An Archaic Mexican Shellmound

and Its Entombed Floors

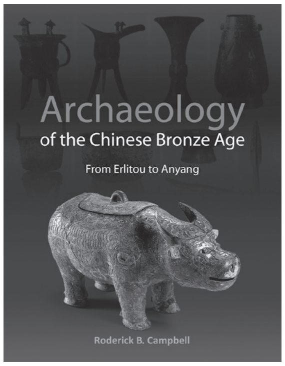
Barbara Voorhies

An Archaic Mexican Shellmound and Its Entombed Floors

UCLA COTSEN INSTITUTE OF ARCHAEOLOGY PRESS

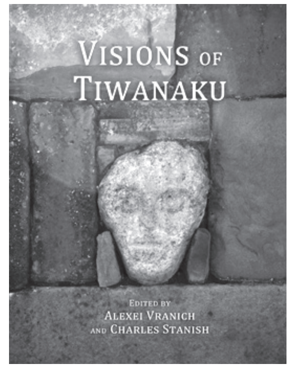
MONOGRAPHS

Monograph 79



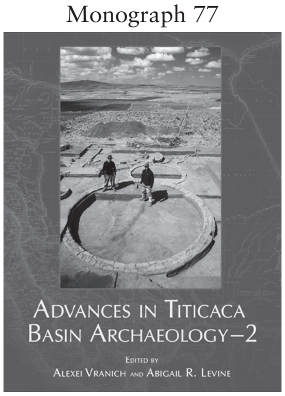
Archaeology of the Chinese Bronze Age:
From Erlitou to Anyang
Roderick B. Campbell

Monograph 78



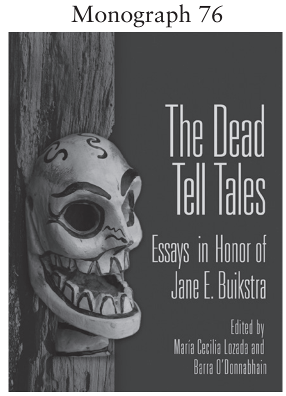
Visions of Tiwanaku
Alexei Vranich and Charles Stanish (eds.)

Monograph 77



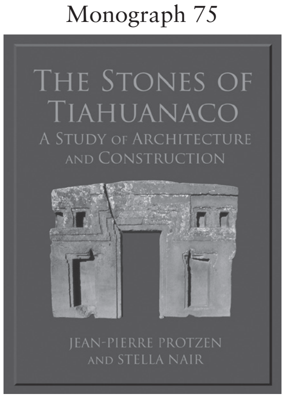
Advances in Titicaca Basin Archaeology–2
Alexei Vranich and Abigail R. Levine (eds.)

Monograph 76



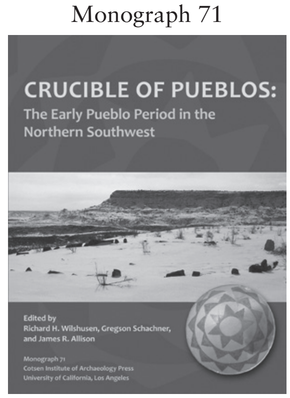
The Dead Tell Tales
María Cecilia Lozada and Barra O'Donnabhain (eds.)

Monograph 75



The Stones of Tiahuanaco
Jean-Pierre Protzen and Stella Nair

Monograph 71



Crucible of Pueblos: The Early Pueblo
Period in the Northern Southwest
Richard H. Wilshusen, Gregson Schachner,
and James R. Allison (eds.)

An Archaic Mexican Shellmound and Its Entombed Floors

Barbara Voorhies
Editor and Principal Author

With Contributions by
Paul Burger
Brendan J. Culleton
Doug H. Drake
Douglas J. Kennett
Isabela Kott
Hector Neff
Elizabeth H. Paris
Heather B. Thakar
Thomas A. Wake

UCLA COTSEN INSTITUTE OF ARCHAEOLOGY PRESS

The Cotsen Institute of Archaeology Press is the publishing unit of the Cotsen Institute of Archaeology at UCLA. The Cotsen Institute is a premier research organization dedicated to the creation, dissemination, and conservation of archaeological knowledge and heritage. It is home to both the Interdepartmental Archaeology Graduate Program and the UCLA/Getty Master's Program in the Conservation of Archaeological and Ethnographic Materials. The Cotsen Institute provides a forum for innovative faculty research, graduate education, and public programs at UCLA in an effort to positively impact the academic, local and global communities. Established in 1973, the Cotsen Institute is at the forefront of archaeological research, education, conservation and publication and is an active contributor to interdisciplinary research at UCLA.

The Cotsen Institute Press specializes in producing high-quality academic volumes in several different series, including *Monographs*, *World Heritage and Monuments*, *Cotsen Advanced Seminars*, and *Ideas*, *Debates*, *and Perspectives*. The Press is committed to making the fruits of archaeological research accessible to professionals, scholars, students, and the general public. We are able to do this through the generosity of Lloyd E. Cotsen, longtime Institute volunteer and benefactor, who has provided an endowment that allows us to subsidize our publishing program and produce superb volumes at an affordable price. Publishing in nine different series, our award-winning archaeological publications receive critical acclaim in both the academic and popular communities.

Edited by Peg Goldstein
Designed by Sally Boylan
Cover design by Sally Boylan
Index by Matthew White

Library of Congress Cataloging-in-Publication Data
Voorhies, Barbara.
An archaic Mexican shellmound and its entombed floors / by Barbara Voorhies ; with contributions by Paul Burger, Brendan J. Culleton, Doug H. Drake, Douglas J. Kennett, Isabela Kott, Hector Neff, Elizabeth H. Paris, Heather B. Thakar, Thomas A. Wake.
pages cm. -- (Monograph ; 80)
Includes bibliographical references and index.
ISBN 978-1-938770-02-9 (alk. paper) ISBN 978-1-950446-00-1(eBook)
1. Chantuto Indians--Antiquities. 2. Excavations (Archaeology)--Mexico--Chiapas. 3. Kitchen-middens--Mexico--Chiapas. 4. Chiapas (Mexico)--Antiquities. I. Title.

F1219.8.C52V65 2015

972'.75--dc23

Contents

Figures

Tables

Acknowledgments

This monograph is the outcome of field research that my research team and I conducted in the first months of 2009 at the Tlacuachero shellmound on the outer coast of Chiapas, Mexico. The success of the project critically depended on the three people who accompanied me to Chiapas: Heather B. Thakar, Carola Flores Fernández, and Bernardo Broitman. I am forever grateful for their expertise, hard work, enthusiasm, and friendship.

I also owe a tremendous debt of gratitude to the following people of La Palma, the small fishing village where we based our operations. Martín de los Santos Montes served as my local organizer, following in the footsteps of his father, Don Martín de los Santos, who formerly helped me in this capacity during several prior field seasons. Francisco Junco Arteaga provided a boat and motor for transport to and from the site. Doña Rafaela Montes de los Santos sustained us with her superb cooking and her everlasting friendship. Our hardworking and spirited field crew made every day at the site an unforgetable experience: Carlos Alberto Fuentes Méndez, Carlos Hilerio Móntes, Audías Junco Arteaga, Julio Junco Arteaga, Porfirio Montes Sosa, Felipe Rojas Vera, Marco Antonio Rojas Alvarez, Eduardo de los Santos Ovalle, Luis Angel de los Santos Ovalle, and Edin Toledo Vera. Jaime Ovalle Palacios, municipality agent in Ranchería La Palma, was the friendly local face of the Acapetahua municipality.

The 2009 field season at Tlacuachero was jointly funded by the National Geographic Society and UC Mexus and was conducted with permission of the Consejo de Arqueología, Instituto Nacional de Antropología e Historia (INAH), and the Reserva de la Biosfera, La Encrucijada. I am immensely grateful for this institutional support. Additional logistical support was provided by the New World Archaeological Foundation, Brigham Young University, under the directorship of John E. Clark. Emiliano Gallego Murieta made the research easier by smoothing the bureaucratic way in his capacity as director of the Centro Regional del INAH Chiapas.

I want to acknowledge the invaluable contributions of all the collaborators in this research. I very much appreciate not only the application of their research skills to the project but also their cooperation during creation of the monograph and their patience throughout the lengthy process from field research to publication. I am also very grateful to two anonymous readers for their very careful reading of the manuscript and thoughtful suggestions how to strengthen the text and to Aric Monts-Homkey for some technical assistance in preparing the manuscript for final submission to CIoA Press. Peg Goldstein smoothed the book's text with her careful editing, and Sally Boylan's wizardry produced the attractive layout. Randi Danforth supervised the entire production process in her capacity as publications director at the press. I am very grateful for this expert help.

This book is dedicated to the memory of Chipotle, my canine companion who faithfully accompanied us during our daily work at the Tlacuachero shellmound.

 xv

Contributors

Paul Burger
Lecturer, Department of Philosophy, California State University–Long Beach (CSULB); M.A. candidate in anthropology at CSULB

Brendan J. Culleton
Research associate, Department of Anthropology, Pennsylvania State University

Doug H. Drake
Archaeology field technician, ASM Affiliates, Inc.

Douglas J. Kennett
Professor of environmental archaeology, Department of Anthropology, Pennsylvania State University

Isabela Kott
Undergraduate student in anthropology and in geography, California State University–Long Beach

Hector Neff
Professor of anthropology and research scientist, Institute for Integrative Research in Materials, Environments, and Society (IIRMES), California State University–Long Beach

Elizabeth H. Paris
Visiting assistant professor, St. Lawrence University

Heather B. Thakar
Assistant professor, Temple University

Barbara Voorhies
Research professor and professor emerita of anthropology, University of California–Santa Barbara

Thomas A. Wake
Senior museum scientist and director of the Zooarchaeology Laboratory, Cotsen Institute of Archaeology

Chapter 1

Introduction

Barbara Voorhies

This volume reports recent research at the Tlacuachero archaeological site in southwestern Mexico, with particular emphasis on superimposed floors deeply buried within its core deposits. The site is a shellmound island within the littoral wetlands of the outer coast of the state of Chiapas (Figure 1.1). The undisturbed core deposits, consisting of bedded shells, were formed during the Archaic period (8000–2000 BCE as per Evans 2008), a time when many Mesoamerican peoples were transforming their lifeways from a sole dependence on wild resources to a reliance upon domesticated plants and animals, an economic shift that eventually had far-reaching social consequences. Accordingly, archaeological sites dating to the Archaic period hold the key to understanding exactly how this process of social change transpired in different environmental settings within the Mesoamerican culture area.

Tlacuachero stands out in terms of prehistorians' understanding of events that transpired in tropical lowland coastal settings during the Archaic period because of the richness of diachronic data that archaeologists have obtained from that site. Investigators working in the coastal lowlands of Mesoamerica with an interest in the topic of this prehistoric economic transition have been constantly beset with a variety of obstacles that greatly hinder research progress (see Voorhies 2004a:3; Zeitlin and Zeitlin 2000). These confounding issues include difficulty in locating sites dating to this time period due to initial low archaeological site visibility, high rates of sedimentation in coastal settings, and sea level encroachment along the outer coast where sites may have once been located. In addition, some known sites that are suspected to be Archaic in age are not datable or are not researchable for edaphic or social reasons. This challenging situation on the Mesoamerican coasts contrasts with the situation in middle-elevation valleys of southern Mexico, where several iconic groundbreaking studies have provided detailed data about this crucial transitional period, including fine-scale information allowing detailed reconstructions of subsistence and settlement patterns (e.g., Acosta Ochoa 2008; Flannery 1986; MacNeish 1967; MacNeish et al. 1972; Marcus and Flannery 1996).

My own investigations at a relatively small number of Archaic period sites in coastal Chiapas led me previously to propose that the ancient people responsible for these sites were hunter-gatherer-fishers with a low level of food production (but see Kennett et al. 2010). I have also proposed that the Chantuto people, the name I use for the Archaic inhabitants of the Chiapas coast, practiced a semimobile lifestyle and exhibited a classic collector settlement pattern as originally defined by Binford (1980). The essential features of this settlement

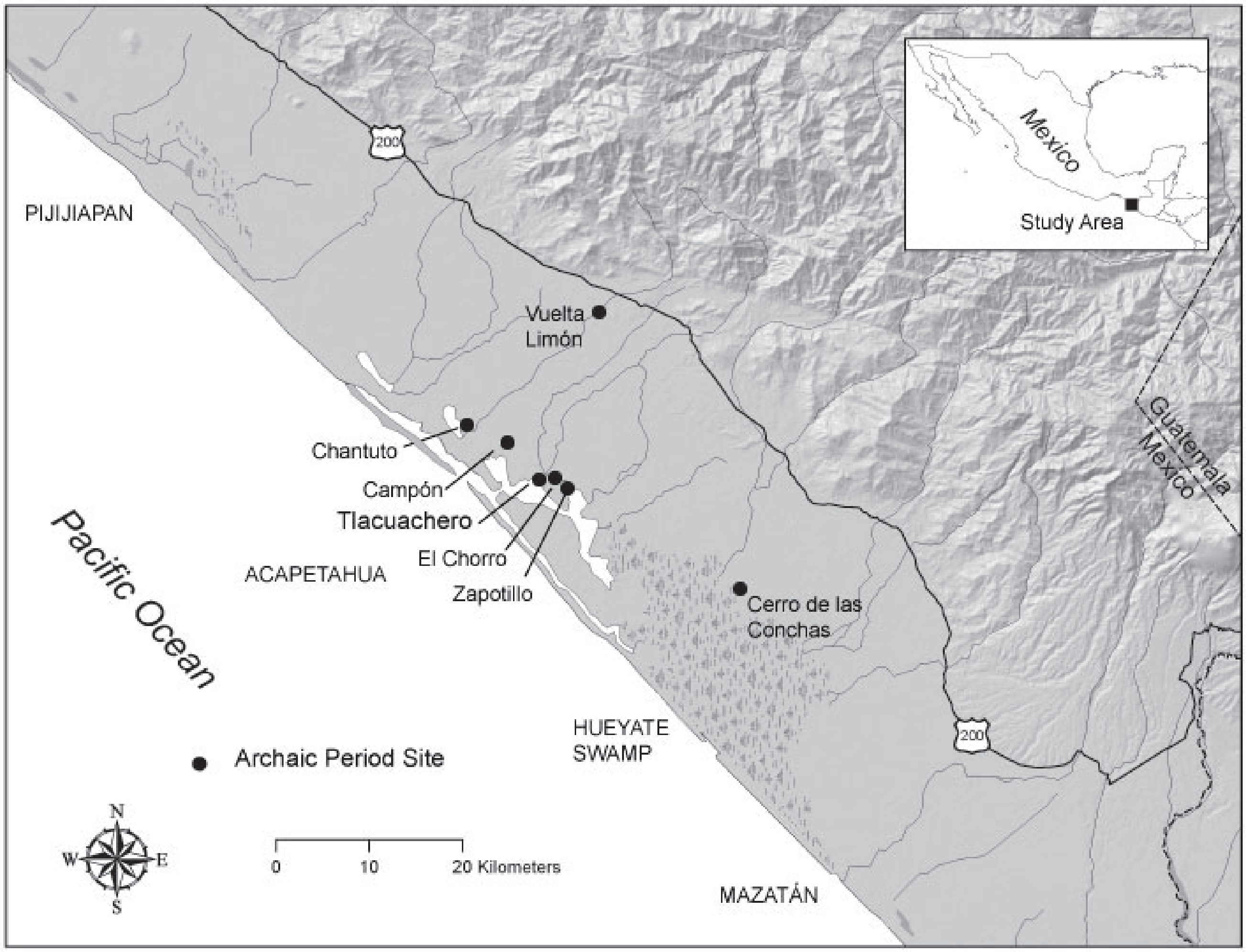


Figure 1.1. The littoral zone of southwestern Mexico showing the location of the Tlacuachero shellmound and some other known sites that date to the Archaic period (illustration by Douglas J. Kennett and Barbara Voorhies).

model are the presence of residential bases and satellite logistical sites, including in this particular case processing stations for wetland resources. Research at the site of Tlacuachero has been crucial in formulating these interpretations because of the wealth of information gleaned from its contents leading me to characterize it as a processing station for wetland resources.

The Tlacuachero shellmound, which formed over a period of at least approximately 600 to 800 cal years (see Chapter 2), stands out in its proven potential to provide insights into the way in which the people who formed this site underwent the transformation mentioned above (Voorhies 2004a). Prior studies conducted at Tlacuachero have demonstrated diachronic change in several different variables that presumably are the result of changing adaptations to a transforming socio-ecological environment: the seasons during which the site was in use; the kinds of plants present in the environment and their management; the size and trophic level of fish procured; and the type of artifacts discarded. For example, Kennett and Voorhies (1996) found that seasonal occupation of the site shifted during the Archaic from an early pattern of year-round occupation to a later pattern when the site was occupied only during the wet season. Similarly, Jones and Voorhies (2004) discovered that evidence for disturbance of the forest environment and the first appearance of cultigens increases significantly in the upper, late deposits compared to the lower, early ones. Cooke et al. (2004) documented shifts in fishing practices over time, in

particular the increase of the relative importance of the low-trophic-level Pacific fat sleeper. Finally Voorhies (2004b) notes that milling stones appear only in the upper Archaic deposits at the site while seeming absent in the early, lower deposits. In these prior studies the level of the floor features, located approximately halfway between the top and bottom of the investigated Archaic period deposits at the site, marks the place where change occurs most strikingly in each of these data sets. That is, before fieldwork in 2009, my colleagues and I viewed the time during which the floors were created as a kind of tipping point in the changing lifeways of the Chantuto people. While recent work at Tlacuachero has not substantially changed these earlier findings, it has changed my perspective now that we know that the period of time during which the floors were created and used was much longer than suspected (Chapter 2).

Another new surprising finding, reported in the present monograph, is that the matrix of the floors is not clay as I had long assumed. The material visibly resembles clay, and in the past I never even questioned its actual composition. To our great surprise, the geochemical analysis performed by Hector Neff and colleagues (Chapter 5) revealed that this substance is carbonate hydroxylapatite and not clay at all. This material is likely a result of diagenesis of an original starting material that may or may not have been fabricated (Chapter 5 and Chapter 10).

In addition to these new discoveries, two chapters in the present volume present data that support and extend some previous findings on diachronic change at the Tlacuachero site. Chapter 8 by Elizabeth Paris presents data on changes within the chipped stone assemblage at the site, whereas Chapter 9 by Thomas Wake and Barbara Voorhies documents change over time in captured fish and inferred related fishing practices.

The most recent investigations at Tlacuachero were carried out under my direction in the early months of 2009. Our work focused principally on the entombed floors at the site. I designed the field project to address a series of related questions. Why were floors formed only in a limited area at the site center? How were they formed? When were they formed? What activities were carried out on their surfaces? Why were they eventually buried by additional layers of shell during the Archaic period? And finally, why was the time of floor formation so crucial in the changing lifeways of the Chantuto people? The various chapter authors use both external and internal methods to examine these floors in almost forensic detail.

Prepared surfaces are not uncommon in shellmounds, especially Archaic sites in the American lower Midwest and Midsouth (Sassaman and Ledbetter 1996:79). Often, the surfaces are interpreted as floors of houses, as at Riverton on the Wabash River, where multiple low, roughly rectangular clay platforms are present (Winters 1969:97). Elsewhere, at some Archaic open-air and cave sites, small clay patches ("pancakes") with clear evidence of burning are interpreted as griddles used in food preparation (Sherwood and Chapman 2005). However, the surfaces at Tlacuachero are sufficiently different from these examples to warrant some other explanation for their function. In other words, we are especially concerned here with identifying the formation process and function of these intriguing floors. A separate but related concern is the formation process and function of the other deposits that surround them and that also were laid down during the Archaic period. I return to this topic in the final chapter of the monograph, but it is also addressed elsewhere by individual chapter authors.

As an introduction to the remaining book chapters I present here a general description of the site and its principal archaeological components, as well as a brief history of the archaeological research that I have conducted there, with particular emphasis on our recent work. Then I focus on a brief description of the contents and structure of the core deposits at the site that were laid down in the Archaic period and have been the object of archaeological research at the site.

General Site Description

The Tlacuachero shellmound forms an island (Figure 1.2) surrounded by a well-developed mangrove forest, with trees reaching as much as 35 m in height (Flores-Verdugo et al. 1992:278). Because of its unique environmental and cultural resources, this coastal wetland has been designated as a protected biological reserve (Reserva Biológica de la Encrucijada). The island is ellipsoid in outline, has a maximum diameter of 125 m, and is 7 m high. It can be reached only by boat in one of two ways. During high tide it is possible to take a small boat with shallow draft directly to the edge of the island by approaching through narrow waterways from the northwest. Otherwise it is necessary to moor a boat at

the edge of the major waterway to the east that connects the Embarcadero Las Garzas with the lower estuary and then wade the rest of the way through the mangroves.

The basic site structure consists of two major stratigraphic formations: an upper formation of dark brown, unbedded, and unconsolidated organic-rich soil that contains abundant potsherds and other artifacts and a lower formation of unconsolidated bedded shell from the marsh clam *Polymesoda radiata* that has very few artifacts (Voorhies 1976, 2004a). These two basic stratigraphic formations are present also in five nearby shellmounds that archaeologists have investigated (Voorhies 2004a). These shellmounds (Cerro de las Conchas, Chantuto, Campón, Zapotillo, and El Chorro) are shown on Figure 1.1.

At Tlacuachero, the upper, sherd-bearing mantle of soil contains mixed cultural deposits from several different time periods subsequent to the Archaic, but with the principal occupation apparently in the Early Classic period as judged by quantity of dated potsherds. In Chapter 3 Heather Thakar discusses the ceramic analysis that she recently used to date the deposits of the upper formation. Several platform mounds visible on the surface of the island (Figure 1.2) consist of the same dark brown soil overlying the entire site. These platforms have never been investigated by archaeologists except for a few probes with a bucket auger that established that they consist of the sherd-bearing dark soil. The probes detected no evidence that stone walls retained the platform fill. Otherwise we have no additional observations about these constructed platforms.

It is the older, shell-bearing deposits that have repeatedly attracted archaeologists to the site, because, as

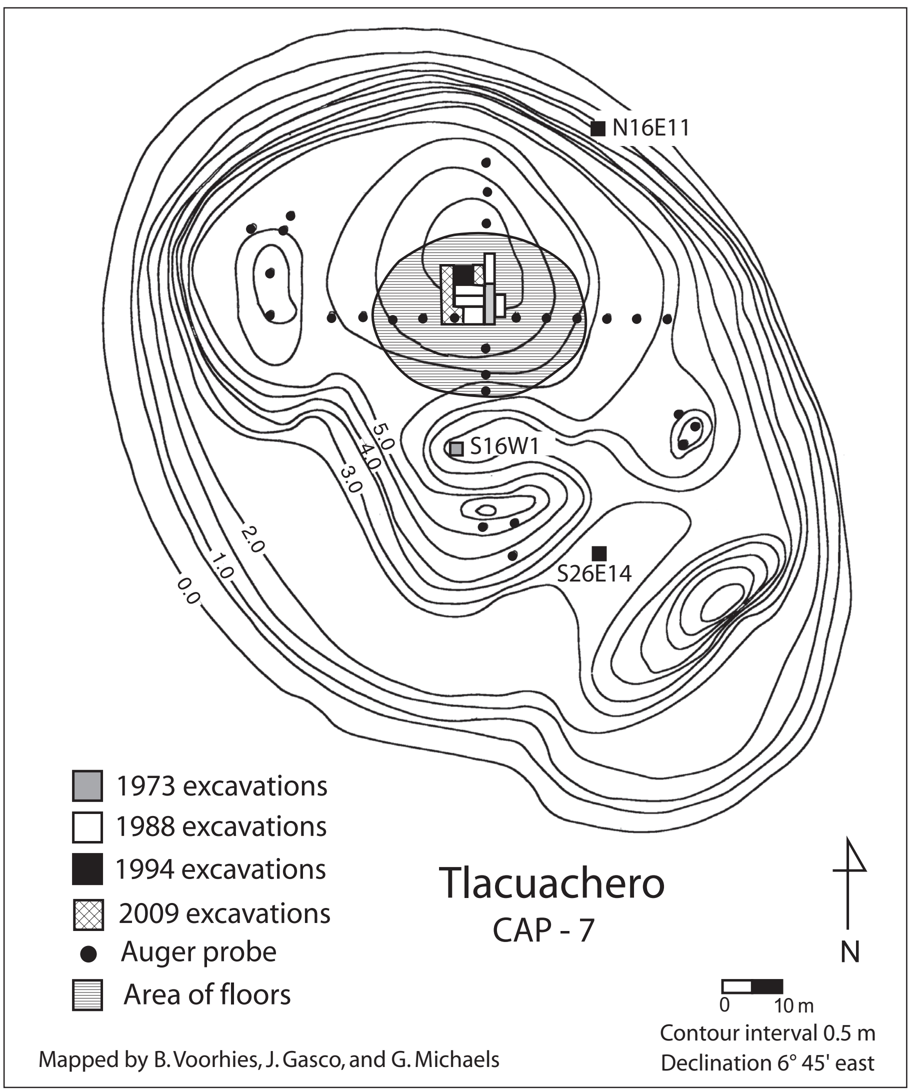


Figure 1.2. Contour map of Tlacuachero showing excavation locations and approximate extent of the deeply buried floors (illustration by Barbara Voorhies).

I mentioned above, they date to a prehistoric time period for which few archaeological sites have been found in the coastal lowlands of Mesoamerica (e.g., Voorhies 2004a; Zeitlin and Zeitlin 2000). The bedded, unconsolidated shells accumulated during the Late Archaic period, generally placed between approximately 3500 and 2000 BCE (Evans 2008) in the general Mesoamerican chronology. In Chapter 2 Culleton et al. present a detailed discussion of the recently acquired radiocarbon dates from the site. In a subsequent section of this chapter, I review the salient characteristics of these lower bedded, unconsolidated shell deposits, left behind by people I have named after Islona de Chantuto, the type site for the Archaic period shellmounds of Chiapas (Drucker 1948).

At Tlacuachero, the Chantuto people created three or more floors in a restricted area that is now positioned under the site summit. This occurred during the Late Archaic period, when unconsolidated shell deposits also were accumulating at the site. A principal focus of the research reported here concerns the archaeology of these floors. The floors are entombed within the lower stratigraphic formation. That is, they are situated within the unconsolidated bedded marsh clam shells. The total extent of the combined floors is large, approximately 900 m^2, but we now know that these successive floors are not perfectly isomorphic but are offset from one another.[1] Because the floors are so deeply buried (the top floor is approximately 4.6 m below the site's summit), they have not been uncovered completely, and we do not know their individual shapes and sizes. However, the combination of auger data and data from the excavations provides a few clues about the floor morphology, which are presented by Heather Thakar in Chapter 4.

