnic migrations that replenished the city. These migrations indicate that economic opportunities were available at Teotihuacan for merchants who do not appear to have been closely affiliated with the state.

For instance, Spence and colleagues (2005:176) note the striking difference between the Gulf-coast traders of the Merchants' Barrio and the *pochteca* of Tenochtitlan: while the latter were politically and ethnically affiliated with the city of their residence, the former lived primarily as foreigners in an adopted city while maintaining close ties to their homelands. This mercantile cosmopolitanism is remarkable for its time and place among societies that faced many challenges to staying interconnected—and is surely one of Teotihuacan's most notable historical legacies.

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