So far, the centrally located, superimposed floors at Tlacuachero are the only ones we have found, despite subsurface investigations in peripheral locations at Tlacuachero and at four other shellmounds in the region. Given this fact, the floors at Tlacuachero must be considered as singular and unique, at least until the archaeological data prove otherwise. Some of the following chapters report different lines of investigation that our team has carried out most recently to determine what activities were conducted on the surfaces of these floors. In Chapter 4 Heather Thakar reports spatial variations in floor surface color and in the density of small bones embedded in the surfaces; in Chapter 5 Hector Neff, Paul Burger, and Isabela Kott report variations in chemical traces; and in Chapter 6 Doug Drake reports spatial variations in phytoliths.

I have worked at the Tlacuachero site on four separate occasions: 1973, 1988, 1994, and 2009. During the first field season, in 1973, I excavated two small test pits, one of which was enlarged to a trench. In subsequent field seasons I enlarged the test pit positioned at the site summit and dug two additional small test pits away from the site center (Figure 1.2). The details of these excavations are summarized in Voorhies 2004a, with the exception of work carried out in the first two months of 2009. The present publication reports new insights from this most recent work. In summary, archaeological work at Tlacuachero has consisted of a series of subsurface auger probes, three test pits positioned away from the summit of the site, and a large lateral excavation positioned at the site summit that has been progressively enlarged over several field seasons.

Excavations in the 2009 Field Season

Our archaeological team conducted the most recent excavations at the Tlacuachero shellmound in the first two months of 2009 with funding from the National Geographic Society and UC Mexus and with permission from the Consejo de Arqueología, Instituto Nacional de Antropología e Historia. The research goal was to collect a new set of data from the floors to address the question of why these floors formed at the site. To accomplish this, we first carried out two different activities. One was clearing out the refilled old excavation at the center of the site down to the surface of the uppermost floor. Accordingly, we exposed the area of Floor 1 that had been examined previously and that is shown in Figure 2.14 in Voorhies 2004a. In addition, we excavated three units, removing separate blocks of deposits extending from the ground surface to the level of the floors, thus exposing a larger area of Floor 1 than had been exposed in the past (Voorhies 2011).

Two of the three new excavation units dug from the ground surface down to the level of the floors were positioned along the western side of the old excavation (Figure 1.3). Unit N1W2 measures 6 x 2 m, with the long axis oriented north–south. Immediately to the south of this unit we placed S2W1, a unit measuring 4 x 4 m. The wall profiles of these units are shown in Figure 1.4 and Figure 1.5, respectively. In addition, in Unit N2E1 we removed an isolated (3 x 3 m) block of

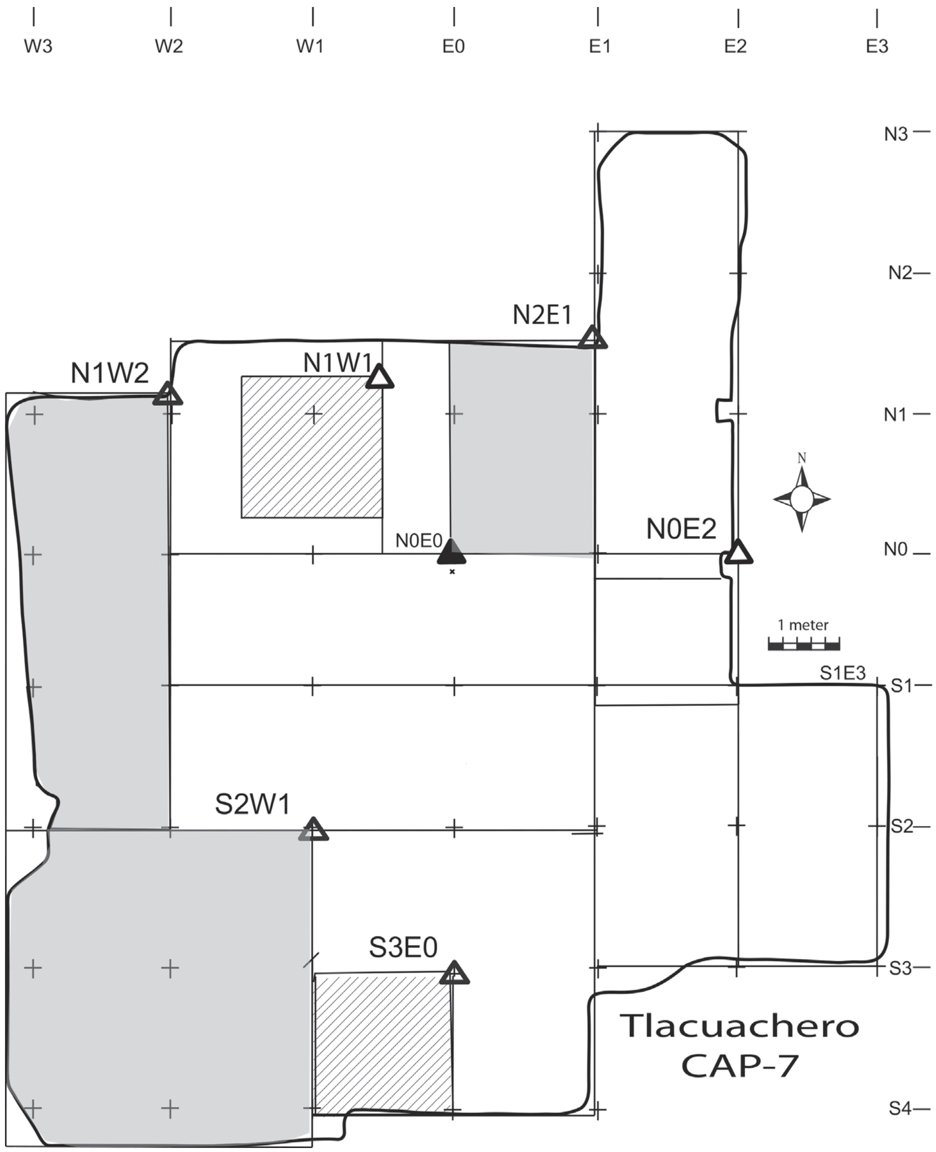


Figure 1.3. Map of the excavation units located at the center of the Tlacuachero site. The shaded units were excavated in 2009 from the ground surface to the level of the floors, whereas the units with diagonal lines were excavated during the same field season from the level of the floors into the lower bedded shell deposits (illustration by Heather B. Thakar and Barbara Voorhies).

intact deposits located at the north end of the old excavation. We dug in arbitary 20-cm levels within each stratigraphic formation in these three units, as well as in the other excavation units discussed below.

At the end of the 2009 field season we had newly exposed 33 m^2 of the uppermost floor, bringing its total exposure to 120 m^2. In Chapter 4 Heather Thakar discusses what we know about the sizes of the floors underlying the uppermost one.

In addition to enlarging the exposed area of the floor surfaces, we excavated two test pits (S3E0 and N1W1) through the floors and into the underlying shell deposits. The purpose of these excavations was to look at the site's lower deposits, which I had not seen since my first excavation at the site in 1973. These test pits are positioned at the northern and southern extremes of the lateral excavation (Figure 1.3).

The test pit at the south end of the lateral excavation, Unit S3E0, measures 2 x 2 m. We had begun this unit in 1988 when we removed Floor 1 and an additional 40 cm of the underlying unconsolidated bedded shells. In 2009 we reopened this unit and excavated to 1.2 m below the upper surface of Floor 1, as measured at the datum of Unit S3E0 (Figure 1.6). That is, the bottom of this test pit reached a total depth of 5.8 m below the ground level. All the deposits we removed

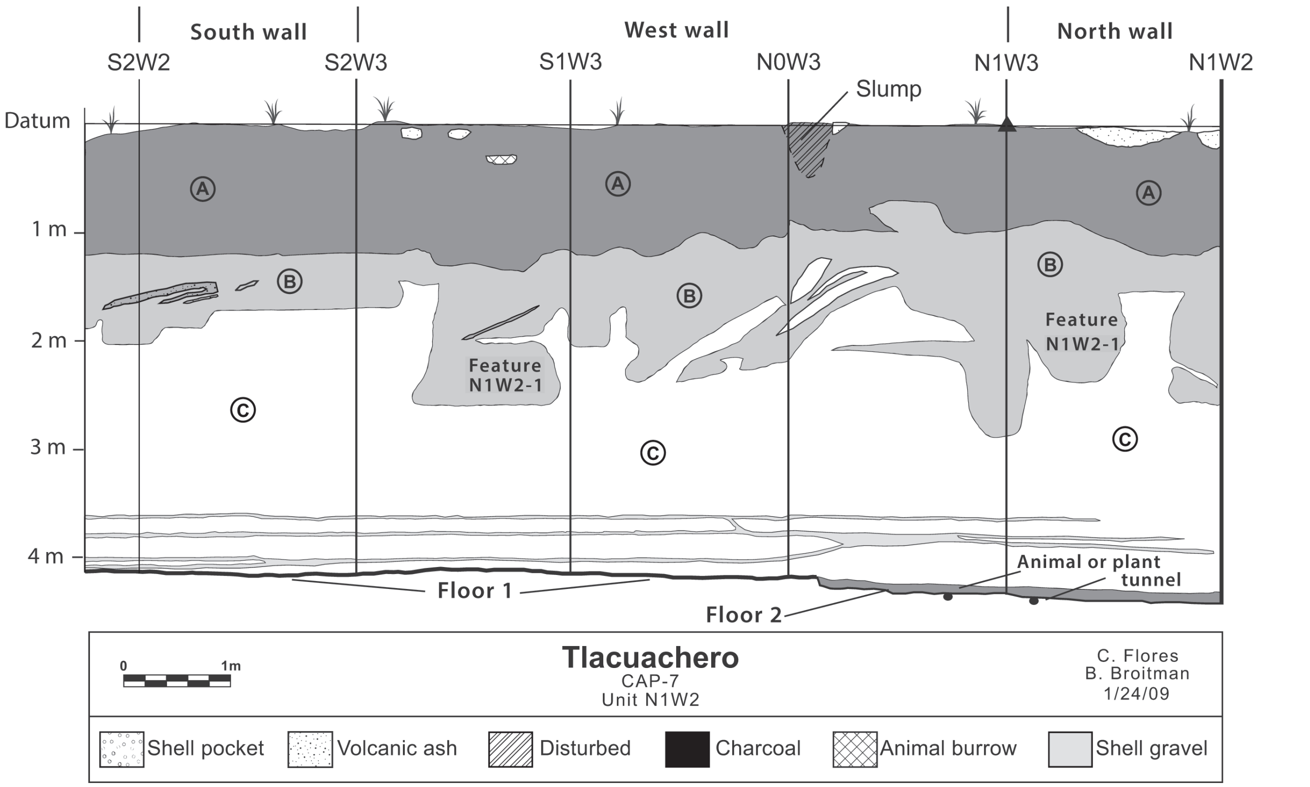


Figure 1.4. Wall profile of Unit N1W2 (illustration by Heather B. Thakar and Barbara Voorhies).

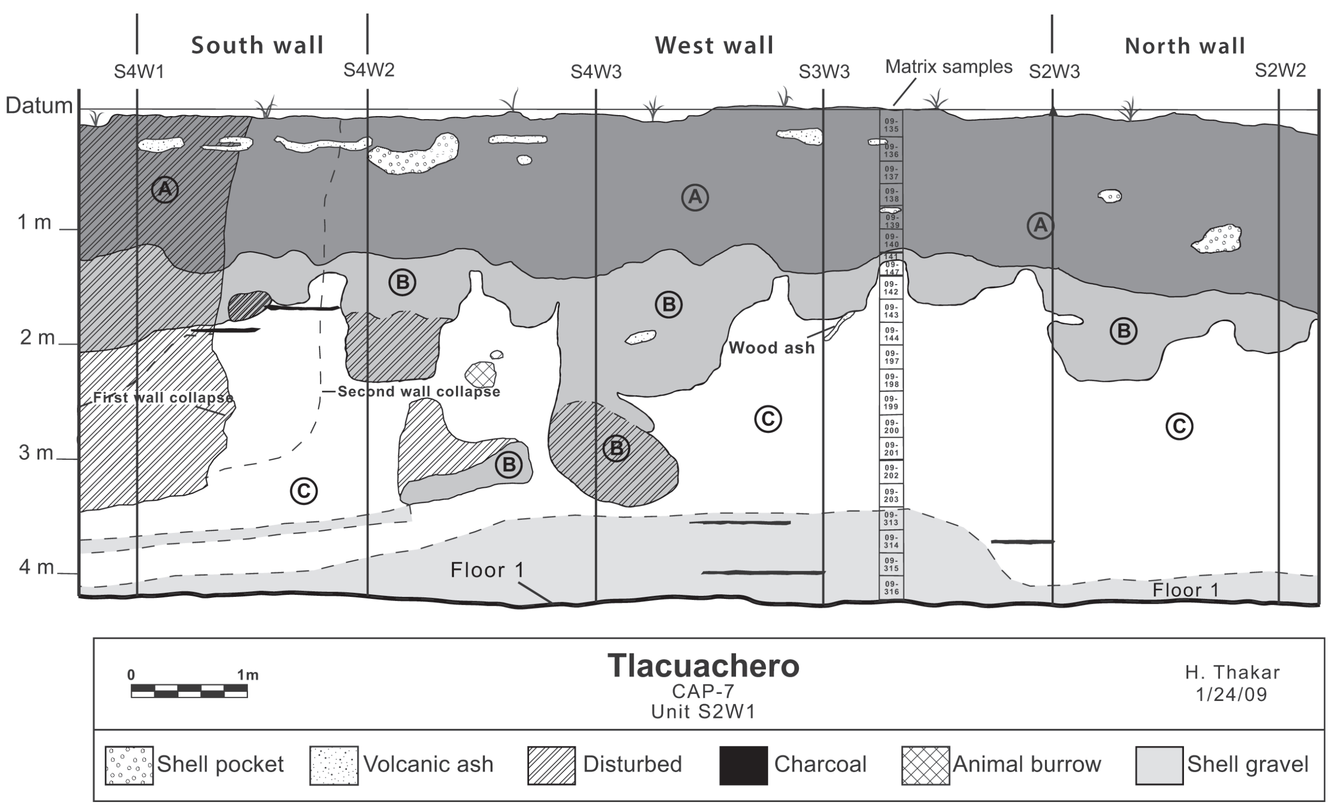


Figure 1.5. Wall profile of Unit S2W1 (illustration by Heather B. Thakar and Barbara Voorhies).

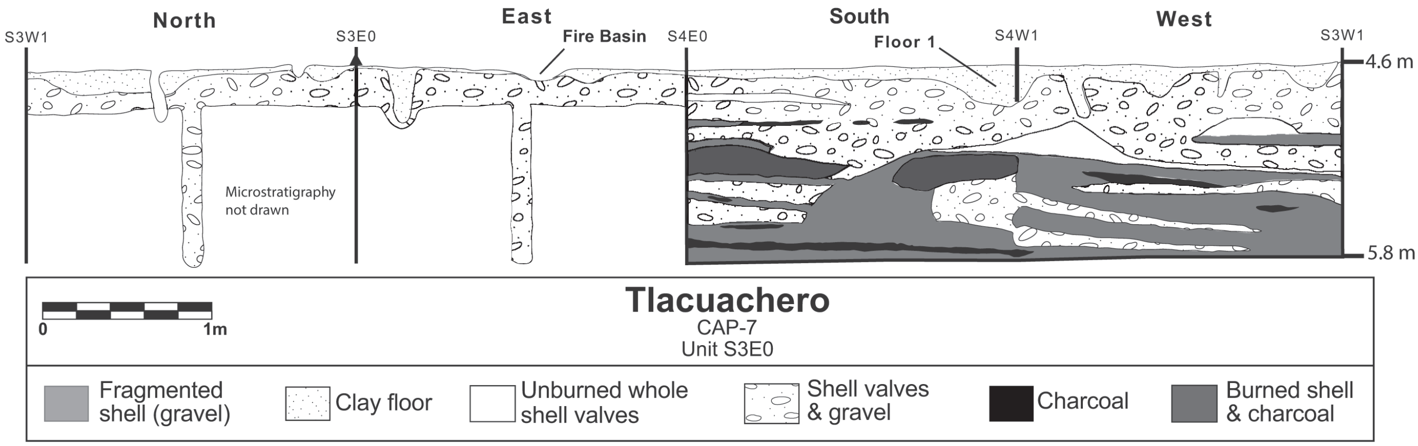


Figure 1.6. Wall profile of Unit S3E0 (illustration by Heather B. Thakar and Barbara Voorhies).

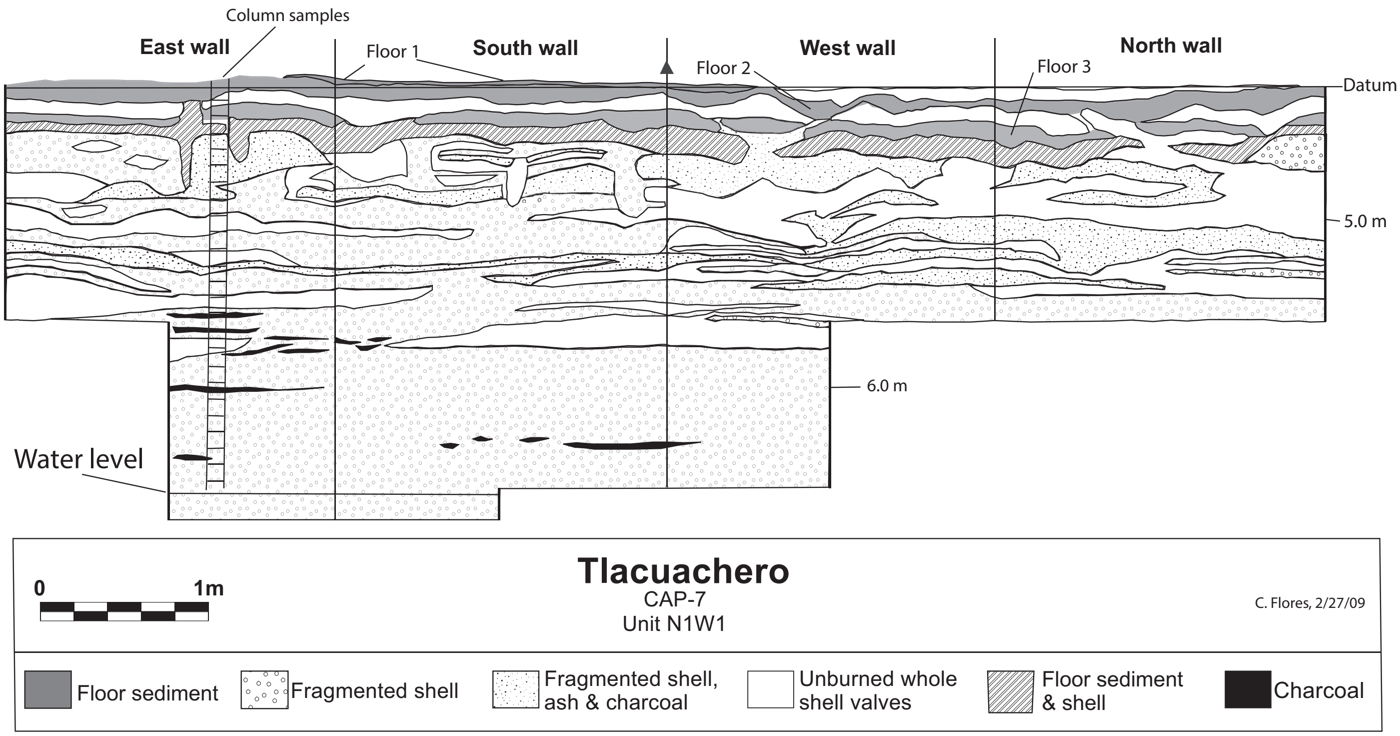


Figure 1.7. Wall profile of Unit N1W1 (illustration by Heather B. Thakar and Barbara Voorhies).

below Floor 1 are unconsolidated bedded shells, which continued below the bottom of the excavation. That is, neither Floor 2 nor Floor 3 was present at the location of Unit S3E0.

We placed Unit N1W1, a 2 x 2 m test pit, at the northern end of the lateral excavation at a location where Floor 1 tapered off and ended. Accordingly, when we began excavating the unit, Floor 1 was present only at its south end. This unit was reduced to 1 x 2 m at the 5.6-m level and to 1 x 1 m at 6.55 m (Figure 1.7). We encountered the water table at 6.63 m and dug the unit to 6.8 m below the site surface but discontinued excavation due to the difficulty of digging underwater. The bottom of this unit thus was 2.6 m below the upper surface of Floor 1 at the unit's datum. Bedded, unconsolidated shell continued below the lowest level in the unit, which means that the bottom of the cultural deposits was not reached. In 1973 I also was unable

to reach the bottom of the bedded shells, which means that we have never located the base of this shellmound.[2]

In the following section I discuss observations on the site stratigraphy based upon these excavations and previous observations.

Contents and Structure of the Lower Formation

In this section I examine the site contents and structure of the lower formation of unconsolidated bedded shells at the Tlacuachero site. Some of this information has been published previously and will be mentioned only briefly. However, our most recent work has provided new information that I present here for the first time. In addition, reconsidering the contents and structure of Tlacuachero is warranted because recently our interpretation of site function and site formation process has been called into question (Clark and Hodgson 2009). These authors propose that Tlacuachero and other Archaic shellmounds of the Chiapas coast were intentionally constructed platforms rather than being formed by the gradual accumulation of food waste. In Chapter 10 I argue that a similar debate typically emerges among archaeologists working in places where exceptionally large shellmounds occur. Perhaps the first step in resolving this recurrent debate is recognition of its ubiquity, but first it is necessary to introduce the reader to the characteristics of the Tlacuachero site.

Contents of the Bedded Shell Deposits

The basic contents of the matrix of the Late Archaic shell deposits at Tlacuachero have proved to be highly consistent internally as well as very similar to the contents of neighboring shellmounds that I have analyzed. For example, the results of hand sorting the matrices of 17 samples from Tlacuachero taken in a column from the excavation sidewall from the top of the stratigraphic unit to Floor 1 (Voorhies 2004a:Table 2.2) revealed the astonishing finding that the shell from the marsh clam (*Polymesoda radiata*) contributes 99.55 percent of the total material in these samples analyzed by weight. The other materials that are significant enough to register in this analysis are shell from other mollusks (0.24 percent), bone (0.07 percent), charcoal (0.03 percent), fine sediment (0.04 percent), and rocks and breccia (0.07 percent), all in miniscule amounts. The breccia is concreted shell that probably formed when mixtures of shell, wood ash, and water were subjected to heat, as in a campfire.

We conducted a similar content analysis on seven column samples from the bedded shell deposits at Cerro de las Conchas, the sole Middle Archaic shellmound in the region that to date has been investigated in detail. The results of the hand sorting of these samples revealed a very similar pattern: marsh clams make up 98.27 percent of the total material analyzed by weight. Shells from other mollusks (0.04 percent), bone (0.1 percent), charcoal (0.02 percent), and fine sediment (0.02 percent) each contribute less than 1 percent of the analyzed samples, whereas rocks and breccia together contribute just over 1 percent (1.13 percent). Accordingly, casual field observations suggesting that the contents of the investigated Chiapas shellmounds are similar are fully supported by detailed quantified analyses.

Structure of the Bedded Shell Deposits

At the beginning of this chapter I noted that Tlacuachero has two basic types of stratigraphic formations; here I present some information about the contact between them and describe more precisely the microstratigraphy present in the bedded shell formation.

Contact between Formations. Previously (Voorhies 2004a) I commented on the irregular contact between the upper and lower formations at Tlacuachero. In geologic terms this type of contact is called an unconformity. That is, it is an erosional surface separating two strata of different ages. That this is an erosional surface is clearly evident from the interrupted microstratigraphy in the uppermost layers of the bedded shells near the contact. The interruptions include pits of various sizes that were dug into the underlying shell after the bedded shell had been deposited. These pits later filled in with the ceramic-bearing dark soil. I also speculated (Voorhies 2004a:419, Note 2) that people might have dug some of these pits to procure shells to produce lime. While this remains a possible explanation for some of the pits intrusive into the shell layers, the size and shape of other pits suggest to me that reptiles, such as iguanas, turtles, and especially crocodiles, also may be agents of disturbance.

I suspect that crocodiles may have contributed significantly to the disturbance documented for the upper stratigraphic formation at Tlacuachero for several reasons. For example, some of the pits are very large and deep, as are the nests of crocodiles. Also, the shape of

Figure 1.8. A bilobed pit that intrudes into the lower bedded shell deposits. The pit could be the remnants of a crocodile's nest (photograph by Barbara Voorhies).

some pits is suggestive of reptilian burrows. For example, one large pit exposed in the southern end of the lateral excavation has a vertical shaft and is bilobed at the bottom (Figure 1.8). It is unlikely that humans could or would dig a pit with this shape into unconsolidated deposits. Figure 1.9 shows a model of a crocodile burrow also with a vertical shaft and a lobe at the bottom. In addition, the bottoms of several large intrusive pits on the west wall of the 2009 excavation have large diagonal streaks that look like they were created by the digging action of a large animal (Figure 1.10).

We know crocodiles are attracted to the shellmounds in the Acapetahua Estuary since they are often seen today lounging on the nearby El Chorro shellmound. American crocodiles make their nests near shallow, brackish lagoons on elevated ground not subject to flooding (Platt and Thorbjarnarson 2000). El Chorro is situated adjacent to water that is deep enough for an adult crocodile to approach, which is a situation these animals prefer. American crocodiles are known to make both mound and hole nests. They exhibit colonial nesting (more than one nest in an area) and reuse nesting areas and even actual nests. This characteristic could explain why multiple large pits occur in the area we investigated. Adult crocodiles typically reexcavate nests when eggs are about to hatch, in order to transfer the neonates to water. This characteristic might explain the large diagonal strata associated with some of the pits.

Whatever the cause or causes of the unconformity, the result is that the very last layers of shell to have been deposited at the site are no longer available for study, thus precluding information about the final episode of the Archaic period formation at this site.

Microstratigraphy. Previously (Voorhies 1976, 2004a), I described the fine bedding in the shell deposits at Tlacuachero, as well as at other neighboring,

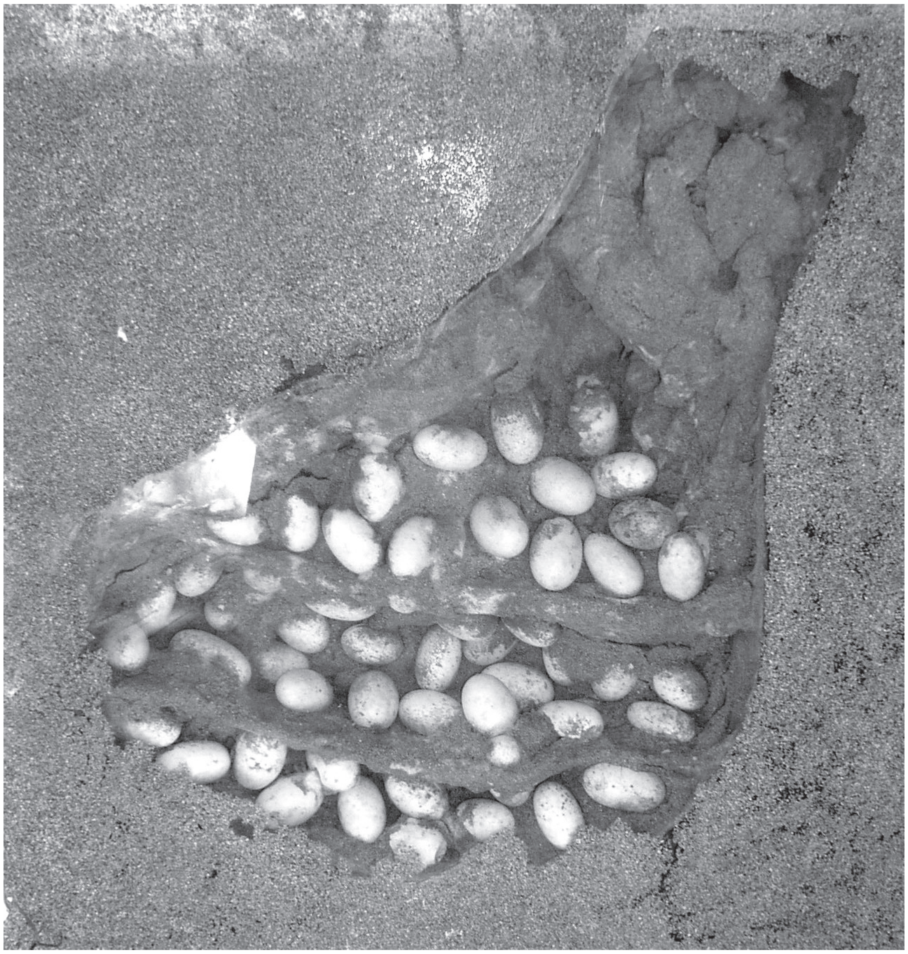


Figure 1.9. A simulated model of a crocodile (*Crocodylus acutus*) burrow (photograph by Barbara Voorhies at the Zoológico Miguel Alvarez de Toro, Tuxtla Gutiérrez, Chiapas).

coeval shellmounds. These are layers of unconsolidated sediment, consisting only of molluscan shells that alternate between thinner layers of gray shell gravel and thicker layers of white, whole marsh clam valves. The fragmentation of shells, their gray color, and the abundant burned particles of plant material all indicate that the layers of gravel were formed by exposure to heat. Field observations indicate that the effect of heating is greatest toward the top of each gravel stratum, where shell particles are small, and diminishes downward, where shell particle size increases (Voorhies field notes, January 1988), which means inconvertibly that the exposure to heat was in situ. Any archaeological interpretations of site formation processes must take these observations into account. We also have noted that each microstratum is both extensive and uniform in appearance along its horizontal extent.

We are also able to establish that some of the shells in the strata of whole valves were subjected to some degree of heating. First, of course, is the fact that the vast majority of shells are not articulated. Articulated shells do occur in the deposits, but they are extremely rare, often tiny (less than 1 cm wide), and usually with internal residue that I presume to be remnants of the animal, although this possibility has never been tested. In contrast, the absence of the presumed meat residue in the vast majority of shells suggests that the meat was removed. The evidence is also clear that at least some of the whole shell valves had been subjected to low intensity heat because of their discoloration. The discoloration is sometimes yellow-orange, the same color we produced experimentally by indirect heating, or even has a kind of negative resist pattern as illustrated in Voorhies 2004a:Figure 2.11.

I have argued that this evidence for extensive in situ burning at the shellmound sites was due to the ancient way in which clams were cooked on-site (Voorhies 2004a:42–48). In this interpretation, a batch of clams was laid out on a bed of embers on the mound's surface,

Figure 1.10. The west wall of Unit N2W1 showing the diagonal strata associated with the bottom of pits intrusive into the bedded shell deposits. Also visible in the photograph are Feature N2W1-1, which appears as a dark patch on the left side of the excavation floor, and a root cast on the right side that is close to the unit's west wall (photograph by Barbara Voorhies).

Figure 1.11. A photograph of unusual dipping microstrata at Tlacuachero. This view is looking westward at the east side of Unit S2W1, which was in the process of excavation. The trowel rests on the unit floor (photograph by Barbara Voorhies).

Figure 1.12. View of the west walls of Unit S1W2 and Unit N1W2 when the balk separating the two units was being removed by Edin Toledo Vera. Note the differences in the thickness of microstrata within the bedded shell deposits that are particularly visible to the right of the balk (Unit N1W2), where the lower layers are thicker than the upper layers. Floor 1 is also exposed in this area of the photograph (photograph by Barbara Voorhies).

which of course was pure shell. The fresh clams were probably covered with a layer of green leaves to keep in the heat and to steam open the mollusks. The heat of the fire would have discolored and fragmented the shells immediately under the fire bed, causing the formation of a new gravel layer. The newly opened clams must have been shucked on the spot and the shells dropped back down after the meat had been removed, thus forming a new layer of unconsolidated and unburned shell valves.

In the large lateral excavation at the summit of Tlacuachero, the microstrata are primarily horizontal and flat lying. They do not occur in lenses, as would be expected if, for example, the shells had been discarded in basket loads. The one known exception is that several coalescing lenticular deposits are present in a limited area in Unit S1E3 (Voorhies 2004a:Figure 2.6). These lenses consist of wood ash mixed with burned shell. Apparently, a hearth or fire pit had been cleaned and the material dumped over the edge of a rise. This is the only place where field investigators observed discrete lenses.

However, we observed inclined parallel microstrata in one area at the southern end of the lateral excavation above the level of the floors (Figure 1.11). They dip to the south—that is, away from the island's summit. This indicates that here the excavations penetrated the southern slope of a rise.

Our recent work has made more clearly evident to me that the fine microstrata are characteristic only of

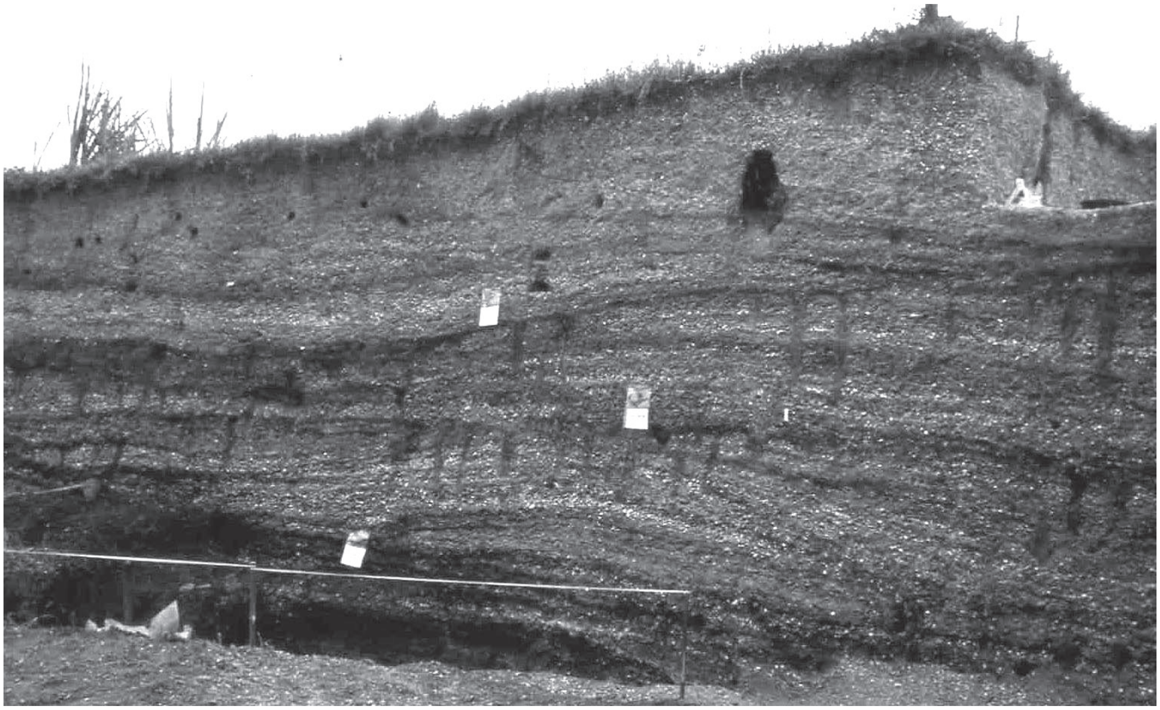
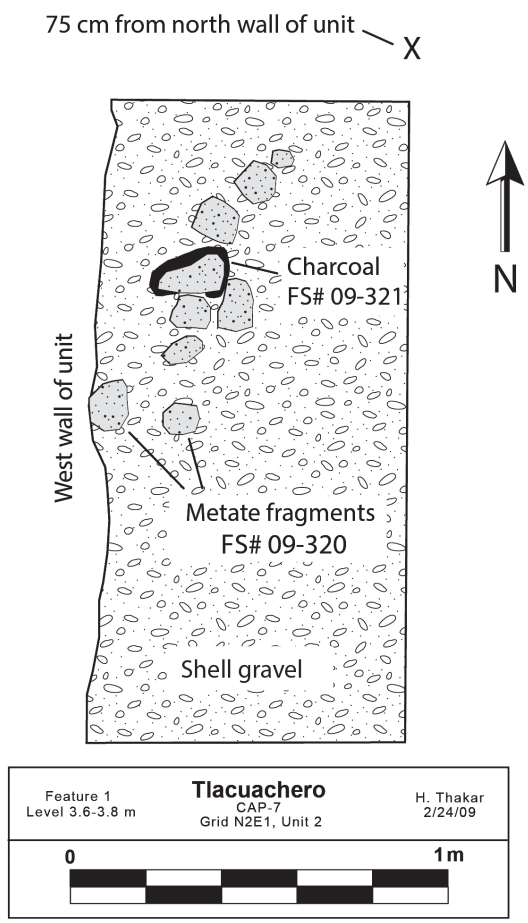


Figure 1.13. A photograph of a long stratigraphic exposure at Locus 1, the Jabuticabeira II shellmound, Santa Catarina, Brazil, showing places where stakes had been driven into the ground (photograph by Barbara Voorhies).

Figure 1.14. Vertical view of two postholes found in Unit N1W1 in the bedded shell deposits below the three floors. Floor 3 is visible on the south wall of the unit, sandwiched between two thin strata of shells (photograph by Carola Flores Fernández).

Figure 1.15. An alignment of nine stones resting on a gravel layer surface in Unit N2E1: (a) photograph of the alignment in oblique view showing the gravel layer and the underlying stratum of whole shell valves; (b) plan view drawing of the alignment (photograph and illustration by Heather B. Thakar).



the younger Archaic period deposits at Tlacuachero. In the lower deposits, the gravel layers are thicker and the strata of whole shell valves become much less evident with depth. Figure 1.12 illustrates the differences in layer thickness as visible on the west wall of Unit N1W2 above the level of Floor 1. As early as 1973 I was aware of this change in the site's stratigraphy, but initially I thought that prolonged compression could be responsible for postdepositional fragmentation of the lower deposits. While compression may be a contributing factor, I am no longer certain that it is the sole or even most compelling explanation for this phenomenon. An alternative consideration is that the depositional processes may have undergone some change during the time of site formation in the Late Archaic period.

The undisturbed nature of the bedded, unconsolidated shell microstrata at Tlacuachero is one of the most notable characteristics of the site structure. We have never found evidence of pits within the bedded shell deposit formation, other than those along the upper contact discussed above. Moreover, the layers show almost no evidence of stakes, at least in the upper bedded shell deposits, where we have made the majority of observations (but see below).

The scarcity of evidence of stakes in the upper bedded shell deposits contrasts with the situation on the floors at the site, where postholes are common (see Chapter 4). Moreover, evidence of posts is sometimes common at other shellmound sites, such as at Jabuticabeira II in Santa Catarina, Brazil (Fish et al. 1997, 2000). At that site investigators have documented an abundance of evidence for stakes that cluster around burial pits (Figure 1.13). Stakes were apparently set up in circles around each burial, most likely as part of the mortuary rituals conducted there (Fish et al. 1997, 2000). The evidence for these stakes is unmistakable in the site profiles.

It is worth mentioning that at Tlacuachero we have found a few root casts that might be confused with places where stakes had been set, but in fact they are very different. The casts consist of tubular consolidated concretions of sand and gravel shell sediments that are much harder than the surrounding unconsolidated deposits. Invariably, they terminate in a branching structure where originally roots spread out from the base of a tree. One of these is visible in Figure 1.10, and some have been plotted on maps in Chapter 4.

In contrast to our observations in the upper, fine-bedded shell strata, we found two closely spaced postholes in the N1W1 unit at the 4.6 m level, just below the floors. These postholes originate from a consolidated patch of fragmented shell gravel (Figure 1.14). The postholes are not present in the overlying floors, thus providing unmistakable evidence that this gravel layer is an occupational surface. Each posthole has a diameter of approximately 14 cm, and one has a known depth of 35 cm. The measurements indicate that the posts were sturdy and set well into the ground.

That gravel layers were at least sometimes occupational surfaces is also indicated by the fact that in Unit N2E1 we found an alignment of eight small rocks—all fragments of grinding stones—resting on the upper surface of a gravel stratum (Figure 1.15). The purpose of the alignment is not clear to us, but we suspect that it may be related to a cooking event because of the concentration of charcoal around and under one of the rocks. This feature resembles one at Cerro de las Conchas (Voorhies 2004a:Figure 2.35) where an alignment of rocks was also associated with charcoal concentrations.

In summary, this monograph presents recent data from Tlacuachero stemming from field research undertaken in 2009. The principal focus of the research is to investigate why and how the floors formed and what activities were carried out on their surfaces. The majority of the chapters are centered on this research problem. However, the two chapters immediately after this one are concerned primarily with dating the deposits. Chapter 2, by Brendan Culleton et al., is focused on dating the Archaic formation and relies on newly acquired high-precision radiometric dates interpreted using a Bayesian framework. In Chapter 3 Heather Thakar employs ceramic cross dating to determine when the upper dark soil mantle was deposited at the site. In addition, two chapters, on chipped stone by Elizabeth Paris (Chapter 8) and on vertebrate faunal remains by Thomas A. Wake and Barbara Voorhies (Chapter 9), examine specific data sets using a diachronic perspective. Finally, in Chapter 10 I consider the overall issue of site formation process at Tlacuachero, in addition to addressing the problem of the function of the floors, and in Chapter 11 I discuss the recurrent debate about formation process and site function of large shellmounds.

Notes

1 Previously (e.g., Voorhies 2004a), I mistakenly assumed that there was only a single floor.

2 We have been able to locate the base of only one of the shellmounds that I have investigated. At El Chorro, the smallest of the shellmounds in our study group, a sediment core revealed that the base of the mound is actually 4.1 m lower than it currently appears. There, the shellmound rests directly on a substrate of mangrove mud.

References Cited

Acosta Ochoa, Guillermo

2008 La cueva de Santa Marta y los cazadores-recolectores del Pleistoceno final—Holoceno temprano en las regiones tropicales de México. Unpublished Ph.D. dissertation, Universidad Nacional Autónoma de México, Mexico City.

Binford, Lewis R.

1980 Willow Smoke and Dog's Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4–20.

Clark, John E., and John G. Hodgson

2009 Settling Down in Middle America. Manuscript on file, Department of Anthropology, Brigham Young University, Provo, Utah.

Cooke, Richard G., Máximo Jiménez, Conrado Tapia, and Barbara Voorhies

2004 A Closer Look at the Archaic Fish Fauna. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 207–299. University Press of Florida, Gainesville.

Drucker, Philip

1948 Preliminary Notes on an Archaeological Survey of the Chiapas Coast. *Middle American Research Records* 1:151–169.

Evans, Susan Toby

2008 *Ancient Mexico and Central America: Archaeology and Culture History*. Thames and Hudson, New York.

Fish, Suzanne, Paul DeBlasis, Maria Dulce Gaspar, and Paul Fish

2000 Eventos incrementais na construção de sambaquis litoral do estado de Santa Catarina. *Revista do Museu Arqueologia e Etnologia*, *Universidade de São Paulo* 10:69–87.

Fish, Suzanne K., Paul Fish, Maria Dulce Gaspar, and Paulo De Blasis

1997 Incremental Events in the Construction of Sambaquis, Southeastern Santa Catarina. Paper presented at the Congresso da Sociedade de Arqueologia Brasileira, Rio de Janeiro, Brasil.

Flannery, Kent V. (editor)

1986 *Guilá Naquitz: Archaic Foraging and Early Agriculture in Oaxaca*, *Mexico*. Academic Press, Orlando.

Flores-Verdugo, F., F. Gonzalez-Farias, D. S. Zamorano, and P. Ramírez-García

1992 Mangrove Ecosystems of the Pacific Coast of Mexico: Distribution, Structure, Litterfall, and Detritus Dynamics. In *Coastal Plant Communities of Latin America*, edited by Ulrich Seeliger, pp. 269–290. Academic Press, San Diego.

Jones, John G., and Barbara Voorhies

2004 Human and Plant Interactions. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 300–343. University Press of Florida, Gainesville.

Kennett, Douglas J., Dolores R. Piperno, John G. Jones, Hector Neff, Barbara Voorhies, Megan K. Walsh, and Brendan J. Culleton

2010 Pre-Pottery Farmers on the Pacific Coast of Southern Mexico. *Journal of Archaeological Science* 37:3401–3411.

Kennett, Douglas J., and Barbara Voorhies

1996 Oxygen Isotope Analysis of Archaeological Shells to Detect Seasonal Use of Wetlands on the Southern Pacific Coast of Mexico. *Journal of Archaeological Research* 23:680–704.

MacNeish, Richard S.

1967 A Summary of the Subsistence. In *The Prehistory of the Tehuacan Valley*. Vol. 1, *Environment and Subsistence*, edited by Douglas S. Byers, pp. 290–310. University of Texas Press, Austin.

MacNeish, Richard S., Frederick A. Peterson, and James A. Neely

1972 The Archaeological Reconnaissance. In *The Prehistory of the Tehuacan Valley*. Vol. 5, *Excavations and Reconnaissance*, edited by Richard S. MacNeish, Melvin L. Fowler, Angel García Cook, Frederick A. Peterson, Antoinette Nelken-Terner, and James A. Neely, pp. 341–495. University of Texas Press, Austin.

Marcus, Joyce, and Kent V. Flannery

1996 *Zapotec Civilization: How Urban Society Evolved in the Oaxaca Valley*. Thames and Hudson, London.

Platt, Steven G., and John B. Thorbjarnarson

2000 Nesting Ecology of the American Crocodile in the Coastal Zone of Belize. *Copeia* 2000:869–873.

Sassaman, Kenneth E., and R. Jerald Ledbetter

1996 Middle and Late Archaic Architecture. In *Archaeology of the Mid-Holocene Southeast*, edited by Kenneth E. Sassaman and David G. Anderson, pp. 75–95. University Press of Florida, Gainesville.

Sherwood, Sarah C., and Jefferson Chapman

2005 The Identification and Potential Significance of Early Holocene Prepared Clay Surfaces: Examples from Dust Cave and Icehouse Bottom. *Southeastern Archaeology* 24:70–82.

Voorhies, Barbara

1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral*, *Mexico*. Papers of the New World Archaeological Foundation, No. 76. Brigham Young University, Provo, Utah.

2004a *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

2004b Tool Assemblages. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 344–396. University Press of Florida, Gainesville.

2011 Informe de proyecto "Los Origines de Arquitectura Publica en la Costa Sur de México." Submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, México. Manuscript on file, Archivo Técnico de Arqueología, Mexico City.

Winters, Howard D.

1969 *The Riverton Culture: A Second Millenium Occupation in the Central Wabash Valley*. Reports of Investigations (Illinois State Museum) No. 13; Monograph (Illinois Archaeological Survey) No. 1. Illinois State Museum and Illinois Archaeological Society, Springfield, Illinois.

Zeitlin, Robert N., and Judith Francis Zeitlin

2000 The Paleoindian and Archaic Cultures of Mesoamerica. In *The Cambridge History of the Native Peoples of the Americas*. Vol. 2, *Mesoamerica*, *Part 1*, edited by Richard E. W. Adams and Murdo J. MacLeod, pp. 45–121. Cambridge University Press, Cambridge.

Chapter 2

Stratigraphy and Chronology of the Archaic Period Deposits at Tlacuachero

Brendan J. Culleton, Barbara Voorhies, and Douglas J. Kennett

In the previous chapter Voorhies introduced the basic site structure of Tlacuachero by describing two major stratigraphic formations: an upper dark brown soil containing abundant cultural material including potsherds and a lower deposit of bedded, unconsolidated shell containing abundant small bones and relatively little cultural material. In this chapter we take a closer look at the stratigraphy of the lower formation as archaeologists have exposed it at the center of the site, and we discuss the chronology of each of the culturally significant stratigraphic units at this location.

The discussion of chronology is based upon 11 radiocarbon dates obtained from carbonized twig samples collected at Tlacuachero during the 2009 field season. In previous years, 10 other radiocarbon dates had been generated for the site (Voorhies 2004:Table 2.4), but these proved unsatisfactory because of the large error ranges associated with each date and stratigraphic age reversals caused by either laboratory errors or unrecognized post-depositional processes. All 10 dates that were available prior to the 2009 field season had been generated using the conventional radiometric method, and they had been produced at four different labs over several decades. The new dates were generated at the Keck-CCAMS (Carbon Cycle Accelerator Mass Spectrometry) facility at the University of California–Irvine using refined AMS technology that allows for high dating precision (small error ranges; Beverly et al. 2010). Further, we selected short-lived samples (that is, small branches or twigs) to reduce the potential for old wood effects, and extended chemical preparation was carried out at the Archaeometry Facility at the University of Oregon (now at Penn State). In other words, the newly acquired data on the site chronology are much more accurate than the data available previously, although interpretation remains limited by the small number of dated samples and, in specific cases, uncertainties regarding their context. Table 2.1 presents the new radiocarbon dates for Tlacuachero.

The new dates and a stratigraphic model have been published previously by Kennett et al. (2011), with the exception of TL279 (UCIAMS-112165), which is reported here for the first time. In that publication the authors demonstrated the benefit of interpreting the radiocarbon dates using a Bayesian statistical approach in OxCal (Bronk Ramsey 2009). This approach to chronological modeling integrates the archaeologist's knowledge about stratigraphic relationships between radiocarbon samples and culturally significant deposits to improve the precision of calibrated age estimates in a sequence (Kennett et al. 2011:247–248). In the simplest case, we may assume that a sample from a deeper level

Table 2.1. Radiocarbon Samples from Tlacuachero Dated by the Keck-CCAMS Facility, University of California–Irvine.

UCIAMS #	Sample Name	Provenience	^{14}C Age (B.P.)	±	2σ Cal (B.P.)
72130	TL134B	N0E3, 1 m, within bedded shells	3905	20	4420–4255
112165	TL279	S2W1, hearth in bedded shells above Floor 1	3865	25	4415–4160
68829	TL340	N2E1, surface of Floor 1	3875	15	4410–4240
68831	TL452	S1E1, within bedded shells, just below Floor 1	3900	15	4420–4255
68832	TL510	N1W2, within bedded shells, just below Floor 1	3890	15	4415–4250
72132	TL598	N1W2, surface of Floor 2	4040	20	4570–4435
72131	TL594	S2W1, surface of Floor 2*	4160	20	4825–4615
68828	TL324	N1W1, hot spot below Floor 2	4260	15	4855–4825
68830	TL357	N1W1, 5.36 m, within bedded shells	4380	15	5030–4865
76143	TL548	N1W1, 6.6–6.7 m, within bedded shells	4380	20	5035–4865
76144	TL570	N1W1, 6.7–6.8 m, within bedded shells	4405	20	5045–4875

*A 0.7 percent probability from 4595 to 4585 cal B.P. is excluded from the range.

Note: Conventional ages are corrected for fractionation using measured δ^{13}C values from the AMS following Stuiver and Polach (1977) and are calibrated with OxCal 4.1 (Bronk Ramsey 2009) using the IntCal09 curve (Reimer et al. 2009). Whole ranges are reported for clarity.

must be older than one above it in the sequence, even though their calibrated age ranges may overlap, allowing the possibility of a reversal. When the excavator's observations of the stratigraphy rule out disturbances, the two dates can be modeled so that one is forced to precede the other, and the calibrated ranges can then be recalculated with this constraint, typically resulting in tighter age estimates for each. Working with OxCal also has the advantage of including undated events into the model (for example, the formation of a floor; the excavation of a pit; deposition of sterile sediments) and then generating age estimates for these events based on the surrounding direct radiocarbon dates. For example, if two dates (as above) are stratigraphically separated by a sandy flood deposit, the timing of the flood is constrained by these dates and a probability distribution can be generated in the absence of a direct date on the deposit. It is also possible to calculate periods of time between events of interest using functions such as *span* or *interval*. These are expressed as a probability distribution similar to calibrated ages, but with the x axis in units of calibrated years rather than cal B.P. In certain parts of the text, these ranges are summarized as a weighted mean (μ) to suggest the central tendency of an interval, though any point estimate does not adequately describe the whole distribution (Michczyński 2007; Telford et al. 2004). OxCal also generates an agreement index (A) for each modeled date and the model as whole, which serves as a statistical measure of how well the model results conform to the original data. Values above a critical value (A′ = 60 percent) indicate agreement between the dates and the model. A high A does not mean that the model assumptions are correct; it simply means that there is no evidence that they are erroneous. The overall agreement index for this model is 97.4 percent, and all the individual indices are above the critical value.

As further data and stratigraphic details have come to light since the Kennett et al. (2011) analysis, we have revised the model to accommodate these new data. What we present in this chapter is essentially the fourth modeling iteration following the three described in that paper. The most important change is the relocation of TL324 from between the presumed upper and lower sections of Floor 2 to the unconsolidated shells below, and therefore the designation of Floor 2 as a single formation episode. In any event, most sections of the sequence are well enough constrained by the AMS dates that the end results do not differ greatly from those published by Kennett et al. (2011).

In this chapter we highlight the results of the chronological modeling by focusing on culturally significant strata and their calibrated age ranges as determined from the available data.

Chronological Modeling of Cultural Strata

This discussion follows geologic convention. That is, we describe the sequence in the order of deposition, from oldest to youngest (Figure 2.1). The culturally significant stratigraphic units that we dated are the following: lowest unconsolidated bedded shell deposits; Floor 3; unconsolidated shells; Floor 2; Floor 1; and the uppermost unconsolidated bedded shell deposits (Table 2.2).

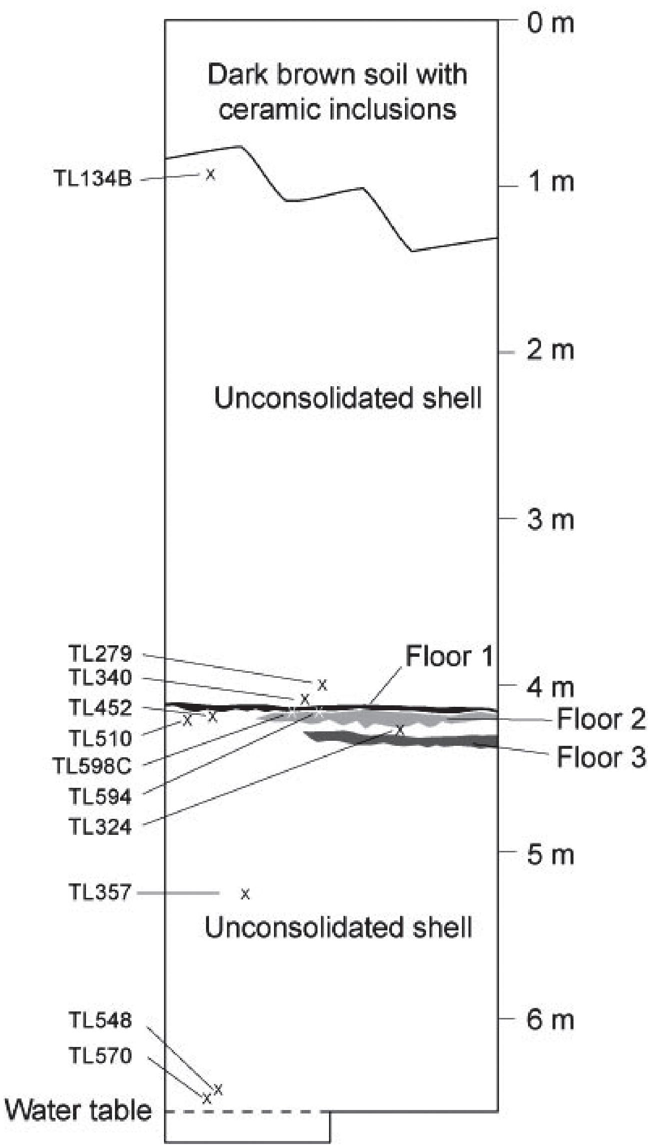


Figure 2.1. Schematic drawing of culturally significant strata at the center of the Tlacuachero island as revealed in the 2009 excavations (illustration by Barbara Voorhies).

Lowest Unconsolidated Bedded Shells

The lowest stratigraphic unit in the 2009 excavations consists of 2.4 m deep deposits of unconsolidated bedded shells of marsh clams exposed at the bottom of Unit N1W1 (from 6.8 m to 4.4 m excavation levels). The contacts between the alternating beds of shell gravel and unbroken valves in these lowest known shell deposits are not as sharply defined as the uppermost bedded shell deposits at the site. Nevertheless, in the lowest shell deposits that we have excavated there is a regular alternation between strata of burned, fragmented shell and strata of unburned, unbroken shell, just as in the upper bedded shell deposits at the site (Figure 2.2). In Figure 2.2 we have labeled only the burned strata to illustrate this situation. As can be seen in the illustration, the layers of labeled burned shell gravel are separated by strata of unburned shell valves, which are not labeled. We suspect that postdepositional processes have resulted in some loss of original integrity of these strata, especially in the stratigraphically lowest strata encountered in our excavations.

We obtained three radiocarbon dates from within this stratigraphic unit, but we have no dates for either the top or bottom of the exposed section (Figure 2.3). Two dates are from samples (TL548 and TL570) that came from approximately 6.7 m below datum and just above the level of the water table at the time of excavation (February 2009). A third date was obtained from a sample (TL357) higher up in this stratigraphic unit, at approximately 5.36 m. The two samples that came from the lowest location were charcoal fragments dispersed in the shell matrix. Sample TL 357, in contrast, was taken from a "hot spot" feature—that is, a place where a small campfire had been located. The three dates were modeled as a sequence nested within the overall stratigraphic section. Using the span query in OxCal, it is estimated that the lowest bedded shell deposits accumulated over a span of 10 to 160 cal years with a weighted mean span of 95 cal years. This depositional event took place in the temporal interval between 5050 and 4870 cal B.P., the earliest and latest 2 sigma ranges of the modeled dates.

It is important to remember that this span represents only the 1.34 m of shell between the AMS ^{14}C dates from about 6.7 m and 5.36 m and does not pertain to the earliest time of site formation. The bedded shell deposits continue below the bottom of the test pit for an unknown depth; the base of the Tlacuachero shellmound has never been reached in our excavations because it is below the

Table 2.2. Modeled AMS ^{14}C Dates and Distributions for the Tlacuachero Sequence.

UCIAMS #	Sample Code	Context	^{14}C Age	2σ Cal B.P.	Modeled 2σ Cal B.P.
72130	TL134B	N0E3, 1 m, within bedded shells	3905 ± 20	4420–4255	4350–4235
112165	TL279	S2W1, hearth in bedded shells above Floor 1	3865 ± 25	4415–4160	4380–4255
		Duration of shell accumulation above Floor 1			*10–135 cal years*
		Start deposition above Floor 1 (boundary)			*4405–4285*
		Duration of Floor 1 use			*0–70 cal years*
68829	TL340	N2E1, surface of Floor 1	3875 ± 15	4410–4240	4405–4290
		Floor 1 formation (boundary)			*4415–4315*
68831	TL452	S1E1, within bedded shells, just below Floor 1	3900 ± 15	4420–4255	4420–4335
68832	TL510	N1W2, within bedded shells, just below Floor 1	3890 ± 15	4415–4250	4420–4335
		Duration of deposition above Floor 2			*0–135 cal years*
		Start deposition above Floor 2 (boundary)			*4505–4345*
		Duration of Floor 2 use			*220–485 cal years*
72132	TL598C	N1W2, surface of Floor 2	4040 ± 20	4570–4435	4570–4435
72131	TL594	S2W1, surface of Floor 2	4160 ± 20	4825–4615	4825–4785, 4765–4610, 4600–4580
		Floor 2 formation (boundary)			*4855–4660*
68828	TL324	N1W1, hot spot below Floor 2	4260 ± 15	4855–4825	4855–4825
		Duration of shell accumulation between Floor 3 and Floor 2			*0–205 cal years*
		Start shell deposition above Floor 3 (boundary)			*4905–4830*
		Floor 3 formation (boundary)			*4940–4840*
68830	TL357	N1W1, 5.36 m, within bedded shells	4380 ± 15	5030–4865	4965–4870
76143	TL 548	N1W1, 6.6–6.7 m, within bedded shells	4380 ± 20	5035–4865	5030–5005, 4980–4885
76144	TL 570	N1W1, 6.7–6.8 m, within bedded shells	4405 ± 20	5045–4875	5050–4920
		Span from water table to Floor 3			*5–155 cal years*
		Duration of Archaic above water table			*600–795 cal years*
		Duration of deposition above Floor 2			*35–225 cal years*
		Duration from water table to Floor 2 formation			*95–385 cal years*

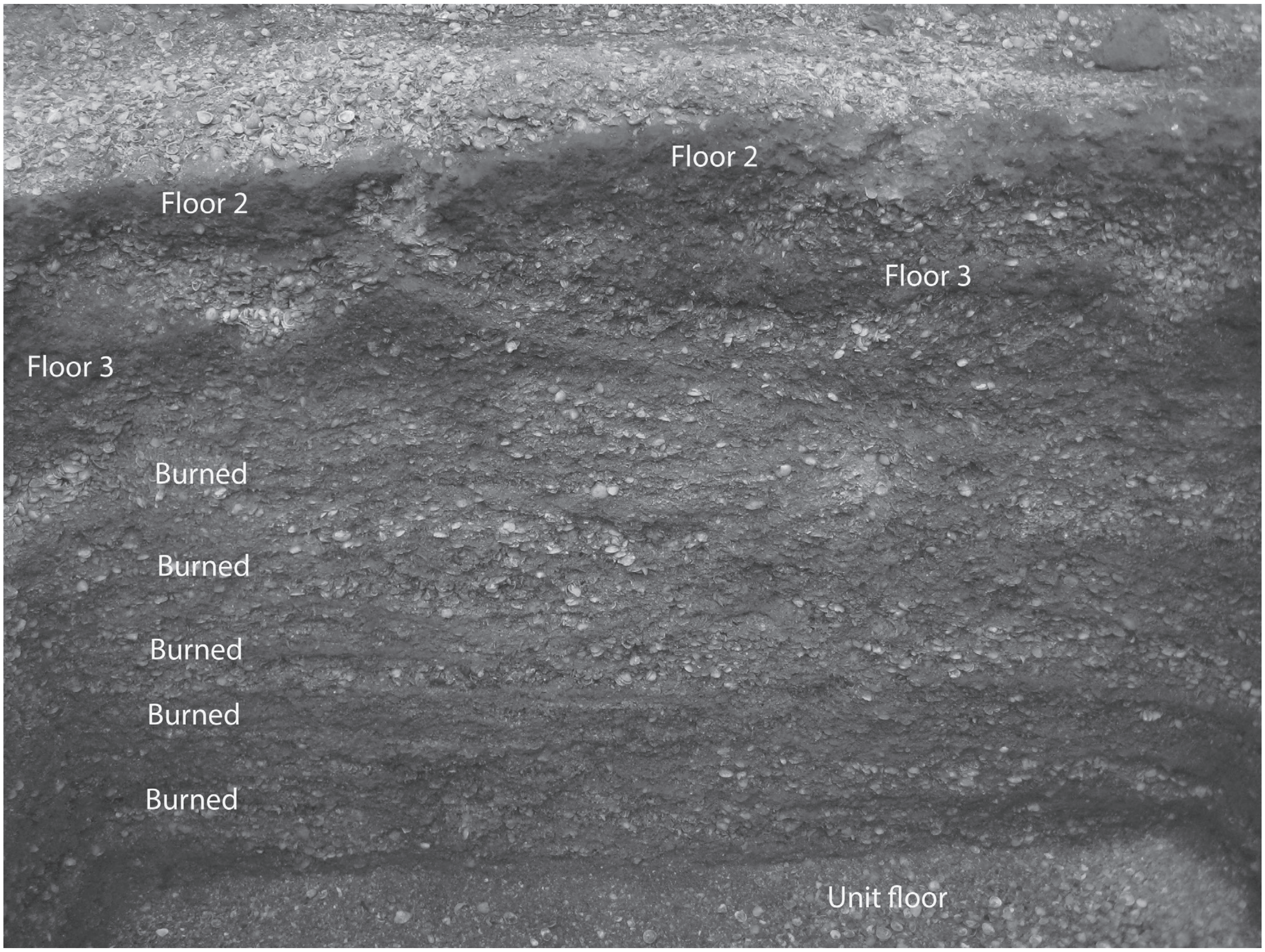


Figure 2.2. A close-up of the stratigraphy on the north wall of Unit N1W1. This photograph shows Floor 2, Floor 3, and the bedded, unconsolidated shell deposits below these floors. The layers of burned shell gravel are labeled, and the intervening layers of whole shell valves are not labeled (photograph by Barbara Voorhies).

current water table. Because of this we do not know for certain whether or not the shellmound was formed on a mangrove mud substrate, as we know is the case for the El Chorro shellmound, a site located 1.60 km from Tlacuachero that has a similar depositional history. Likewise, we do not know for certain the nature of the deepest deposits at the site, but there is reason to think they are unconsolidated shell beds. Obviously, the age of these deepest deposits is undetermined.

Floor 3

In the central part of the site where we conducted the 2009 excavations, the lowest bedded shell deposits are overlain by a layer of fine sediment visually resembling clay (but see Chapter 5) that the field archaeologists have designated Floor 3. As discussed by Thakar in Chapter 4, this floor was found in only one test pit (Unit N1W1) at the site, which means that we have extremely limited information about it. In most of our large lateral excavation, we did not excavate below the floors positioned above the level of Floor 3, but in all the locations where we did excavate below the overlying floors (see Figure 4.1), the third floor was not present. A detailed discussion of this situation is presented in Thakar's Chapter 4.

Floor 3 consists of a matrix of well-sorted, fine, reddish-brown sediment. The sediment is unbedded and contains inclusions of shells, a few pebbles, and some bones. This is the only location in any of the floors where we observed stream-rolled pebbles. The stratum varies in thickness between 6 cm and 18 cm,

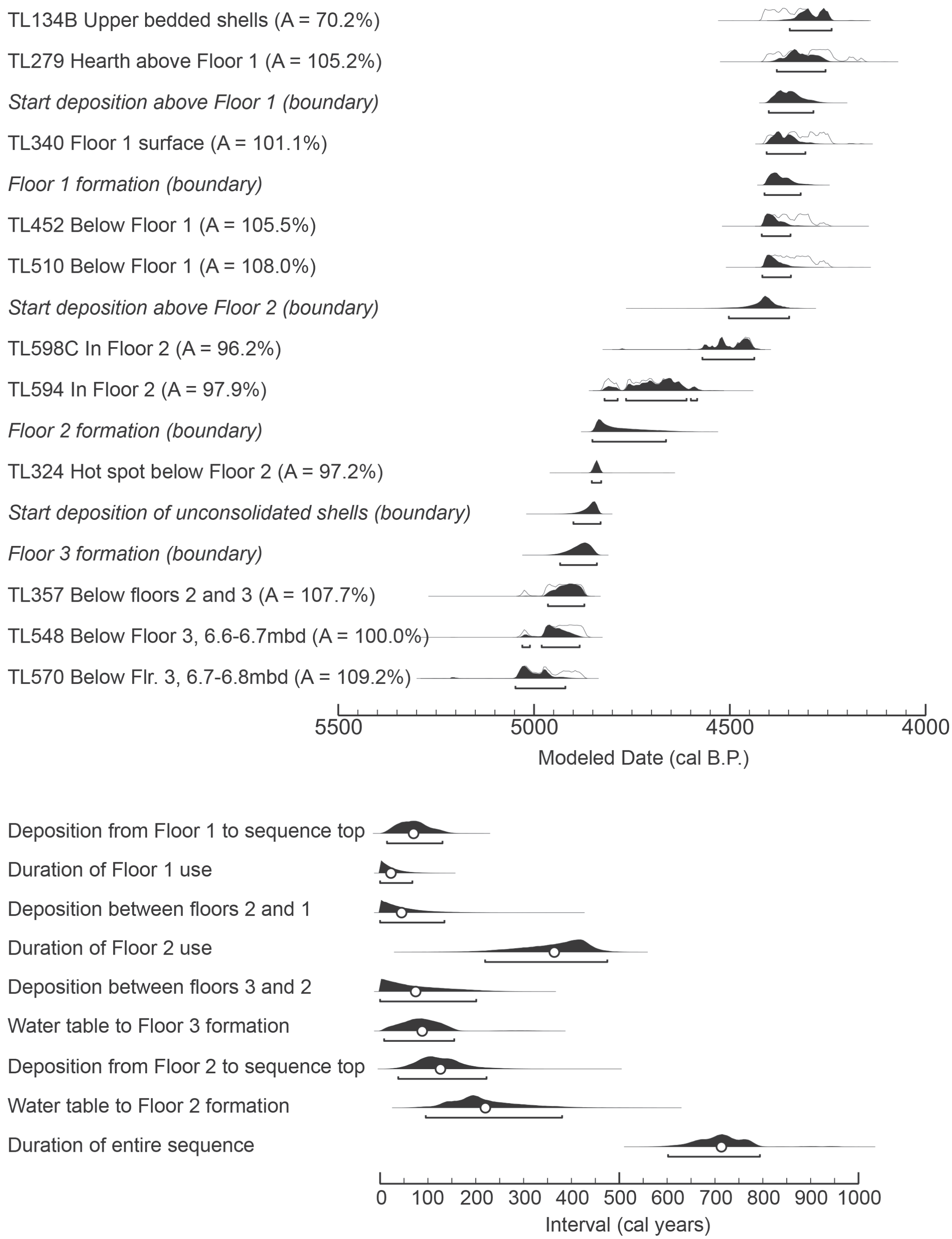


Figure 2.3. Modeling results showing probability distributions of modeled dates (top) and intervals (bottom) from Tlacuachero. Prior distributions (routine calibration) are shown in outline and posterior distributions (modeled) are solid. Agreement indices (A) for individual calibrations are statistical measures of the correspondence between the prior and posterior distributions. Values below a critical value (A′c) of 60 percent indicate that the stratigraphic assumptions of the model may be in error and need to be reassessed. Open circles represent the weighted mean for the interval distributions following Telford et al. (2004) (illustration by Brendan J. Culleton).

judging from the excavator's drawing of the four walls of Unit N1W1 (Figure 1.7). As can be seen in Figure 1.7, the upper contact of Floor 3 is a relatively flat horizontal plane, whereas the lower contact is irregular. However, the 4 m^2 surface area exposure of Floor 3 is interrupted by patches of clamshells and other irregularities (Figure 4.10). The lower contact of Floor 3 rests directly upon a stratum of whole clamshells within a matrix of fine sediment. We know so little about this stratum that we cannot determine with confidence whether or not it should be considered a separate floor (for example, Floor 4); it was not deemed a separate floor by the unit excavator. It is possible that the fine sediment simply percolated downward from Floor 3 into the underlying stratum of whole clamshell valves after the floor was created. This is the current interpretation, admittedly based on limited evidence.

Floor 3 is estimated to have been created sometime between 4935 and 4835 cal B.P. by treating it as a boundary between the lower bedded shells and the overlying unconsolidated shells. For modeling purposes, the boundary command here proposes an undated event, the formation of Floor 3, and treats it as a practically instantaneous event (that is, completed in one year) rather than a time-transgressive process of accretion.

Unconsolidated Shells Separating Floors 2 and 3

Overlying Floor 3 is a single bed of unconsolidated marsh clam shells that are mainly unbroken and unburned. This stratum varies in thickness (Figure 2.2) but is generally 10 to 20 cm thick. It is unbedded and internally homogeneous. Because of this, it appears to have been laid down as a single event. Like other similar strata at the site, it contains small flecks of charred plant material throughout the matrix of shells. Assuming it is a single event, the modeled age of sample TL324 dates the deposit at 4855 to 4825 cal B.P. If considered as a more gradual accumulation, the *interval* command estimates a duration of shell deposition between Floor 3 and Floor 2 (each modeled as boundaries) between zero and 205 cal years, with an average of 75 cal years.

Floor 2

Floor 2 overlies this stratum of unbroken marsh clam shell valves. The floor has a matrix of fine, well-sorted, reddish-brown sediment that resembles clay, which contains inclusions of shell and occasional small bones. It is unbedded and varies in thickness from only a few centimeters in limited places to 20 cm in other locations. Usually, however, it is about 10 cm thick. In general, the upper contact of the floor was more uniformly level than its lower contact. It should be noted that this lower contact of Floor 2 was exposed only in Unit N1W1, despite the fact that the floor surface was exposed over a much larger area.

The formation date of Floor 2 is estimated as 4855–4660 cal B.P. by treating it as a boundary constrained by TL324 below it and two charcoal samples collected from the surface of Floor 2 (TL594 and TL598). Both of these samples are from floor matrix samples obtained from the surface of the floor (see Chapter 4) for the primary purpose of obtaining information about the floor's characteristics. The two dates differ in age by about 200 cal years or more (TL594: 4820–4580 cal B.P., TL598: 4570–4435 cal B.P.), but it is notable that they are each consistent with the sequences of dates below and above Floor 2, respectively. This suggests a pause in shell accumulation for an extended period after Floor 2 was created. Modeling two boundaries that constrain the actual use of Floor 2—the formation of Floor 2 and the resumption of shell deposition above Floor 2—it would have been exposed for an interval of 210 to 480 cal years after its formation.

Unconsolidated Bedded Shells

As mentioned above, a boundary representing the onset of shell deposition above Floor 2 was modeled to help constrain the period of that floor's use. It suggests that the stratum of unconsolidated bedded shells was initially deposited between 4510 and 4340 cal B.P. Two dates were obtained from samples taken immediately below Floor 1 at a location where Floor 2 was not present. These samples are not in direct vertical position compared to the dated samples at lower elevations that we have discussed so far, which means that the previous modeling assumption that they are in sequential chronological order (Kennett et al. 2011) may in fact be unwarranted. Here we take the more conservative approach of modeling the two dates within a phase, which makes no assumptions about their order within the bedded shells. Having said that, running parallel versions of the current model—one assuming stratigraphic order (a sequence) and one not assuming any order (a phase)—produces

nearly identical results for the strata of interest, indicating that the model is not particularly sensitive to prior assumptions about these two dates.

Sample TL452 comes from Unit S1E1, where Floor 1 is underlain by unconsolidated bedded shells and Floor 2 is not present. The charcoal sample was collected from a small excavation unit that penetrated Floor 1 where it was dispersed in the unconsolidated shell layer. Sample TL510 is also from dispersed charcoal recovered from shell underlying Floor 1, in this case from Unit N1W2. At 2-sigma, the unmodeled calibrated dates for these samples are essentially identical: TL452, 4420–4255 cal B.P.; TL510, 4415–4250 cal B.P. Modeling suggests that the deposit of shells accumulated over an interval lasting from zero to 135 years.

Floor 1

Floor 1, the uppermost of the three floors, consists of a matrix of tan, well-sorted, fine sediment resembling clay with inclusions of molluscan shell and some bones. This floor has a level upper surface, but its lower contact is irregular in the areas where it overlies shell deposits, as in the south-central portion of the lateral excavation (Unit S3E0) and to a lesser extent in the northwest, as in Unit N3E2, where a layer of shell lies between floors 1 and 2. In the western portion of the lateral excavation, Floor 1 directly overlies Floor 2 where it is relatively thin and has a more regular lower contact. The thickness of this floor varies greatly. It is generally about 4 to 10 cm thick where it directly overlies Floor 2, but in some places in the northeast area it is 15 cm or more in thickness. Voorhies (2004:52–54) has noted previously that it appears that the agents of formation of Floor 1 made no effort to level the shell deposits when the floor was created over them; rather they were concerned only with producing a flat-lying upper surface.

The formation of Floor 1 was defined as the upper boundary for the unconsolidated bedded shells below it, and the floor is estimated to have been created between 4415 and 4320 cal B.P. One dated sample (TL340) comes from a hot spot resting on the surface of Floor 1. Constrained by the deposition of shells above it (see below), the modeled calibrated age of TL340 is 4410–4305 cal B.P., and the interval during which Floor 1 could have been occupied ranges from zero to 70 cal years.

Uppermost Unconsolidated Bedded Shells

After the formation of Floor 1 in the central part of the site and after the hot spot represented by sample TL340 was created on its surface, deposition of bedded marsh clam shells resumed. Modeled as a boundary, this is estimated to have occurred between 4405 and 4285 cal B.P. A new date, acquired subsequent to the Kennett et al. (2011) study, was run on charcoal from an informal fire feature embedded in the shell deposits overlying Floor 1(TL279). The sample came from within the 3.8- to 4-m excavation level at about 4 m. This sample, along with a sample obtained from near the top of the exposed section of bedded marsh clam shells at a depth of 1 m (TL134B), was used to date the uppermost section of bedded shells at the site center. The two dates were placed within a sequence (that is, in stratigraphic order), and since TL134B was near the top of the bedded shells, that date was used as a terminus post quem for the overall sequence using the before command (known as TPQ in earlier versions of OxCal). TL279 has a modeled age of 4380–4255 cal B.P., and TL134B dates to 4350–4240 cal B.P. This last burst of shell accumulation, resulting in approximately 3 m of shell, spans 15 to 135 cal years at 4405–4240 cal B.P.

Summary

The earliest shell deposits at the Tlacuachero shellmound are currently beneath the water table and have not been directly AMS ^{14}C dated, but we can infer from the lowest dates in this sequence (at 6.7 to 6.8 m below datum) that deposition started before about 5005 cal B.P., taking the weighted mean modeled age of TL570 (Figure 2.4). The next 2.4 m of unconsolidated bedded shell accumulated over 10 to 160 cal years before being capped by the formation of Floor 3 between 4935 and 4835 cal B.P. After an interval of the use of Floor 3 and the accumulation of 10 to 20 cm of bedded shell that spanned zero to 205 cal years (μ: 75 cal years), Floor 2 was laid down between 4855 and 4655 cal B.P. The broad age estimate is due to the long period between the floor's formation and eventual burial by the subsequent stratum of bedded shells. We estimate that activities carried out on Floor 2 occurred over the course of 220 to 475 cal years, representing the most prolonged break in shell accumulation in the Archaic deposits at Tlacuachero.

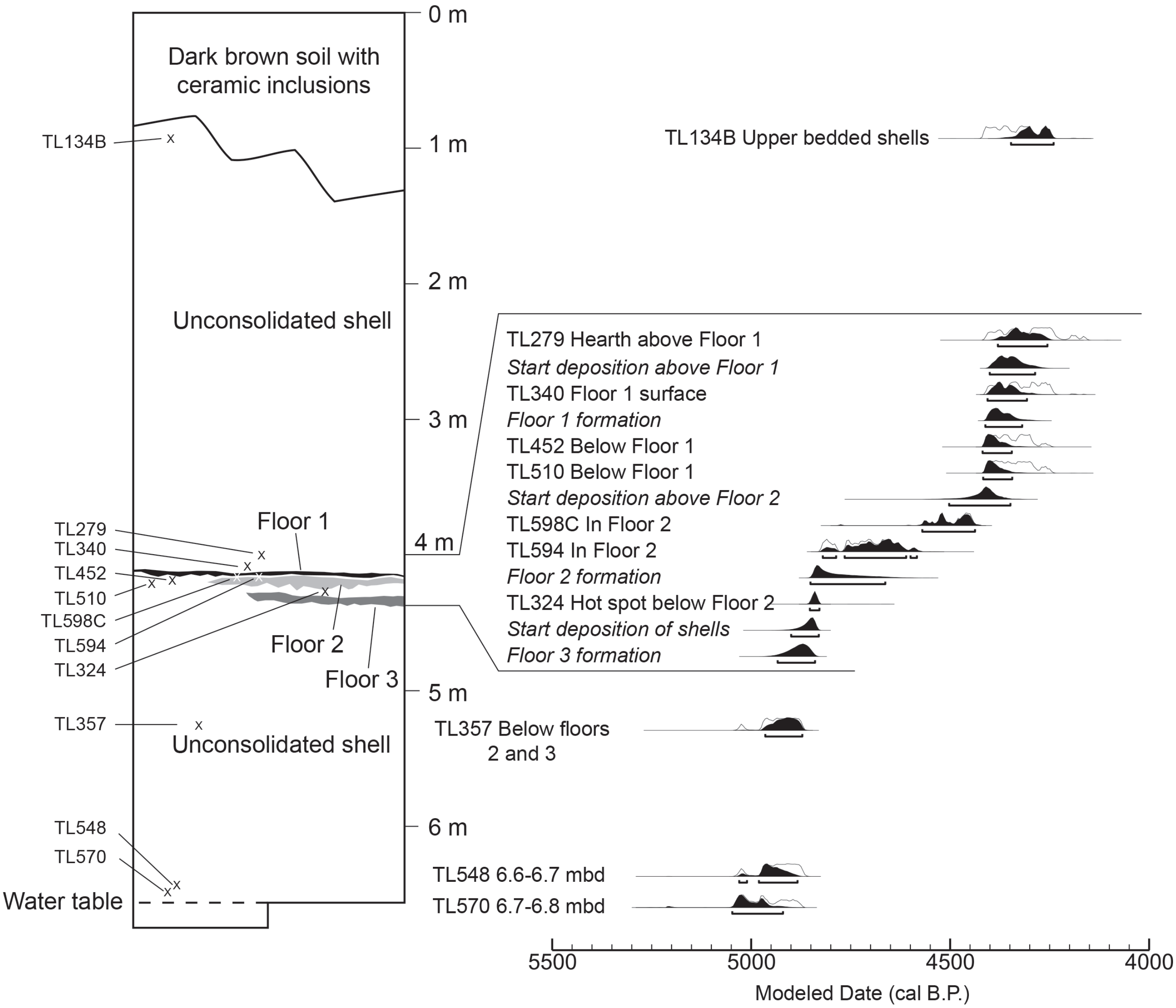


Figure 2.4. OxCal modeling results scaled to the stratigraphic section at Tlacuachero. The locations for all samples analyzed are plotted on the stratigraphic section and keyed to the probability distributions to the right of the profile (illustration by Brendan J. Culleton).

Shell deposition resumed between 4505 and 4350 cal B.P., producing the stratum of unconsolidated shells over as much as 135 cal years (μ: 45 cal years), until the formation of Floor 1 at 4415–4320 cal B.P. Floor 1 was used for up to 70 cal years (μ: 25 cal years) before the uppermost stratum of unconsolidated shells began to accumulate between 4405 and 4285 cal B.P. This uppermost Archaic section of the Tlacuachero mound accumulated over an interval of 15 to 135 cal years, with a mean likelihood of 70 cal years.

Deposition from the lowest dated level above the water line to the top of the Archaic shell deposits comprises a period of 605 to 795 cal years, which, as noted above, includes a period of use of Floor 2 of 220 to 475 cal years, when no shell accumulated at this location. Accretion of the shellmound from the current water table to the formation of Floor 2 occurred over 95 to 385 cal years, and accretion after Floor 2 was buried occurred during a period of 35 to 230 cal years.

References Cited

Beverly, R. K., W. Beaumont, D. Tauz, K. M. Ormsby, K. F. von Reden, G. M. Santos, and J. R. Southon
2010 The Keck Carbon Cycle AMS Laboratory, University of California, Irvine: Status Report. *Radiocarbon* 52:301–309.

Bronk Ramsey, Christopher
2009 Bayesian Analysis of Radiocarbon Dates. *Radiocarbon* 51:337–360.

Kennett, Douglas J., Brendan J. Culleton, Barbara Voorhies, and John R. Southon
2011 Bayesian Analysis of ^{14}C Dates from a Prehistoric Mexican Shellmound. *Radiocarbon* 53:245–259.

Michczyński, Adam
2007 Is It Possible to Find a Good Point Estimate of a Calibrated Radiocarbon Date? *Radiocarbon* 49:393–401.

Reimer, P. J., M. G. L. Baillie, E. Bard, A..Bayliss, J. W. Beck, P. G. Blackwell, C. Bronk Ramsey, C. E. Buck, G. S. Burr, R. L. Edwards, M. Friedrich, P. M. Grootes, T. P. Guilderson, I. Hajdas, T. J. Heaton, A. G. Hogg, K. A. Hughen, K. F. Kaiser, B. Kromer, F. G. McCormac, S. W. Manning, R. W. Reimer, D. A. Richards, J. R. Southon, S. Talamo, C. S. M. Turney, J. van der Plicht, and C. E. Weyhenmeyer
2009 IntCal09 and Marine09 Radiocarbon Age Calibration Curves, 0–50,000 Years Cal BP. *Radiocarbon* 51:1111–1150.

Stuiver, Minze, and Henry A. Polach
1977 Discussion: Reporting of ^{14}C Data. *Radiocarbon* 19:355–363.

Telford, R. J., E. Heegaard, and H. J. B. Birks
2004 The Intercept Is a Poor Estimate of a Calibrated Radiocarbon Age. *The Holocene* 14:296–298.

Voorhies, Barbara
2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

Chapter 3

Dating the Tlacuachero Post-Archaic Deposits: Ceramic Analysis

Heather B. Thakar

In this chapter I discuss the ceramics that we recovered from the upper formation during the 2009 excavations. The purpose of this analysis of ceramics is to determine the age and possible function of the post-Archaic occupation at Tlacuachero. The analysis relies on typological comparison with known ceramic sequences and vessel assemblages from nearby sites. I rely on seriation of the ceramic types to assess the chronological association of excavated post-Archaic deposits. The ceramic-bearing post-Archaic deposits excavated in 2009 are not associated with any architectural features or other significant artifacts useful for cross dating or assessing site function.

Previous analysis of ceramic material excavated from Tlacuachero in 1973 documented numerous reversals in sherd chronological and stratigraphic rank order (Voorhies 1976). However, the relatively small size of the 1973 ceramic assemblage and the limited availability of comparative sherd chronologies allowed only a tentative assessment (Voorhies 1976:136). This prior finding for mixed deposits postdating the Archaic period deposits is reconsidered here based on new ceramic materials from the recent excavation at Tlacuachero.

There have been no previous attempts to ascertain site function during post-Archaic occupation at Tlacuachero. Our knowledge of this occupation is limited to acknowledgement of earthen mounds and ceramic-bearing deposits that cap the Archaic shell-mound. This analysis augments these baseline data through consideration of changes in primary vessel forms associated with each temporal period. This provides an assessment of variation in vessel function during the post-Archaic.

Using both Ford's (1972 [1962]) method of seriation and multidimensional scaling, I determine that after the Archaic, the Tlacuachero island was most intensively occupied during the Middle to Late Preclassic and Early Classic periods, but with minor contributions from the Early Preclassic and Postclassic periods. However, extensive mixing of the deposits precludes finer-grained chronological determination.

Based on the relative distribution of vessel forms (following Lesure and Rodríguez López 2009:138), I identify a shift from serving vessels (open dishes and bowls) to storage vessels (jars) moving from the Preclassic assemblages to the Early Classic assemblages. This may imply stylistic changes, long-term regional trends in the composition of vessel form assemblages, and the possibility of changes in site function during the Preclassic to Early Classic transition.

Sample Collection and Context

All the stratigraphic and ceramic data used in this chronology come from the 2009 excavation of three new units at Tlacuachero: S2W1, N1W2, and N2E1. These were the only areas where we excavated intact ceramic-bearing deposits during the most recent investigations at the site.

As mentioned, units S2W1, N1W2, and N2E1 were excavated in 20 cm arbitrary levels from the ground surface to the level of the floors. In Unit S2W1, ceramic-bearing cultural deposits continue to a depth of 3.2 m below the site datum, but with 95 percent of all the ceramic materials occurring above 2.2 m below the site datum. In units N1W2 and N2W1, ceramic-bearing cultural deposits terminated at 2.2 m below the site's reference points. In all three units the ceramic-bearing upper mantle is consistent with previous descriptions of Stratum A, which is a dark, organic-rich, unbedded, and unconsolidated soil with constituents of mixed temporal association due to anthropogenic and animal disturbance. (See Chapter 1 for further discussion of the specific taphonomic factors that are implicated.)

Although spatially varied, the overall density of ceramic fragments encountered during the 2009 excavation at Tlacuachero was quite high. Therefore, during excavation the field crew focused specifically on the recovery of rim and decorated body sherds, which are the most informative for determination of ceramic type or vessel form. The analyzed ceramic assemblage recovered from these contexts consists of 1,776 rim and decorated body sherds.

Ceramic Typological Comparison

The primary goal of this analysis is to identify which time periods are represented by the post-Archaic cultural deposits at Tlacuachero. A detailed account of the ceramic types has been reported previously in a technical report (Voorhies 2011). Most of the ceramic types and forms are also discussed and illustrated in Voorhies 1976. I provide here a brief summary of the most salient characteristics, forms, and chronological comparisons that provide the foundation for subsequent seriation and function analyses.

I constructed a preliminary ceramic typology by sorting the sherds into categories based on their similar attributes. These attributes are paste characteristics (the nature and size of inclusions; color; hardness and thickness), vessel forms, and surface treatment (slip, decoration). Then I constructed a chronology of these sherd classes through systematic comparison with known ceramic sequences from the broader region. To do this I relied on ceramic chronologies developed by archaeologists working in nearby areas, particularly those in the comparative collections of the New World Archaeological Foundation curated in San Cristóbal de las Casas, Chiapas. I also consulted related publications. These comparative assemblages provided the baseline for establishing the ceramic chronology at Tlacuachero.

The majority of the 24 ceramic types I identified correspond to those identified in the ceramic assemblage from Voorhies's 1973 excavation at Tlacuachero (Voorhies 1976:109–138). However, since this early assessment of the ceramic assemblage at Tlacuachero, much more field research has been conducted, and researchers have refined local ceramic sequences. More recently published ceramic chronologies from the Upper Grijalva Valley and the Soconusco, particularly at Chiapa de Corzo and Izapa, respectively, provided fine-grained ceramic seriations from unmixed contexts that I used to chronologically situate the 2009 ceramic assemblage from Tlacuachero (see Bryant et al. 2005; Lowe et al. 1982; Paillés H. 1980; Pfeiffer 1983).

More than three-quarters of the total ceramic assemblage (1,397 ceramic fragments) compare favorably with known ceramic types that are considered temporally diagnostic. This comparative evidence indicates the presence of ceramic material from the Middle Preclassic period through the Early Classic period, with minor contributions from the Early Preclassic (represented by one Barra phase sherd) and Postclassic (represented by three sherds) periods. Previous assessment of ceramic assemblages from Tlacuachero provided a strong indication of Middle Preclassic and Late Preclassic occupation of the site. In the 1973 excavation assemblage from Tlacuachero, roughly 25 percent of all temporally sensitive ceramic materials were associated with the Late Preclassic, based on the comparative collections and publications available at the time (Voorhies 1976:Table 24). Despite some revision to chronological attributions of specific ceramic types, I documented a similar proportion of Middle Preclassic and Late Preclassic ceramics in the 2009 excavation assemblage. More than one-third of the temporally diagnostic sherds (36.72 percent) in the 2009 Tlacuachero ceramic assemblage compare favorably with regional types securely associated to the Middle Preclassic and Late Preclassic periods (see Table 3.1).

Table 3.1. Chronological Attribution of Temporally Diagnostic Ceramic Types (and the Number of Sherds Associated with Each) Used in Construction of the Seriation Chart.

	Early Preclassic	Middle Preclassic	Late Preclassic	Proto Classic	Early Classic	Postclassic	Temporally Undiagnostic
Monte Incised	1						
Samaro Coarse		10					
Santa Rosa Polished Orange II		45					
Blackware II		152	X				
Burnished Gray		17	X				
Orange Fineware		41	X				
Bichrome II		6	X				
Brownware			96				
Black and Brown Bichrome			25				
Zoned Bichrome			6				
Black and Redware			12				
Santa Rosa Polished Orange I			103	X			
Blackware I				41			
Black over Brownware				31			
Carved Redware II					6		
Izapa 5					12		
Monkey-Vesselware (Izapa 6)					144		
Plainware: Fine (Izapa Jaritas)					401		
Kato Tripod					36		
Polychrome					2		
Dull Redware					207		
Plumbate						1	
Ventosa Gray						2	
Plainware: Coarse							369
Soconusco 76							11
Number of sherds by period association	1	271	242	72	808	3	380
Percent of all sherds by period association	0.06%	15.25%	13.62%	4.05%	45.67%	0.17%	21.39%

Note: Detailed type descriptions are presented in Voorhies (1976, 2011).

Early Preclassic Ceramic Types and Forms

A single unpolished, unslipped body sherd with incised crosshatched lines (Figure 3.1) was recovered from the lowermost ceramic-bearing deposit of Unit S2W1. This specimen corresponds well with Monte Incised tecomates found at Altamira (Lowe 1967:102–103) and previously described in the 1973 ceramic assemblage from Tlacuachero (Voorhies 1976:109, see also Figure 57d, Figure 57e). Thus this sherd is tentatively identified as Monte Incised and likely pertains to the Barra phase. This single body sherd provides the only evidence in the analyzed 2009 ceramic assemblage for Early Preclassic occupation at Tlacuachero. Due to the very small sample size, the Early Preclassic is omitted in the following seriation analysis.

Middle Preclassic Ceramic Types and Forms

The ceramic material from Tlacuachero associated with the Middle Preclassic period comprises a much greater percentage (19.40 percent) of the chronologically diagnostic assemblage than the ceramic material from the Early Preclassic. Several of the identified Preclassic ceramic types at Tlacuachero (Samaro Coarse, Santa Rosa Polished Orange II, Blackware II, Burnished Gray, Orange Fineware, and Bichrome II) appear throughout the larger region during the Middle Preclassic. This is not surprising, as the late Middle Preclassic was a time of cultural florescence in the Upper Grijalva Basin, the adjacent Central Depression, the Isthmus of Tehuantepec, and, most pertinently, the Pacific coast (Miller et al. 2005:262).

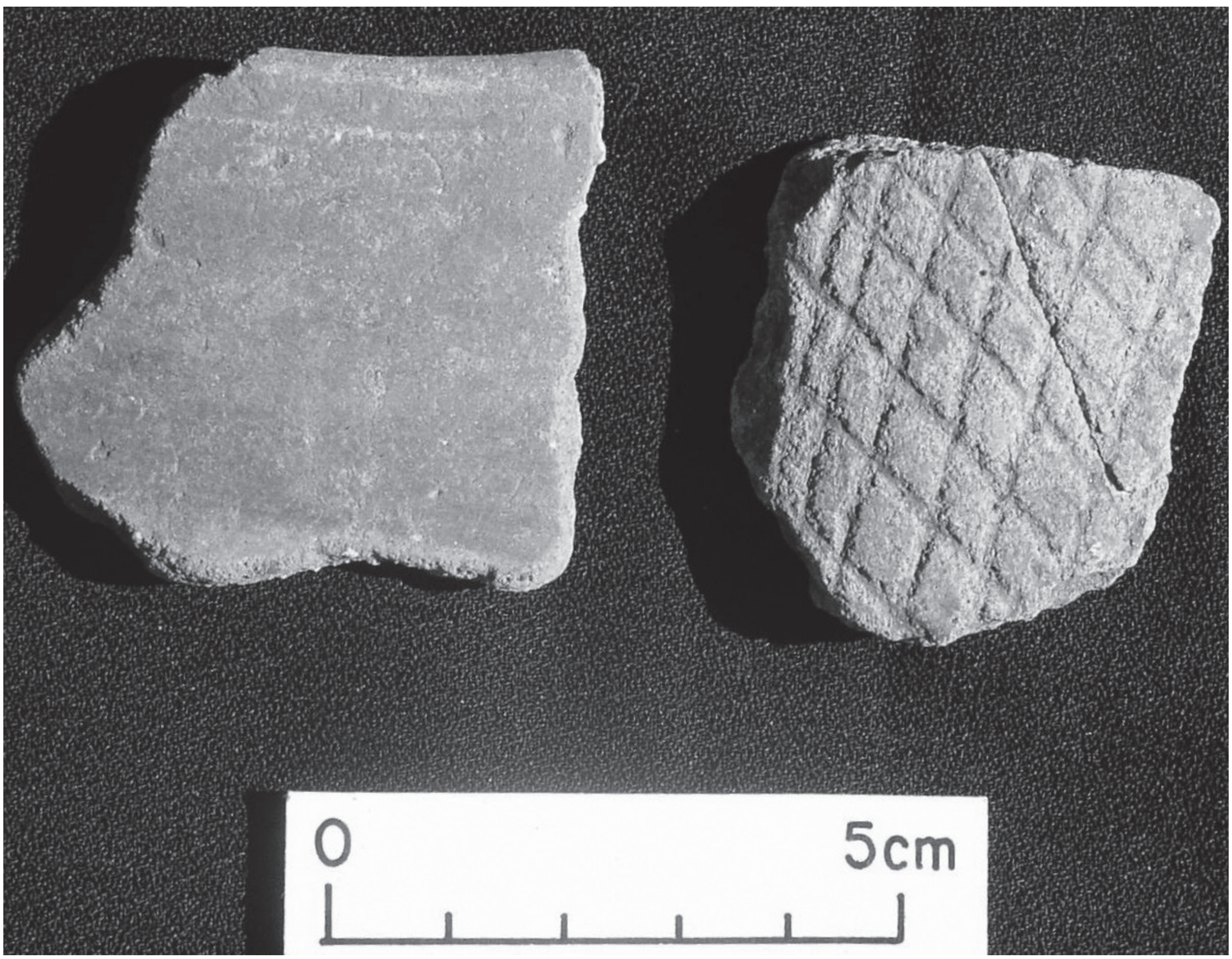


Figure 3.1. Photograph of two potsherds dating to the Preclassic period recovered at Tlacuachero in 2009. Left: a red-slipped tecomate rim sherd. Right: Monte Incised tecomate body sherd fragment (photograph by Barbara Voorhies).

Three distinct varieties of coarsely smoothed tecomates (see Figure 3.2) correspond well with the Samaro Coarse ceramic type pertaining to the early Middle Preclassic (Clark et al. 2005:92–98). The first variety (rims n = 1, 25 percent) is characterized by thick incurving walls, a rounded lip, and a horizontal ring of finger impressions imposed onto a thickened ridge below the rim. The second variety demonstrates a simple silhouette, incurving walls, and no exterior decoration excepting a slight groove immediately below the vessel mouth (rims n = 2, 50 percent). The third variety (rims n = 1, 25 percent) is distinguished by a rounded, exteriorly thickened lip and incurving walls encircled by a strip of finger impressions imposed on a raised modeled appliqué. These three varieties also correspond well, respectively, to the Variety 4, Variety 5, and Variety 6 Late Dunas phase tecomates found at Pampa El Pajón (Paillés 1980:55–59, figures 31–33) as well as with Dili phase tecomates at Chiapa de Corzo (Dixon 1959:33–34, Figure 42).

Santa Rosa Polished Orange II appears closely related to Polished Orange at Santa Rosa (Brockington 1967:10–11), hence its name. Voorhies previously identified and illustrated this ceramic type in the 1973 assemblage from Tlacuachero (Voorhies 1976:114, Figure 62). Santa Rosa Polished Orange II also compares favorably in paste, decoration, and form with type collections of Mundet Red: Grooved Variety from Santa Marta Rosario and Chiapa de Corzo. This type is widespread in the Upper Grijalva Valley throughout the Middle Preclassic (Miller et al. 2005:215–216). Similar to collections from San Isidro in the Middle Grijalva Valley, the Polished Orange II ceramics are decorated with parallel concentric rings around the superior surface of wide-everted rims. The high percentage of wide-everted rim dishes (rims n = 29, 90.63 percent) with flat bottoms also strongly suggests a late Middle Preclassic or early Late Preclassic chronology, as there is an apparent retraction of this particular form during the Late Preclassic (Miller et al. 2005:229).

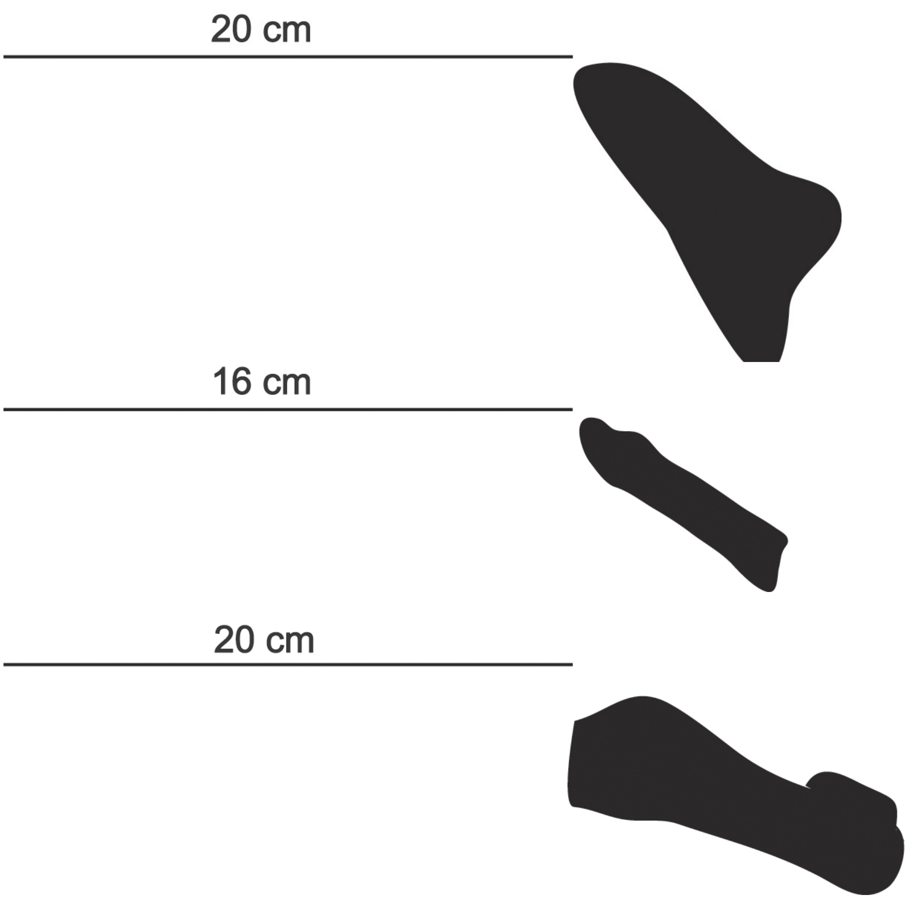


Figure 3.2. Rim profiles of Samaro Coarse tecomates recovered from Tlacuachero in 2009: (a) Variety 1; (b) Variety 2; (c) Variety 3 (illustration by Heather B. Thakar).

Blackware II was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies 1976:120, figures 66 and 67. The thick, polished, waxy black-slipped surfaces with brown hues of Blackware II compare favorably with the Middle Preclassic Libertad Black-brown ceramic group from the Upper Grijalva Valley (Miller et al. 2005:179–196) and with Polished Blackish Brown from Santa Rosa (Brockington 1967:8–9). Similar ceramics have also been found in large quantities at Chiapa de Corzo and Santa Marta Rosario. Miller et al. indicate that these collections all fall neatly within the expected variation of the Libertad ceramic group (2005:185). The small jars with out-sloping necks and globular bodies (rims n = 66, 58.93 percent) and the dishes with narrow-everted rims (rims n = 33, 29.46 percent) that characterize the ceramic type at Tlacuachero are also characteristic of the Libertad Black-brown: Libertad and Groove-Incised varieties (Miller et al. 2005:180, 187). This tradition was well developed at La Libertad by the beginning of the Middle Preclassic Enub-Foko phase (Miller et al. 2005:263) and is likely antecedent to later mottled black-brown and incised types, including some of the Twixt, San Jacinto, and Sibak groups (Miller et al. 2005:185).

Burnished Gray compares favorably in many aspects of paste and incised decoration with Blackware II. However, what we classify as Burnished Gray lacks any slip or polish. While this may be due to erosion of the surface, we cannot be certain. The small jars with short out-sloping necks and globular bodies (rims n = 2, 16.67 percent) and the wide-everted rim dishes (rims n = 9, 75 percent) that characterize the Burnished Gray assemblage at Tlacuachero are identical to the equivalent Blackware II forms. Thus we classify Burnished Gray alongside Blackware II and the other Middle Preclassic materials.

Classification of Orange Fineware has proven difficult. Intensive searching of the comparative collections available at the New World Archaeological Foundation provides few satisfactory comparisons. There is some resemblance to modeled examples of Polished Reddish Brown types recovered at Santa Rosa (Brockington 1967:10, Figure 10g); however, specimens from Tlacuachero typically have thinner walls and are harder fired. Two Eschalón sherds labeled Chumate from the Costa Pacífica de Chiapas collection are identical in color and paste to the sherds described for Orange Fineware. However, dozens of other Eschalón sherds labeled Chumate in this collection were significantly heavier and coarser and lacked decoration. There is also resemblance to Foko phase Mundet Red ceramic varieties (particularly the incised and modeled varieties) in the Upper Grijalva region comparative collection. Similar modeled zoomorphic designs on the superior surface of wide-everted rim dishes (rims n = 9, 47.37 percent), small rounded bowls with medial flanges (rims n = 1, 5.26 percent), and cylindrical vessels with vertical walls and direct rims (rims n = 4, 21.05 percent) appear in this collection (Miller et al. 2005:221, see also figures 3.30b, 3.40, 3.44a, 3.44i, 3.45b). However, despite these favorable comparisons at Tlacuachero, the overall quality of the sherds appears somewhat higher (harder and thinner). At Mirador, Peterson (1963:12–16) indicates that some early examples of the Orange-Red pottery had a harder, better polished, and slightly browner slip—more comparable to the sherds in the Tlacuachero assemblage. Miller et al. include Orange-Red pottery from Mirador as a variety of the Mundet ceramic group (2005:220). This suggests that the Orange Fineware identified at Tlacuachero may indeed be within the expected variation subsumed by the Middle Preclassic Mundet ceramic variety. However, similarly modeled wide-everted rim margins increased in importance at Chiapa de Corzo and Mirador during the Late Preclassic (Miller et al. 2005:224). Thus, although this type was widespread during the Middle Preclassic, it remains unclear whether the presence of this ceramic type reflects Middle or Late Preclassic occupation at Tlacuachero.

Bichrome II was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:132, Figure 76). Rims of unidentified simple silhouette vessels (n = 6, 100 percent) are painted with white and red specular hematite on the outside of the vessel. A white band is located along the exterior of the rim, and the rest of the vessel below is painted red on all six specimens recovered in the 2009 assemblage. The interior of the vessel is smoothed but unpainted. Voorhies (2005:132) suggests this ceramic type is Late Preclassic or Early Classic based on personal communication with Gareth W. Lowe. However, Bichrome II compares favorably to the Middle Preclassic type Dava Red-and-white: Dava Variety in key identifying attributes, particularly paste, finish, and form (see Miller et al. 2005:117–120). Bowls with thin, slightly incurved walls (rims n = 2, 33.33 percent), with a band of red

along the exterior of the direct rim and with white slip below, are the only identifiable form in the Tlacuachero assemblage. Similar red-on-white bichromes are reported from southeastern Mazatán and the adjacent Pacific coast of Guatemala (Miller et al. 2005:120) during the Middle Preclassic. It is possible that the six Bichrome II sherds recovered from Tlacuachero represent a Middle Preclassic occupation; however, I regard this association as tentative.

Late Preclassic Ceramic Types and Forms

The ceramic material from Tlacuachero attributed to the Late Preclassic comprises a similar percentage (17.32 percent) of the chronologically diagnostic assemblage as the ceramic material associated with the Middle Preclassic. The vast majority of the Late Preclassic ceramic assemblage (associated with Brownware, Brown and Black Bichrome, Zoned Bichrome, Black and Redware, and Santa Rosa Polished Orange I) recovered from Tlacuachero is closely related to an earlier Middle Preclassic type. Indeed, three ceramic types (Blackware II, Burnished Gray, and Orange Fineware) primarily associated with the Middle Preclassic may continue in use through the Late Preclassic period. There appears to be fair amount of continuity in ceramic types and vessel form throughout the Preclassic.

Brownware was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:112, Figure 60). This ceramic type is very similar to Blackware II in paste, form, and decoration. The thick, polished, waxy slipped surfaces of both types differ principally in color. Brownware is a rich chocolate brown, whereas Blackware II is black. In both color and form, Brownware from Tlacuachero compares more favorably with Middle Preclassic Polished Brown from Mirador than with Libertad Black-brown (Peterson 1963:12–14, Figure 12). Dishes with wide-everted rims and out-slanting walls (rims n = 63, 85.16 percent) and bowls with direct slightly out-curved or out-flaring walls (rims n = 9, 12.16 percent) constitute the primary forms of Brownware recovered at Tlacuachero and a "special variety" of Polished Brown (Peterson 1963:12). These vessel forms, as well as the more complex grooved and incised decorations associated with the assemblage from Tlacuachero, suggest a strong affinity with Late Preclassic Twixt Brown assemblages from the Upper Grijalva Valley (see Bryant and Clark 2005:274–277). The relationship between Brownware and Blackware II is evident. However, it is likely that Brownware is chronologically later than Blackware II and reflects a Late Preclassic occupation at Tlacuachero.

Brown and Black Bichrome is similar in color to Brownware on one surface and slipped black on the obverse. Plates with wide-everted rims and out-slanting sides (rims n = 2, 40 percent) and simple-silhouette bowls with direct rims (rims n = 2, 40 percent) constitute the primary vessel forms in the small assemblage recovered from Tlacuachero. These ceramic types were identified previously in the 1973 assemblage at Tlacuachero and are described in Voorhies (1976:120). Voorhies (2004:120) indicates that this ceramic type dates to the Late Preclassic period.

The Zoned Bichrome ceramic type was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:112, Figure 59). Rims of a flat-bottom dish with out-slanting walls (rims n = 2, 66.66 percent) and a simple-silhouette bowl or cylindrical vessel (rims n = 1, 33.33 percent) are represented among the few sherds attributed to this ceramic type. Voorhies (1976:112) noted similarities between the zoned bichromes found at Tlacuachero and zoned bichromes recovered from Late Preclassic deposits at Perseverancia on the Pacific coast of Chiapas. Bryant and Clark (2005:280) indicate that the incised zoned specular red on the burnished unslipped type at La Perseverancia is similar to Late Preclassic Utatlán pottery from the Guatemala highlands and the Utatlán Dichrome-Incised variety identified in the Upper Grijalva Basin.

Black and Redware ceramics are primarily distinguished as bichrome vessels with polished black and red surfaces. Vessel exteriors are slipped red and vessel interiors are slipped black. The black interior surface is well polished with a high luster. The entire assemblage consists of flat-bottom dishes of varying height with out-slanting walls (rims n = 6, 60 percent), dishes or bowls with out-slanting walls and a labial flange (rims n = 2, 20 percent), and dishes or bowls with out-slanting walls and a slightly everted rim (rims n = 2, 20 percent). Decoration is limited to one or two grooved lines just below the lip on the exterior of the vessel and/or a single incised dashed line on the interior of the vessel lip. This ceramic type was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:120) as a Late Preclassic ceramic type.

Santa Rosa Polished Orange I was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:109, Figure 58). The characteristic thick, polished, waxy black slip heavily mottled with orange diagnostic of this type compares favorably with Sibak Mottled-incised ceramics from Ojo de Agua and El Cerrito (Bryant and Clark 2005:325). In both collections, the color of the black slip is intergraded with distinctive reddish-yellow mottling that appears to have been intentionally caused. Bowls or dishes with out-sloping walls and wide-everted rims (rims n = 45, 65.23 percent) and small bowls with incurved walls (rims n = 4, 6.15 percent) common in the Tlacuachero assemblage are also a well represented form of Sibak Mottled-Incised. Bryant and Clark (2005:325) indicate that this ceramic type is characteristic of pottery dating to the Late Preclassic/Protoclassic period. However, it must be noted that there appears to be great continuity between Blackware II (Libertad Black-brown), Brownware (Twixt Brown-incised), and the ceramic type Polished Orange I (Sibak Mottled-incised). There appears to be continuity between these forms.

Protoclassic Ceramic Types and Forms

The ceramic material from Tlacuachero associated with the Protoclassic comprises a relatively small percentage (5.15 percent) of the chronologically diagnostic assemblage. There is a clear association between ceramic types (Black over Brownware and Blackware I) of this temporal period and those of the Late Preclassic. This suggests decreased occupation at Tlacuachero during the Protoclassic relative to the preceding temporal period. This pattern was originally noted by Voorhies in the 1973 ceramic assemblage from Tlacuachero (1976:137) and is strongly affirmed in the 2009 ceramic assemblage from Tlacuachero (Voorhies 2011).

Black over Brownware was identified previously in the assemblage at Tlacuachero and is described in Voorhies (1976:114, Figure 61). Bryant and Clark (2005:338) identify Black over Brownware from Tlacuachero as a variety of the Protoclassic San Jacinto Black ceramic type. Dishes with wide-everted rims (rims n = 7, 38.89 percent), dishes with narrow-everted rims (rims n = 3, 16.67 percent), bowls with incurving walls (rims n = 1, 5.56 percent), and dishes or bowls with out-sloping sides (rims n = 7, 38.89 percent) constitute the primary forms identified in the Tlacuachero assemblage. The same forms are common in the San Jacinto Black ceramic type. Based on this comparison, it appears most likely that the presence of Black over Brownware indicates a Protoclassic occupation at Tlacuachero.

Blackware I compares favorably in form, paste, and decoration with Protoclassic Tabil Black: Incised ceramics from Ojo de Agua in the Upper Grijalva Valley. Voorhies identified and illustrated this ceramic type based on specimens recovered in the 1973 assemblage from Tlacuachero (1976:120, Figure 65). Bryant and Clark (2005:342) specifically note that two illustrated specimens of Blackware I from Tlacuachero provide a fine example of Tabil Black: Incised Variety. Flat-bottom dishes with narrow-everted rims (rims n = 15, 45.45 percent), squat thin-walled jars or bowls with out-sloping incised necks (rims n = 9, 27.27 percent), bowls with slightly out-sloping, almost vertical walls (rims n = 9, 27.27 percent) account for the identifiable forms in the Blackware I assemblage recovered from Tlacuachero in 2009. These comparisons seem to securely indicate the presence of a Protoclassic occupation at Tlacuachero. Bryant and Clark (2005:280) indicate that both Tabil Black (Blackware I) and San Jacinto (Black over Brownware) represent the final evolution of the Libertad (Blackware II) and Twist (Brownware) ceramic types that are dominate the Preclassic ceramic assemblage at Tlacuachero.

Early Classic Ceramic Types and Forms

By and large, the ceramic material from Tlacuachero is dominated by material associated with the Early Classic period (57.83 percent). There is a clear distinction between ceramic types (Carved Redware II, Izapa 5, Monkey-Vessel Ware, Plainware: Fine, Kato Tripod, Polychrome, and Dull Redware) of this temporal period and those of the Preclassic. The ceramic assemblage at Tlacuachero indicates a significant Early Classic occupation at Tlacuachero. This pattern was originally noted by Voorhies in the 1973 ceramic assemblage from Tlacuachero (1976:137) and is strongly affirmed in the 2009 ceramic assemblage from Tlacuachero (Voorhies 2011).

Carved Redware II was identified previously in the assemblage at Tlacuachero and is described in Voorhies (1976:124, Figure 69). Small shallow dishes slipped dark red and carved with geometric incisions (rims n = 3, 50 percent) and similarly decorated bowls with vertical walls and mammiform supports (rims n = 3, 50 percent) comprise the entire assemblage of Carved Redware II. This

vessel is similar, though not identical, to whole specimens recovered from Izapa (Jaritas phase Type 5; see also Lee 1973:Figure 3). Additional specimens, referred to here as the ceramic type Izapa 5, are identical in paste, form, and decoration to specimens in the type collection for Jaritas phase Type 5 at the New World Archaeological Foundation. These red-slipped small rounded bowls with incurving walls and incised geometric designs (rims n = 4, 100 percent) securely establish an Early Classic occupation at Tlacuachero.

Monkey-Vessel Ware was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:124, Figure 70). This ceramic type is dominated by large wide-mouthed jars with concave bases, rounded bodies, and constricted necks (rims n = 34, 80.95 percent). Decoration consists of a thin brownish red wash and incised designs identical to those found in the Jaritas phase Type 6-6 comparative collection (see also Lowe et al. 1982:144, Figure 7.19f).

Plainware: Fine was identified previously in the assemblage at Tlacuachero and is described in Voorhies (1976:124, Figure 70–71). This ceramic type is dominated by large wide-mouthed jars with concave bases, rounded bodies, and cambered rim necks (rims n = 165, 97.05 percent). Decoration consists of incised designs identical to those found in the Jaritas phase comparative collection from Izapa. Bryant and Clark (2005:330) include this type as a variety of the Late Protoclassic/Early Classic Entre Rios ceramic group.

The ceramic type Kato Tripod consists of flat-bottom dishes with flared walls, a low medial flange, and nubbin foot supports (rims n = 30, 100 percent). These tripod vessels are washed red; other decoration is minimal. These vessels are identical in paste, form, and decoration to tripod vessels in the Izapa Kato phase comparative collection at the New World Archaeological Foundation (see also Lowe et al. 1982:147, Figure 7.20h).

The Polychrome ceramic type consists of vessels of unknown form. The principal identifying attributes include a polished black-slipped interior and a well-smoothed, unslipped exterior painted in horizontal stripes of red, white, and black. Indistinct geometric and curvilinear designs are eroded and dull. This ceramic type was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:131) as an Early Classic ceramic type.

Dull Redware ceramics are generally smooth and are slipped reddish brown with a dull luster. The composition of these sherds includes a reddish-gray paste with a dark core and inclusions of very fine sand granules. Among the few identifiable forms are flat-bottom dishes (rims n = 13, 10.24 percent), large jars (rims n = 3, 2.36 percent), and shallow plates with out-slanting walls (rims n = 2, 1.57 percent). Decoration includes incised linear designs. This ceramic type was identified previously in the 1973 assemblage at Tlacuachero and is described in Voorhies (1976:116, Figure 64) as an Early Classic ceramic type.

Postclassic Ceramic Types and Forms

A single Plumbate body sherd representing an unknown vessel form is present in the 2009 ceramic assemblage. This single specimen of Tohil Plumbate represents the strongest evidence of Postclassic occupation at Tlacuachero in the collection under study. This sherd supports the previous finding by Voorhies (1976:132–133) of the presence of Tohil ceramics at the site, including a whole avimorphic vessel associated with a burial.

The only other ceramic type dating to the Postclassic period is represented by two thin-walled, small bowl fragments (rims n = 2, 100 percent). There is no evidence of decoration or slip of the hard-fired, smoothly polished gray paste. Voorhies (personal communication 2009) indicates that this ceramic type is Late Postclassic in age. Due to the very small sample size, the Postclassic material is omitted in the following seriation and form analysis.

Distribution and Function of Primary Vessel Forms

Three primary categories of vessel form can be readily distinguished based on the 782 rim fragments in the Tlacuachero assemblage: tecomates, dishes/bowls, and jars. Table 3.2 provides the relative distributions of vessel forms and expands on variation within each category. Some of the rim fragments (n = 160, 20.46 percent of the collection) were too small or damaged to ascertain vessel form; however, the remaining rim fragments (n = 622, 79.54 percent) conform to one of these three primary vessel forms. Although these broad categories obscure a fair amount of variation, respectively they correspond well to multipurpose, serving, and storage vessels. Lesure and Rodríguez López (2009:15) note that sites with all three vessel forms appear to reflect a full array of domestic activities.

The basic tecomate (neckless jar) form is a restricted-rim globular vessel that dominates late Early Preclassic assemblages throughout the Soconusco (Lesure and Rodríguez López 2009). This broad pattern is reflected in the ceramic assemblages at Los Cerritos and El Grillo, two Early Preclassic earthen mound sites in the same estuarine system as Tlacuachero (Kennett and Voorhies 2002; Kennett et al. 2007). At Los Cerritos, tecomates comprise 94.18 percent of the ceramic assemblage (Kennett and Voorhies 2002:20) whereas at El Grillo, tecomates comprise 81.37 percent of the ceramic assemblage (Kennett et al. 2007:21). Lesure and Rodríguez López (2009:118) characterize these utilitarian vessels as cooking pots and as multipurpose vessels for storage, transport, and preparation of foods and liquids (Lesure and Rodríquez López 2009:141). Morgan (2011:203) further suggests that highly versatile and transportable tecomates common throughout the region may have been particularly useful for seminomadic populations.

At Tlacuachero, where we have not found evidence of a significant Early Preclassic occupation, tecomates constitute a mere 3.73 percent of the Middle Preclassic rim assemblage and they are absent in the Late Preclassic, Protoclassic, and Early Classic assemblages. Decreased use of this vessel form at the end of the Early Preclassic is well documented throughout the region (Lesure and Rodríguez López 2009:142–144, figures 9.25 and 9.26). Thus the minimal presence of this vessel form in the Tlacuachero assemblage is consistent with regional diachronic trends and may suggest that Middle and Late Preclassic inhabitants of the Soconusco were considerably less mobile than their Early Preclassic predecessors.

The category of dishes and bowls subsumes a significant amount of stylistic variation (as reflected in Table 3.2). Indeed, this is typical throughout the region at sites dominated by dishes, where many varieties of vessel form and decoration are reported (Lesure and Rodríguez López 2009:15). However, I consider all the open vessels with unrestricted orifices to be serving vessels, following Lesure and Rodríguez López (2009:140). This vessel form comprises 54.04 percent of the Tlacuachero rim assemblage during the Middle Preclassic period, 97.9 percent during the Late Preclassic period, and 82.35 percent during the Protoclassic period. This pattern provides a strong indication that serving vessels were the dominant vessel form throughout the Preclassic occupation at Tlacuachero. The adoption, increasing abundance, and elaboration of this new form throughout the Preclassic occupation at Tlacuachero suggest a significant change in vessel function and possibly site function as well.

This shift is mirrored at Chiquiuitan, a multiple-earthen-platform mound site located within the Chiquimulilla coastal estuary in Guatemala. There, tecomates dominate ceramic assemblages throughout the Early Preclassic period, but this form drops off sharply during the Middle Preclassic period, when dishes and bowls constitute 83 percent of the assemblage (Morgan 2011:202). Morgan (2011:203) indicates that this shift in vessel form at Chiquiuitan correlates with additional evidence at the site of a shift from a more mobile to a more sedentary type of settlement. She further speculates that along with a growing demand for serving vessels, ceramics may have become a means for fulfilling a more social function, such as conferring status and/or prestige among people partaking of food.

However, contrary to expectations, at Tlacuachero the percentage of dishes/bowls drops to a mere 21.37 percent of the Early Classic rim assemblage. This significant decrease in the inferred serving vessels at Tlacuachero compared to the preceding Preclassic period suggests another possible change in site function.

Jars with short and tall necks of varying rim diameters and overall dimensions were likely associated with storage. At the site of El Varal on the Chiapas coast, Lesure and Rodríguez López (2009:140) document an expanded importance of jars (particularly low-necked ollas) at the end of the Early Preclassic. This expansion co-occurs with a decrease in the use of tecomates at the Chiapas coastal sites of both El Varal and Paso de la Amada. It is possible, at least in their early Middle Preclassic appearance, that low-necked jars take over some of the functions previously performed by tecomates, such as water storage (Lesure and Rodríguez López 2009:145).

At Tlacuachero, short-necked jars with globular bodies comprise 42.24 percent of the rim assemblage during the Middle Preclassic period, before dropping to a meager 1.4 percent during the Late Preclassic period and 17.65 percent during the Protoclassic period. This dramatic decrease in the relative importance of jars throughout the Preclassic is reversed in the Early Classic period, when wide-mouthed jars with constricted or chambered necks comprise 78.63

Table 3.2. Vessel Forms Represented in the Ceramic Assemblage by Ceramic Type.

Ceramic Type	Monte Incised	Samaro Coarse	Polished Orange II	Blackware II	Burnished Gray	Orange Fineware	Bichrome II	Brownware	Brown and Black Bichrome	Zoned Bichrome	Black and Redware	Polished Orange I	Blackware I	Black over Brownware	Carved Redware	Izapa 5	Plainware: Fine	Monkey-Vessel Ware	Kato Tripod	Polychrome	Dull Redware	Plumbate	Ventosa Gray
Total rim count	1	6	32	112	12	19	6	74	5	6	10	65	33	18	6	4	42	170	30	2	127	0	2
Tecomate	1	6																					
Dish (flat-bottom, wide-everted rim)			29	2	9	9		63	2			45		7									
Dish (flat-bottom, narrow-everted rim)				33									15	3							13		
Dish (flat-bottom, out-slanting wall, direct rim)										4	6						2				2		
Dish or bowl (out-slanting wall, slight labial flange)											2												
Dish or bowl (slightly out-sloped wall, slightly everted rim)											2												
Dish or bowl (out-slanting wall, thickened rim)													2										
Dish (out-slanting walls, medial flange, tripod support)																			30				
Bowl (vertical walls, simple silhouette)						4			1	2			1				1						
Bowl (out-curved or out-flared walls)								9															
Bowl (out-slanting walls, direct rim)														7									
Bowl (slightly incurved walls, direct rim)												4	6	1									2
Bowl (vertical walls, mammiform supports)															4								
Bowl (small rounded base with medial flange)						1																	
Bowl (small incurved walls, rounded base)																4							
Bowl (large, thick incurved walls, direct rim)																	1						
Jar (short vertical or out-flaring neck, globular body)				66	2			1	1			1	9				1						
Jar (wide-mouthed, constricted necks, labial flange, concave base)																	1	165					
Jar (wide-mouthed, chambered necks, labial flange, concave base)																	34						
Jar (tall, constricted neck, everted rim)																	1				3		
Vessel form unknown	0	0	3	11	1	5	6	1	1	0	0	15	0	0	0	0	1	5	0	2	109	0	0

Note: Ceramic types are organized in roughly chronological order. Detailed form descriptions are presented in Voorhies (1976, 2011).

percent of the rim assemblage. These large storage vessels first appear during the Early Classic occupation at Tlacuachero and may reflect a relatively greater need for the storage of potable water, foodstuffs, or both to support a larger, more permanent population at the site.

Seriation Sequence

The ceramic typology and comparative chronology presented above support a significant Middle to Late Preclassic and Early Classic period occupation at Tlacuachero. In this section, I use Ford's (1972 [1962]) seriation method to track the relative contribution of temporally diagnostic ceramic types, grouped by temporal period, to each level-specific assemblage. All ceramic materials were carefully provenienced by stratigraphic level during excavation. This allows each level-specific assemblage to be regarded as a distinctive unit of analysis. As previously noted, the ceramic-bearing post-Archaic deposits at Tlacuachero are not associated with any architectural features or other significant artifact class useful for cross dating or for assessing the chronological integrity of these deposits. However, Ford's ceramic seriation method allows us to visually evaluate the chronological relationship between the different excavated levels at Tlacuachero. The goal of this analysis is to determine if specific levels or portions of the site can be attributed to a specific period of occupation, as well as to ascertain the degree of disturbance within the post-Archaic ceramic-bearing deposits.

In the first seriation constructed, I considered the entire ceramic assemblage. This included all the temporally sensitive ceramic types (n > 20) from units S2W1, N1W2, and N2E1. In this initial analysis I treated each ceramic type as an independent variable. However, the ceramic types did not occur in any chronologically consistent stratigraphic positions (see Figure 3.3).

Subsequently, I constructed a second seriation for the combined site assemblage. In this version I grouped the ceramic types into broad temporal periods (Middle Preclassic, Late Preclassic, Protoclassic, Early Classic) based on typological comparisons with known ceramic sequences from nearby archaeological sites. Once again, the ceramics did not occur in the chronologically correct stratigraphic positions (see Figure 3.4). This finding is consistent with Voorhies's previous assessment that the upper, ceramic-bearing stratum (Stratum A) is mixed (Voorhies 1976, 2004, 2011), possibly due to extensive crocodile dens as well as to prehistoric anthropogenic disturbance. (See Chapter 1 for further discussion.)

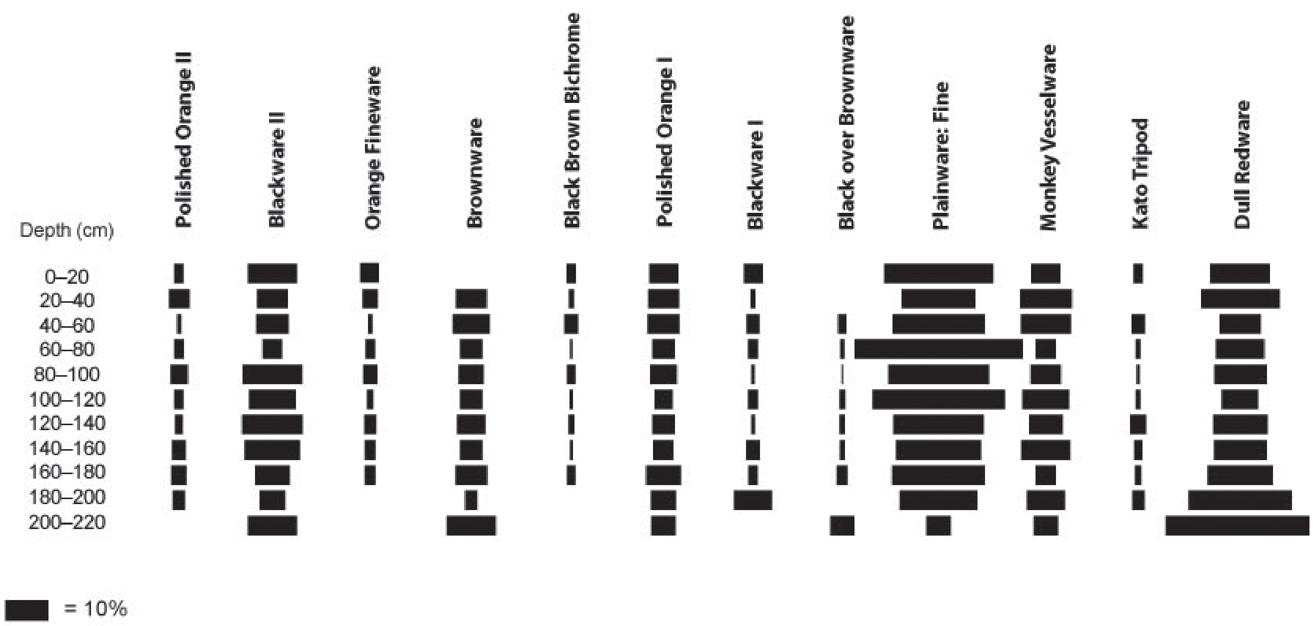


Figure 3.3. Ford's method of seriation of all temporally sensitive ceramic types from units S2W1, N1W2, and N2E1 at Tlacuachero (illustration by Heather B. Thakar).

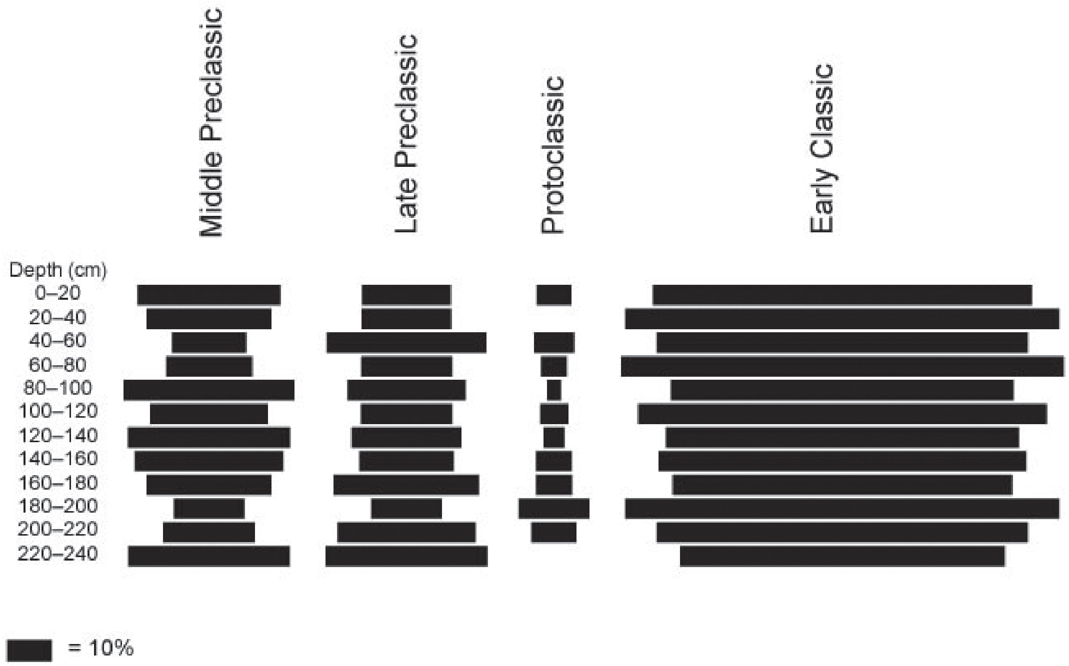


Figure 3.4. Ford's method of seriation of all temporally sensitive ceramic types grouped by time period from units S2W1, N1W2, and N2E1 at Tlacuachero (illustration by Heather B. Thakar).

Despite this overall finding, it is possible that portions of the site/excavation units might exhibit greater chronologic integrity than generally noted for the site overall. If so, these portions of the site would be more likely to provide information specific to a single occupational component. Seriation of each unit-specific assemblage facilitated assessment of whether all post-Archaic ceramic-bearing deposits in all portions of the site were equally mixed. Independent seriations were performed for each unit—S2W1, N1W2, and N2E1—using excavation levels as the unit of analysis. As with the combined site assemblage, I constructed two seriations for each unit—the first with all the temporally sensitive ceramic types represented independently, and the second with these types collapsed into broad temporal periods (see Figure 3.5). In all six versions of Ford's method of seriation, the only clear pattern was that there was no clear discernible stratigraphic pattern. Indeed, every seriation bore a striking resemblance to Figure 3.4. This affirms the results of the previous seriation for the combined site assemblage and demonstrates extensive stratigraphic mixing of all the post-Archaic ceramic-bearing deposits at Tlacuachero that we excavated in 2009.

The one exception to this general finding is the archaeological pit feature, labeled N2W1-1, which in the field looked as though its contents might not have been disturbed. It is also of interest because human bones were found within the pit feature, suggesting that at some time it was used for human burials. However, the bones were disarticulated and dispersed when we found them. The seriation of diagnostic ceramics grouped by temporal period (Figure 3.6) indicates mixing of this material as well.

Multidimensional Scaling

As a final attempt to discern evidence of chronological integrity among the excavated levels at Tlacuachero, I also performed nonmetric multidimensional scaling of the ceramic assemblage. When used for the purpose of ceramic seriation, multidimensional scaling (MDS) graphically represents quantitative relationships among various contexts and assemblages in two-dimensional space. Thus the MDS technique generates a rank ordering of intra-assemblage dissimilarities by reducing the number of dimensions in which the data are represented (see Drennan 1976 and Marquardt 1978 for

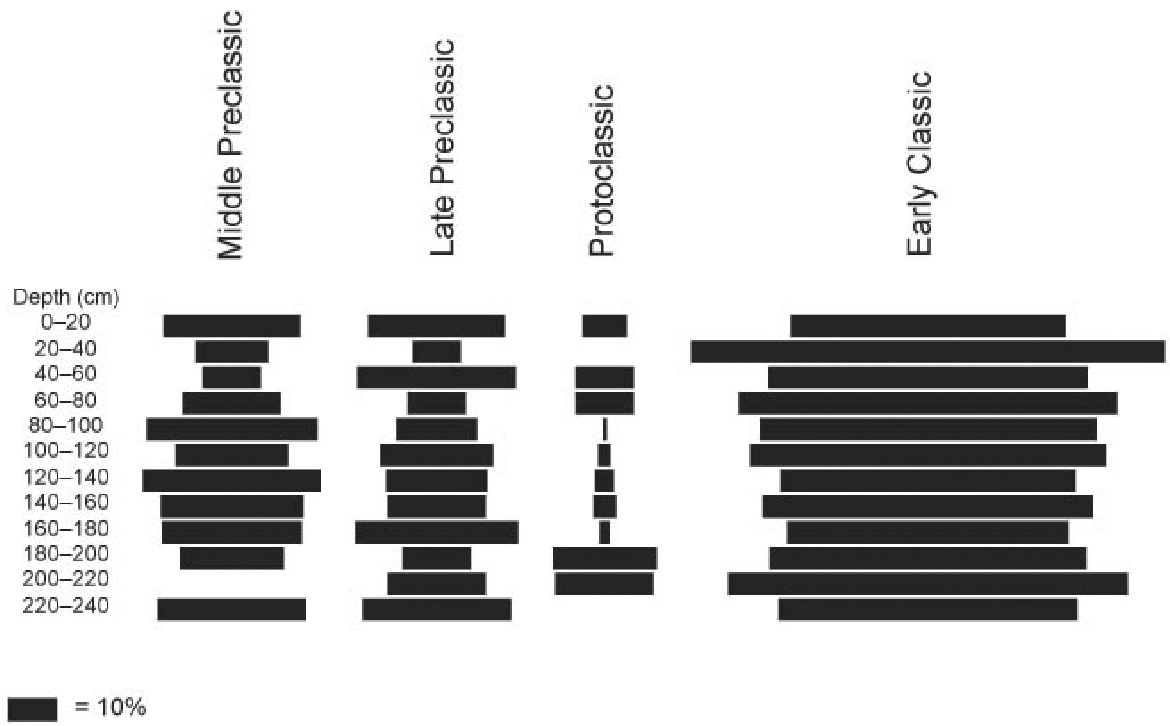


Figure 3.5. Ford's seriation method of all temporally sensitive ceramic types grouped by time period from the upper 2.4 m of deposits in Unit S2W1. Sherds occurring below 2.4 m were excluded due to their extremely low frequencies (illustration by Heather B. Thakar).

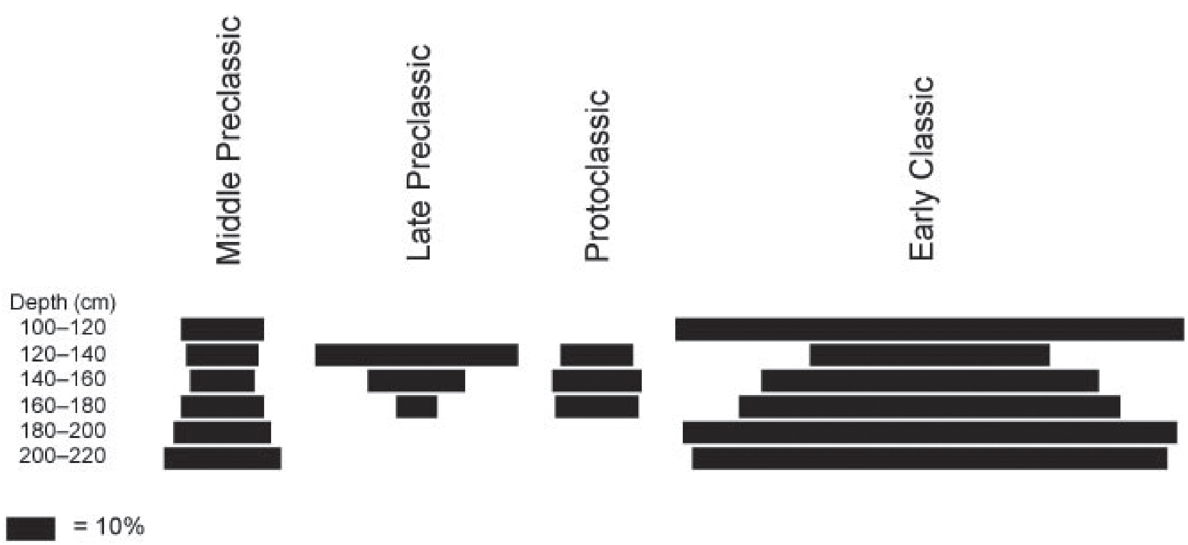


Figure 3.6. Ford's seriation method of temporally sensitive ceramic types grouped by time period for potsherds recovered from Feature N1W2-1 (illustration by Heather B. Thakar).

further discussion of this method). The spatial distance between graphed assemblages indicates their degree of dissimilarity. Widely spaced assemblages reveal notable intra-assemblage compositional differences whereas closely spaced assemblages indicate similarities. MDS seriations for assemblages characterized by temporal differences are commonly represented in chronological order along an arc or a curve. The advantage of this seriation technique is the quantitative measure of dissimilarity. This measure is used to highlight patterns not readily noticeable in Ford's seriation method of the same assemblage.

MDS seriation is considered here as a means to quantitatively evaluate even the slightest chronological patterns between the different excavated levels at Tlacuachero. Thus I created a dissimilarity matrix of distance coefficients between level-specific assemblages using the city block coefficient. Then I used multidimensional scaling to arrange these coefficients into a relative sequence. These procedures were performed using the statistical software package SYSTAT 9.0. As with Ford's seriation method, I began with an initial assessment of the combined site assemblage, followed by independent evaluation of each unit-specific assemblage.

As shown in Figure 3.7, MDS seriation of the combined site assemblage did not produce any recognizable arc configuration. It is evident that there is no chronological patterning in the stratigraphic rank order (from right to left), indicating that there are no well-demarcated temporal patterns among excavation levels. All versions of MDS seriation produce similar results. This result statistically confirms that the post-Archaic ceramic-bearing deposits at Tlacuachero excavated in 2009 are thoroughly mixed.

Although MDS seriation confirms that all level assemblages appear to be mixed, there is some clustering among sequential levels when we consider the combined site assemblage. Closely spaced assemblages are statistically more similar to each other than widely spaced assemblages. Notably, the ceramic assemblages from levels 0–0.20 m, 0.20–0.40 m, and 0.40–0.60 m cluster closely. This indicates that the ceramic assemblages in these three levels are statistically quite similar. However, variation between these assemblages does not fall in the expected chronological order. Also, levels 1.20–1.40 m and 1.40–1.60 m are both close together, and they fall in the expected chronological order. One possible explanation for this pattern is that some levels are characterized by differential mixing of materials from earlier and later periods of occupation. In the case of levels 0–0.20 m, 0.20–0.40 m, and 0.40–0.60 m, extensive mixing of sherds from different periods is likely responsible for similarities in the three assemblages, whereas in the case of levels 1.20–1.40 m and 1.40–1.60 m, there is less mixing of sherds from different time periods. Therefore these level assemblages may reflect relatively less stratigraphic disturbance, and the similarity may be due to depositional contemporaneity. Unfortunately, there are few clear indicators that can be used to sort out the degree of chronological mixture evident in the post-Archaic deposits at Tlacuachero.

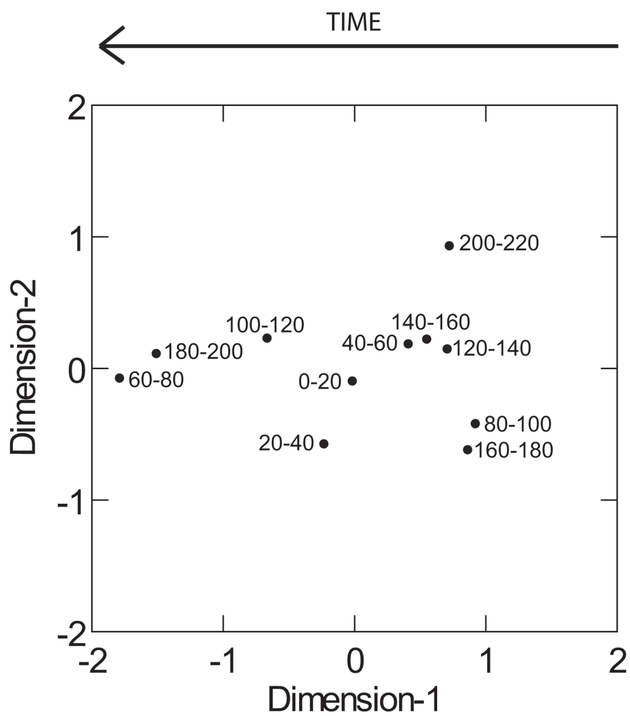


Figure 3.7. Multidimensional scaling of all temporally sensitive ceramic types grouped by time periods from units S2W1, N1W2, and N2E1 at Tlacuachero (illustration by Heather B. Thakar).

Chronological Interpretation and Conclusion

In summary, chronological assessment based on Ford's seriation method, and multidimensional scaling of ceramic types recovered from the post-Archaic deposits at Tlacuachero indicate that these materials have been thoroughly mixed. Neither method was able to identify consistent stratigraphic patterns in the distribution

of temporally sensitive ceramic indicators. Therefore this study affirms Voorhies's 1976 assessment of the ceramic assemblage.

In this analysis we have assumed that the time of deposition is approximately the same as the time of manufacture, as has been inferred from comparative collections. Working from this assumption, the ceramic material from Tlacuachero suggests varying degrees of site use from the Early Preclassic period through the Postclassic period. This is reflected in the relative abundance of distinct ceramic types, as well as shifts in primary vessel forms. Due to stratigraphic mixing, it is impossible to determine whether occupation was continuous throughout this time frame. However, it is evident that the intensity of site use increased significantly during the Middle to Late Preclassic period, decreased in the Protoclassic period, and peaked during the Early Classic period.

This analysis of the ceramic assemblage from Tlacuachero provides a broad approximation of post-Archaic occupation at Tlacuachero. Continued refinement of regional ceramic chronologies may help clarify some of the issues noted in this analysis. However, fine-grained chronological determinations of the post-Archaic deposits at Tlacuachero likely will always be inhibited by extensive stratigraphic mixing of these deposits attributed to both anthropogenic and animal disturbances.

References Cited

Brockington, Donald L.
1967 *The Ceramic History of Santa Rosa, Chiapas, Mexico*. Papers of the New World Archaeological Foundation, No. 23. Brigham Young University, Provo, Utah.

Bryant, Douglas Donne, and John E. Clark
2005 Protoclassic Ceramics. In *Ceramic Sequence of the Upper Grijalva Region, Chiapas, Mexico*, Part 1, edited by Douglas Donne Bryant, John E. Clark, and David Cheetham, pp. 283–349. Papers of the New World Archaeological Foundation, No. 67. Brigham Young University, Provo, Utah.

Bryant, Douglas Donne, John E. Clark, and David Cheetham (editors)
2005 *Ceramic Sequence of the Upper Grijalva Region, Chiapas, Mexico*, parts 1 and 2. Papers of the New World Archaeological Foundation, No. 67. Brigham Young University, Provo, Utah.

Clark, John E., Barbara Arroyo, and David Cheetham
2005 Early Preclassic and Early Middle Preclassic Ceramics. In *Ceramic Sequence of the Upper Grijalva Region, Chiapas, Mexico*, Part 1, edited by Douglas Donne Bryant, John E. Clark, and David Cheetham, pp. 21–141. Papers of the New World Archaeological Foundation, No. 67. Brigham Young University, Provo, Utah.

Dixon, Keith A.
1959 *Ceramics from Two Preclassic Periods at Chiapa de Corzo, Chiapas, Mexico*. Papers of the New World Archaeological Foundation, No. 5. New World Archaeological Foundation, Orinda, California.

Drennan, Robert
1976 A Refinement of Chronological Seriation Using Nonmetric Multidimensional Scaling. *American Antiquity* 41:290–302.

Ford, James A.
1972 [1962] *A Quantitative Method for Deriving Cultural Chronology*. Pan American Union Technical Manual, No. 1. Pan American Union, Washington, D.C. Reprinted as Museum of Anthropology Museum Brief, No. 9. University of Missouri, Columbia.

Kennett, Douglas J., and Barbara Voorhies
2002 Informe de temporado del campo "Proyecto Costero Arcaico-Formativo, Chiapas." Submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, México. Manuscript on file, Archivo Técnico de Arqueología, Mexico City.

Kennett, Douglas J., Barbara Voorhies, John G. Jones, Hector Neff, Dolores R. Piperno, Thomas A. Wake, Karry L. Blake, Brendan Culleton, Josué Augusto Gómez García, and Natalia Martínez Taqueña
2007 Informe técnico final del proyecto "Costero Arcaico-Formativo, Chiapas." Submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, México. Manuscript on file, Archivo Técnico de Arqueología, Mexico City.

Lee, Thomas A.
1973 Secuencia de fases postformativas en Izapa, Chiapas, Mexico. *Estudios de Cultura Maya* 9:75–84. Seminario de Cultura Maya, Universidad Nacional Autónoma de México, Mexico City.

Lesure, Richard G., and Isabel Rodríguez López
2009 Pottery. In *Settlement and Subsistence in Early Formative Soconusco: El Varal and the Problem of Inter-Site Assemblage Variation*, edited by Richard G. Lesure, pp. 115–146. Cotsen Institute of Archaeology, University of California, Los Angeles.

Lowe, Gareth W.
1967 Appendix: Results of the 1965 Investigations at Altamira. In *Altamira and Padre Piedra, Early Preclassic Sites in Chiapas*, edited by Dee F. Green and Gareth W. Lowe, pp. 81–130. Papers of the New World Archaeological Foundation, No. 12. Brigham Young University, Provo, Utah.

Lowe, Gareth, Thomas Lee, and Eduardo Martínez Espinosa
1982 *Izapa: An Introduction to the Ruins and Monuments.* Papers of the New World Archaeological Foundation, No. 31. Brigham Young University, Provo, Utah.

Marquardt, William H.
1978 Advances in Archaeological Seriation. In *Advances in Archaeological Method and Theory*, edited by Michael B. Schiffer, pp. 257–314. Academic Press, New York.

Miller, Donald E., Douglas Donne Bryant, John E. Clark, and Gareth W. Lowe
2005 Middle Preclassic Ceramics. In *Ceramic Sequence of the Upper Grijalva Region, Chiapas, Mexico*, Part 1, edited by Douglas Donne Bryant, John E. Clark, and David Cheetham, pp. 141–264. Papers of the New World Archaeological Foundation, No. 67. Brigham Young University, Provo, Utah.

Morgan, Molly
2011 Early Formative Transitions in Settlement and Subsistence at Chiquiuitan, Guatemala. In *Early Mesoamerican Social Transformations: Archaic and Formative Lifeways in the Soconusco Region*, edited by Richard G. Lesure, pp. 191–216. University of California Press, Berkeley.

Paillés H., Maricruz
1980 *Pampa El Pajón, an Early Estuarine Site, Chiapas, Mexico*. Papers of the New World Archaeological Foundation, No. 44. Brigham Young University, Provo, Utah.

Peterson, Frederick A.
1963 *Some Ceramics from Mirador, Chiapas*. Papers of the New World Archaeological Foundation, No. 15. Brigham Young University, Provo, Utah.

Pfeiffer, Linda A.
1983 Pottery Production and Extralocal Relations at Rio Arriba, Chiapas, Mexico. Unpublished Ph.D. dissertation, Department of Anthropology, University of California–Santa Barbara.

Voorhies, Barbara
1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico.* Papers of the New World Archaeological Foundation, No. 76. Brigham Young University, Provo, Utah.
2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.
2011 Informe de proyecto "Los Origines de Arquitectura Publica en a Costa Sur de Mexico." Submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, México. Manuscript on file, Archivo Ténico de Arqueología, Mexico City.

Chapter 4

The Tlacuachero Floors: Description and Sampling Methods

Heather B. Thakar

Recent excavation at Tlacuachero documented at least three distinct, superimposed occupational surfaces referred to here as floors. The three floors discussed in this paper are deeply buried under the highest area of the island site; the uppermost floor was originally found at 4.6 m below the ground surface when it was discovered in 1973 (Voorhies 1976). During their excavation, these floors were thought to be intentional constructions based on the following five characteristics:

- Each floor has a unique lithology compared to adjacent strata.
- The floors consist of a matrix of fine yellow-orange sediment that superficially resembles clay (but see Chapter 5) and contains abundant inclusions of whole fish vertebrae as well as whole clamshell valves and shell fragments.
- The floors have abrupt edges where they adjoin the bedded shell deposits.
- The floors have level upper surfaces, whereas the lower contacts are uneven.
- The floors are located only in the central part of the site and are superimposed, but they are not perfectly congruent in size and shape.

Originally, Voorhies assumed that the fine fraction of the matrix of the upper floor was clay because the particle size, color, and plasticity of the material superficially resembled clay. Moreover, clay has been widely used through time and space as a construction material for floors. However, we now know that the construction material that resembles clay is not clay at all but likely originated as fine-grained shell particles and wood ash (Chapter 5, this volume). This means that the fine-grained sediment was not mined as originally thought but may have been fabricated or possibly formed as a result of anthropogenic activities carried out at the site. For more information about the floor material, see chapters 5 and 10 of this volume.

The primary purpose of this chapter is to provide a detailed description of the floors exposed during the 2009 excavations at Tlacuachero, along with a description of the methods used to sample their matrices. In addition, I examine spatial patterning of the cultural and noncultural features present on the floor exposures.

Identification of Floors

Occupational or activity surfaces produced by anthropogenic leveling and compaction of sediment are broadly regarded as floors in archaeological literature

(Barba 2007:440), and it is not uncommon or exceptional to encounter such activity surfaces at hunter-gatherer archaeological sites. The members of this project are not in agreement as to whether the floors at Tlacuachero were deliberately constructed features or incidental by-products of human behavior. The members of the field team (see Chapter 10) think that the floors must have been deliberately constructed, whereas Neff and his colleagues (see Chapter 5) remain dubious about this. Whichever the case, the floors were easily recognized in the field.

Distinct episodes of floor formation were distinguished in the field on the basis of stratigraphic position, matrix color, texture, degree of compaction, and density of inclusions. The label Floor 1 refers to the uppermost occupational surface, as it was the first floor encountered during the course of excavation. During the 2009 field season, Floor 1 was exposed throughout the entire excavation area, except for a small area in the northwestern corner of the excavation where the floor ended. There, Floor 1 is progressively thinner toward the north until tapering off altogether. Beyond the edge of the floor are several isolated patches of floor material resting directly on a substrate of shell. This is the only place where we have observed an edge of one of the floors, and it provides an opportunity to consider how these floors were formed. The material of Floor 1 appears to have formed as a single stratum, since there are no internal structures such as bedding contacts or laminations. In places where Floor 1 overlies unconsolidated shell deposits, the lower deposits were not leveled, built up, or prepared in any way prior to the formation of Floor 1.

In the western portion of the 2009 excavation area, the field crew carefully peeled away Floor 1 to expose a second floor immediately below. Although directly superimposed in the area investigated, these two strata were easily distinguished. The surface of this second floor, henceforth referred to as Floor 2, was significantly harder and its upper surface slightly more irregular than the surface of Floor 1. The matrix itself also appeared markedly different. Floor 2 was orange-red in color and visibly contained a higher quantity of embedded shell fragments than the tan-colored Floor 1.

A small portion of a third floor surface, referred to as Floor 3, was encountered only in a single small excavation unit (2 x 2 m) dug below Floor 2 in the northern area of the excavation but was absent in several other places where archaeologists dug below floors 1 and 2. Floor 2 and Floor 3 were separated by a thin stratum of clamshells and thus were not directly superimposed. Although we provide a brief description of the 4 m^2 exposure of Floor 3, the spatial analysis of surface features will focus necessarily only on floors 1 and 2. These are the only occupational surfaces with sufficient lateral exposures to allow consideration of spatial distribution of features and attributes of the matrices.

Size and Shape of Floors

The currently available data are not sufficient to determine the full size or shape of any of the three identified floors. However, Voorhies determined the approximate spatial extent of the combined floors, which cover an estimated area of 900 m^2 positioned under the site summit (Figure 1.2). She achieved this with a coring program using a bucket auger. Auger holes were spaced at 5-m intervals along two axes oriented in the cardinal directions, with their point of origin located where Floor 1 was known to be present. It was an easy matter to detect the presence of the floors since the fine sediment of the floors was readily distinguishable from the shell deposits raised in the auger bucket. Evidence of the floors was detected in the auger holes nearest the intersection of the axes on each of the four radii and was absent farther from it. Data from the auger holes allowed Voorhies to plot with confidence the approximate extent of the combined floors, despite the fact that they are so deeply buried (Voorhies 2004:34). However, in some locations on each axis, just beyond the restricted area of the combined floors, the auger probes retrieved shell deposits with small amounts of fine sediment also present. Voorhies interpreted this as a result of the fine-grained material being secondarily deposited by erosion at locations downslope of the floors.

Voorhies conducted these auger tests in 1978, when Floor 1 had been exposed in only the very small area excavated in 1973 (Voorhies 1976). At that time she had no idea that there was more than one floor at the site, since only Floor 1 was present in the location of her initial excavations. For this reason she assumed that the entire area of stratum represented only one floor. We now know that at least three floors formed sequentially in the central part of the site. We also know that these floors are not perfectly congruent but rather in plan view are offset to some degree from each other. For

example, floors 2 and 3 are not present in the eastern and southern parts of the excavation. Figure 4.1 illustrates the known extent of floors 1, 2, and 3. The extent of Floor 3 is even more difficult to define, since it has been exposed only in one test pit, but we know that it is not present in the excavations below Floor 1 where Floor 2 is also absent.

Description of Floor Features

Due to compaction of the floor surfaces, distinct features on the surfaces of Floor 1 and Floor 2 were well preserved and usually easily defined. During excavation in 2009, a unique assortment of cultural and noncultural features was documented on the surface of each floor.

Features of Cultural Origin

The primary evidence of human activities on the floor surfaces consists of post molds, rock emplacements, finger-molded holes, carbon stains, fire basins, and a burial. Some of these features are shown on Figure 4.2. Several of these principal cultural feature types were first documented at Tlacuachero during Voorhies's 1988 excavation and are described in detail in Voorhies 2004:51–61. In this section, I briefly review the definition of each

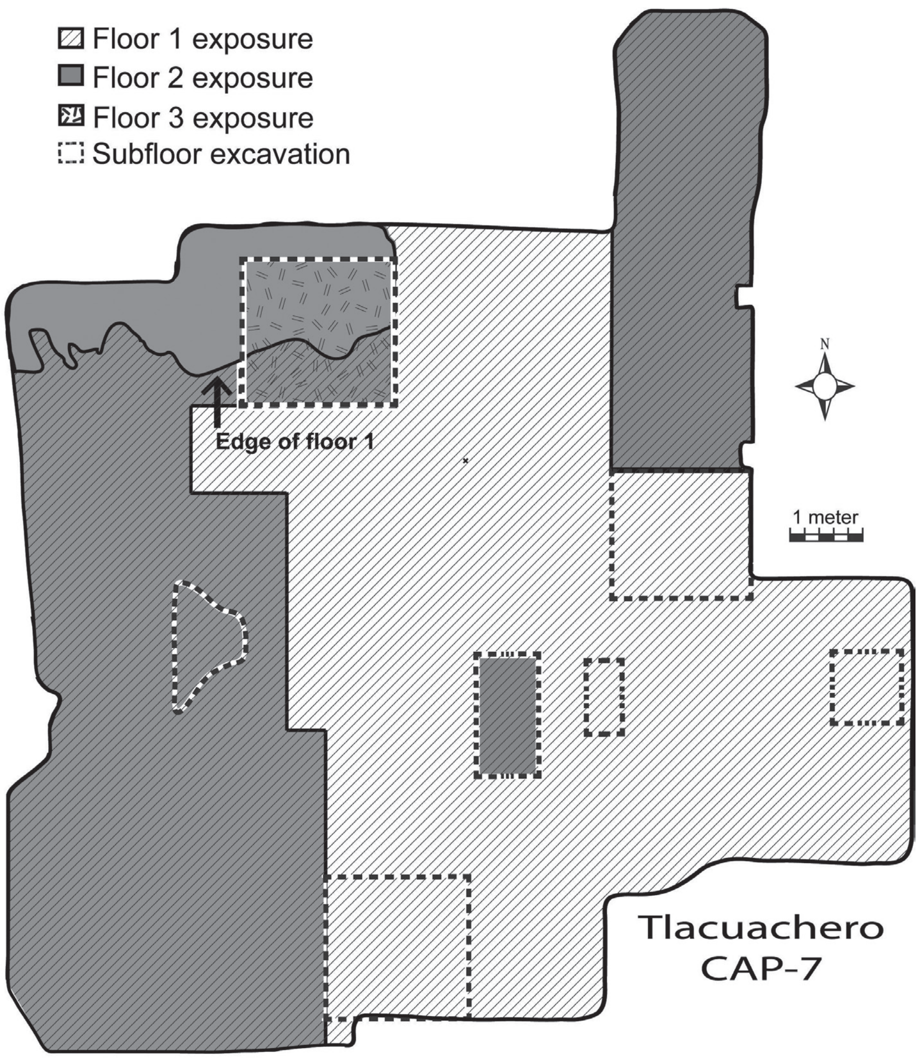


Figure 4.1. Areal exposures of Floor 1, Floor 2, and Floor 3. The perimeter of the drawing represents the limits of excavation at the end of the 2009 field season (illustration by Heather B. Thakar).

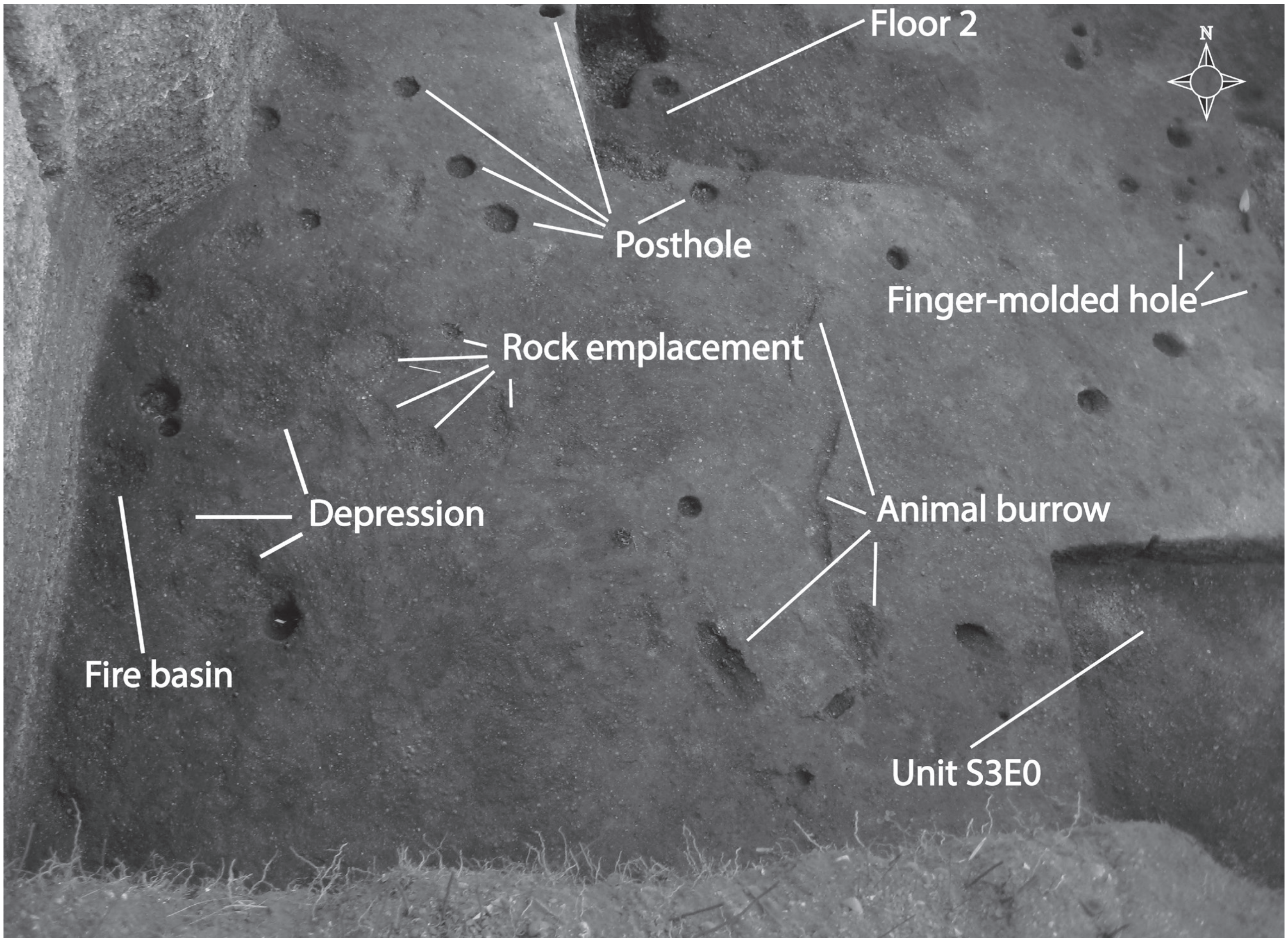


Figure 4.2. Photograph of the southwest corner of the Floor 1 exposure showing postholes, rock emplacements, finger-molded holes, depressions, animal burrows, and a fire basin. Also shown is an area in the upper right corner where Floor 1 was removed to expose Floor 2 and an area in the lower right corner where Unit S3E0 was excavated below Floor 1 (photograph by Barbara Voorhies).

feature type and augment the descriptions with new data from the 2009 field season at Tlacuachero.

Postholes are by far the most common feature type recorded on the surfaces of the two uppermost floors. These circular holes penetrate through the floor surfaces. Archaeologists did not recover any actual posts or remains of posts from these features. Indeed, the materials removed from the interior of these holes were the same as the matrix of overlying strata. Postholes are negative impressions that document the presence, size, and location of posts pushed into the floor surface. It is possible to distinguish two general categories of postholes based on the diameter and depth of the hole. "Large" postholes generally range between 10 to 25 cm in diameter and have deep, straight vertical walls. These postholes document the former presence and location of large vertical posts, similar in size to structural supports. "Small" postholes generally range from 5 to 10 cm in diameter and tend to be shallower in depth, although they also penetrate the floor surface. These postholes document the presence and location of small posts, or more accurately stakes.

The great quantity of postholes on the floors at Tlacuachero may have served several different functions. Indeed, many distinct structure types incorporate posts of varying sizes and functions. Among these, buildings are perhaps the most common possibility that archaeologists consider. At Tlacuachero the large postholes may indicate the presence of simple wall-less structures similar to traditional vernacular houses occupied by some modern inhabitants of the Acapetahua Estuary on the nearby island of Campón (see Wauchope 1938). Part-time occupants of Campón are farmer-fishermen who live temporarily in wall-less structures with palm-thatched roofs

(Figure 4.3a). These buildings are constructed with large upright supporting posts (Figure 4.3b, Figure 4.3c) cut from the nearby mangroves, with smaller posts added wherever necessary to provide additional strength and support. The Mexican fan palm leaves used for thatching are locally available within the wetlands, where the palms grow on high ground. It is possible that some of the large postholes on the floor surfaces at Tlacuachero are related to the presence of a similar building.

However, it is important to consider the full range of structures that incorporate large supporting posts. Among some of the more likely options are food-processing structures, such as the vertical-pole fish-drying racks, called *tapescos* by the modern inhabitants of the Acapetahua Estuary. Historically, fishermen in the local area preserve relatively large fish by butchering, salting, and sun drying them on *tapescos* (Figure 4.4a, Figure 4.4b). These are pole scaffolds consisting of upright supporting posts with forked upper ends, upon which are laid horizontal poles. The prepared fish are draped over the horizontal poles, where they dry in the sun. The specific size of the supporting posts varies with the desired height of the *tapesco*, which must be high enough to keep the fish away from marauding pigs and dogs. All the fish-drying racks that we have seen in the Acapetahua area have vertical uprights, unlike the tripod-pole meat-drying racks described by Binford (1978:97–99).

Another type of structure with vertical posts that can be seen today in the Acapetahua Estuary is the rustic worktable, also called a *tapesco*, which also doubles as a platform fish-drying rack (Figure 4.5a, Figure 4.5b). These rectangular structures have four vertical posts that support an upper working surface constructed of horizontal poles laid side to side. They are usually low enough to allow people to clean fish and perform other tasks on the upper surface. It is possible that some of the postholes evident on the floor surfaces at Tlacuachero may be related to the presence of similar food-processing structures.

Large vertical upright posts, such as those evidenced by large postholes at Tlacuachero, are also incorporated in the construction of food-storage structures, such as maize cribs constructed by the Puuc Maya in the northern peninsula of the Yucatán (Figure 4.6). These elevated wooden structures are fabricated with large (10–20 cm) corner post supports arranged in a rectangular fashion, with a series of other upright posts to support each side. The large corner posts are set deep into the sediment and are often doubled up if necessary to support the weight of the stored food items. Smaller upright wooden posts may be added between corner posts for additional support (Smyth 1990:60). It is possible that some of the large postholes evident on the constructed floor surfaces at Tlacuachero may be related to similar elevated wooden food-storage structures.

Many other wooden structures incorporate a large number of postholes that are much smaller than those of the traditional houses, *tapescos*, and maize cribs described above. Indeed, the significant quantity of small postholes recorded on the prepared floor surfaces at Tlacuachero indicates that it is also important to consider the potential function of structures incorporating small posts. Hunter-gatherers often construct small domed brush shelters or huts (Voorhies 2004:60). Simple shelters may easily be constructed with small branches thrust into the ground, bent, and tied together to provide the basic framework, which can then be covered with plant material such as palm fronds to provide a temporary shelter or sun screen. It is possible that some of the small postholes evident on the constructed floor surfaces at Tlacuachero may be related to the presence of similar simple domed structures, as Voorhies has proposed (2004).

Rock emplacements or impressions are another frequent cultural feature documented on the surface of the floors at Tlacuachero. The term *rock emplacement* was originally used by Voorhies to describe negative impressions left by medium-size stones placed on freshly prepared or recently wetted floor surfaces. These distinctive depressions consistently occur in circular or semicircular clusters. With just one notable exception (see Voorhies 2004:60), no actual stones were recovered in situ from their original position in these rock emplacements; they had been removed at the time of floor abandonment. Rather, these features document the former presence, size, and location of circular stone features.

As with postholes, the potential function of circular stone features can be quite varied. Although individual circular stone features frequently define the perimeter of hearths at hunter-gatherer occupation sites, particularly when associated with carbon and/or wood ash, another possible explanation is that rock emplacements indicate the use of stones to raise storage containers above the floor level, protecting the contents from water, sediment moisture, and potential vermin (Voorhies 2004:60). Elevating stones are a

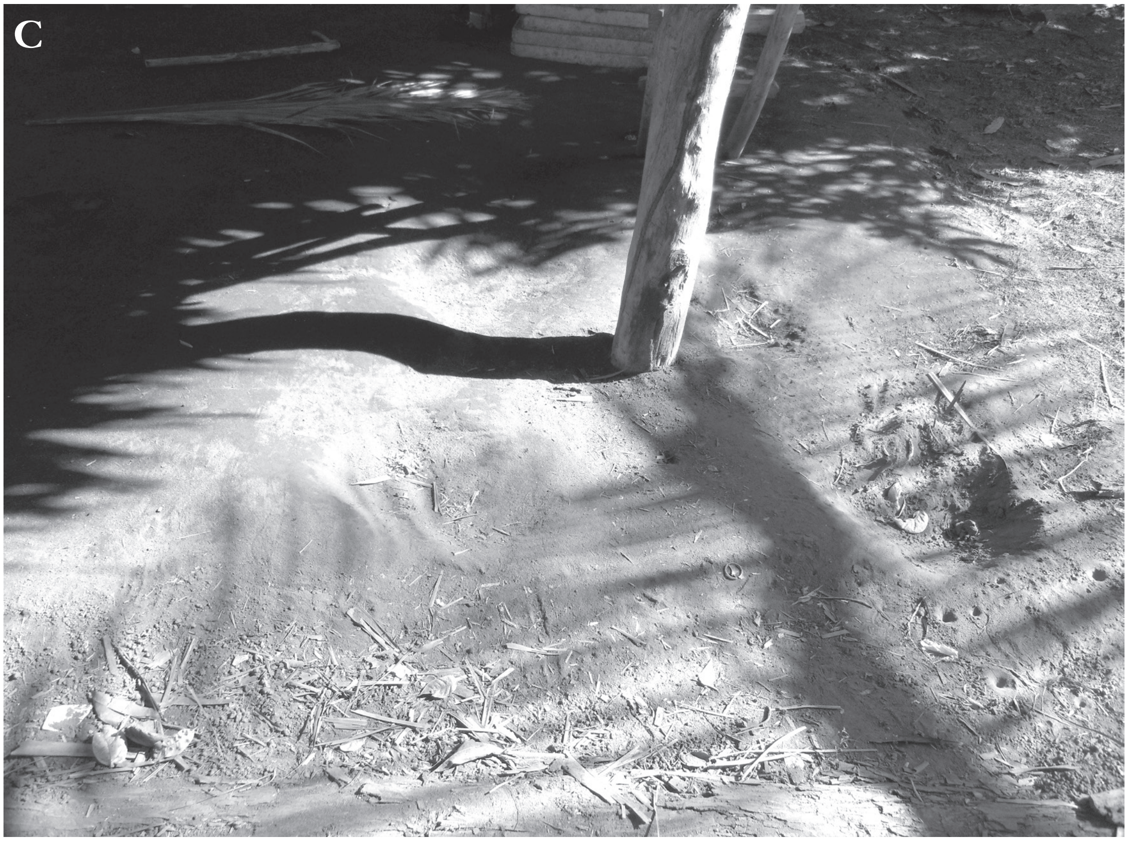


Figure 4.3. A modern wall-less, palm-thatched structure with earthen floor on the island of Campón: (a) view of building; (b) peripheral margin of floor irregularity between and around the building's support post; (c) debris caught in peripheral surface depressions at the edge of the structure (photographs by Heather B. Thakar).

common feature of both indoor and outdoor storage facilities among traditional Maya households in tropical Mesoamerica (Smyth 1990:51). The presence of numerous, closely spaced circular stone features (or evidence thereof) without associated indicators of fire, as at Tlacuachero, may indicate the presence of elevating stones rather than hearths.

Finger-molded semicircles are perhaps the most perplexing cultural feature type documented on the surface of floors at Tlacuachero. These distinctive semicircular rings consist of small circular holes with rounded bases and smoothed walls molded into the constructed floor surface. Voorhies (2004:54–59) describes and discusses an apparently complete example of this feature type encountered during her 1988 excavation at Tlacuachero. This particular set of finger holes, in the middle of the excavation, is an open semicircle with a maximum diameter of 1.40 m and a small central depression where a rock was once positioned. Excavation in 2009 documented at least nine additional finger-molded semicircles, some of which are at least partially superimposed. It is evident that they were deliberately shaped and carefully molded into freshly prepared floor surfaces on several separate occasions, providing clear proof of some degree of spatial organization over time.

There is a strong possibility that these finger-molded semicircles functioned as scoreboards for a dice game. This possibility is based upon the similarity between the features at Tlacuachero and modern game boards created by several different indigenous groups (Tarahumara, Pima, Papago, and Walapai) of the Greater Southwest and descriptions of dice games recorded by 16th-century chroniclers in central Mexico (Voorhies 2013).

Carbon stains appear on the surfaces of both Floor 1 and Floor 2. These features are discrete areas where significant quantities of charcoal (and sometimes wood ash) are visibly incorporated into the floor surface. Such patches occur infrequently, in various shapes and sizes, ranging from 20 cm to 120 cm in length. These features are not consistently associated spatially with

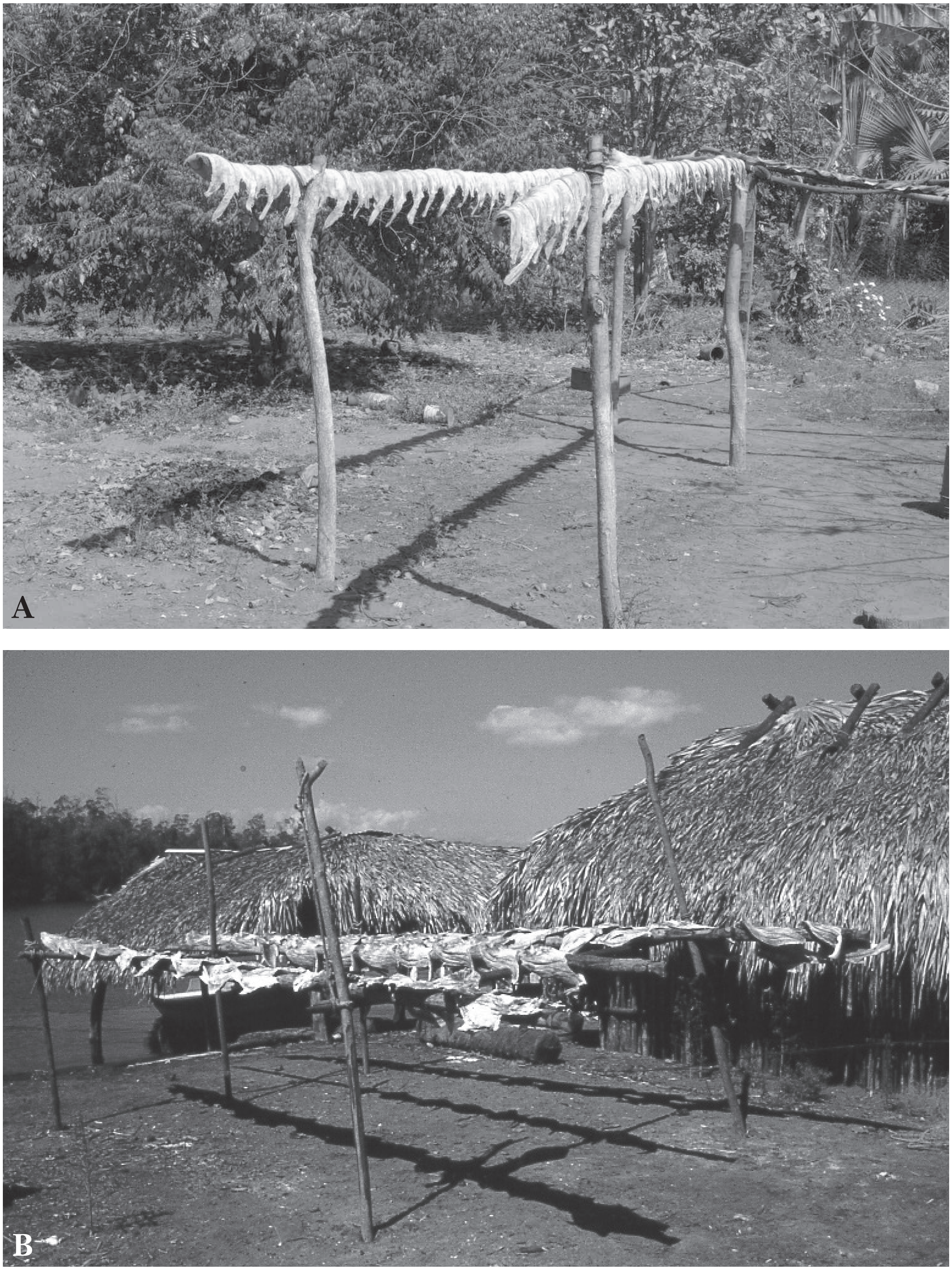


Figure 4.4. Vertical-pole fish-drying racks, locally called *tapescos*, used by the modern inhabitants of the Acapetahua Estuary (a: photograph by John G. Hodgson; b: photograph by Barbara Voorhies).

Figure 4.5. Platform *tapescos:* (a) platform table with dried fish together with a vertical-pole fish rack (photograph by Barbara Voorhies); (b) view of the Chantuto shellmound taken in 1947 by Philip Drucker. The men stand by a platform *tapesco*, used for fish butchering and occasionally for drying fish (photograph courtesy of the National Anthropological Archives, Smithsonian Institution).

Figure 4.6. A raised corncrib, a type of food-storage structure used by the Puuc Maya in northern Yucatán (photograph from Smyth 1990:54, Figure 4b. Reprinted courtesy of Cambridge University Press).

any other cultural or noncultural features. Although the origin of these features certainly is fire related, the activities that led to the creation of these features could be quite varied. Concentrations of carbon and ash may indicate the location where hearth fill was dumped after cleaning or where accumulated refuse was burned. High densities of carbon and ash may also accumulate in food preparation areas. Stahl and Zeidler (1990) document similar uneven, patchy accumulations of carbon and debris, up to 20 cm thick, around hearth areas in Achuar dwellings in tropical Ecuador. The specific function, or rather activities, that led to the presence of carbon stains on the floor surfaces at Tlacuachero may be related to one or more of these possibilities.

A final cultural feature to mention is the human burial that was embedded in Floor 1 in Unit NOE2. The burial was of an adult male lying in a simple pit in a flexed supine position. No grave goods or other artifacts were associated with this burial (Voorhies 1976:67–69) when Voorhies encountered it during the 1973 excavations. The outline of the burial pit was not detected. The burial was poorly preserved and partly disarticulated at the time of its recovery. This individual had a highly abrasive diet that produced rapid dental attrition.

Features of Unknown or Noncultural Origin

A second feature class, of unknown or noncultural origin, consists of surface depressions, animal burrows, and root casts. These features provide insight regarding both human behavior and other taphonomic processes that affected the surfaces of Floor 1 and Floor 2. In this section I briefly define and describe each feature type based on new data from the 2009 field season at Tlacuachero.

Depressions of unknown origin are present on the surfaces of the floors at Tlacuachero. These depressions (Figure 4.2) are generally slight but are noticeable in comparison to the otherwise level surface of the floors. Many of these features are small circular depressions that do not exceed 10 cm in diameter; others are much larger, irregular, and elongate. In all cases the depressions are relatively shallow and do not exceed 5 to 10 cm in depth. It is unlikely that any single cultural or noncultural process can account for the quantity and variation of surface depressions documented on the constructed floors at Tlacuachero.

Animal burrows are another notable noncultural feature recorded on the surface of each floor and are significant indications of postdepositional processes active at Tlacuachero. These features (Figure 4.2) were tunneled into the upper portion of the floor surfaces. Most of these features are narrow (10-cm-wide)

tunnels that parallel the horizontal hard surfaces rather than penetrate them. In at least one incidence, a large posthole was conveniently incorporated into a burrow, allowing access between two floor surfaces. Evidence of burrowing on individual floor surfaces ranges from minimal (Floor 1) to somewhat more extensive (Floor 2). The most extensive burrows include enlarged tunnel segments that reach up to 25–30 cm in width; the largest of these may be more correctly identified as nests. Any number of burrowing animals could potentially be responsible for these features. Rodents, such as the giant pocket gopher *Orthogeomys grandis* and the small rodent *Oryzomys* spp., are prolific burrowers native to the region (Voorhies 2004:171). It is likely that one of these species is responsible for the animal burrows documented on the surface of the constructed floors at Tlacuachero.

Root casts are noncultural features produced by postdepositional calcification of plant root cavities. These features indicate the size and location of long-decayed plant roots. The residual calcifications are narrow (not more than 10 cm in diameter) and tubular and taper with depth, ending in branching structures (Figure 1.10). Excavations at Tlacuachero encountered several root casts that extended down to the level of the floor surfaces but only one that actually penetrated through a floor surface.

Spatial Distribution of Features

The goal of this section is to evaluate spatial relationships between various feature classes as a means of better understanding the potential use and function of individual feature types and of the constructed floor surfaces themselves.

Features on Floor 1

At the end of the 2009 excavations, Floor 1 was exposed in an area of approximately 120 m^2. This large lateral exposure of Floor 1 yields compelling evidence for broad spatial patterning by feature type. Figure 4.7a and Figure 4.7b provide two maps illustrating the location and size of all features that originate from the surface of Floor 1. To enhance clarity, I present separately the principal cultural feature types, which are plotted on Figure 4.7a, and feature types of unknown or noncultural origins, which are plotted on Figure 4.7b. Unfortunately, there is no evidence available to facilitate temporal segregation of these features. Therefore the spatial arrangement of the features documented on the surface of Floor 1 must be regarded as a palimpsest, or an amalgamation of superimposed features that represent traces of overlapping activities pertaining to variable periods of time. This phenomenon is best demonstrated by the partial superimposition of multiple finger-molded semicircles in the north-central portion of the excavated area.

Postholes are the most frequent cultural features on the surface of Floor 1. Altogether we recorded the location and size of 84 postholes, with relatively equal representation of the two size categories described above (41 large postholes and 43 small postholes). Large postholes are most frequent in the central/western portion of the excavated area. Previously, Voorhies (2004:54–55) speculated that the pattern of some postholes evident at the end of the 1988 field season marked the perimeter of a building. However, lack of additional supporting evidence, such as distinctive drip lines, wall pole depressions, lumps of wall daub, or foundation stones (Voorhies 2004:52), cast serious doubt on this interpretation. Now that a larger area of Floor 1 has been exposed, this previously considered outline of a former building is even more dubious. It is possible to identify linear and/or circular arrangements of postholes that support both of the potential functions (fish racks and/or traditional wall-less buildings, respectively) discussed previously. Evidence from additional data sets is necessary to fully evaluate the function of large postholes on Floor 1 (see Chapter 10).

There is a distinct spatial separation of large and small postholes on the surface of Floor 1. Small postholes cluster in the eastern and southern portions of the excavated area, whereas larger postholes are found predominately in the central and western areas. These smaller postholes occur scattered among rock emplacements. Previously, Voorhies (2004:60) suggested that the dense cluster of small postholes in the southeastern portion of the excavated area indicated the repeated construction of small structures that sheltered either site inhabitants or materials raised above the floor by circular stone features. Although this explanation cannot be ruled out at this time, the strong spatial correlation between small postholes and rock emplacements does lend credence to the latter idea.

Sixteen circular or semicircular rock emplacement features were documented on the surface of Floor 1. The vast majority of these features are concentrated in the eastern margin of the lateral excavation area.

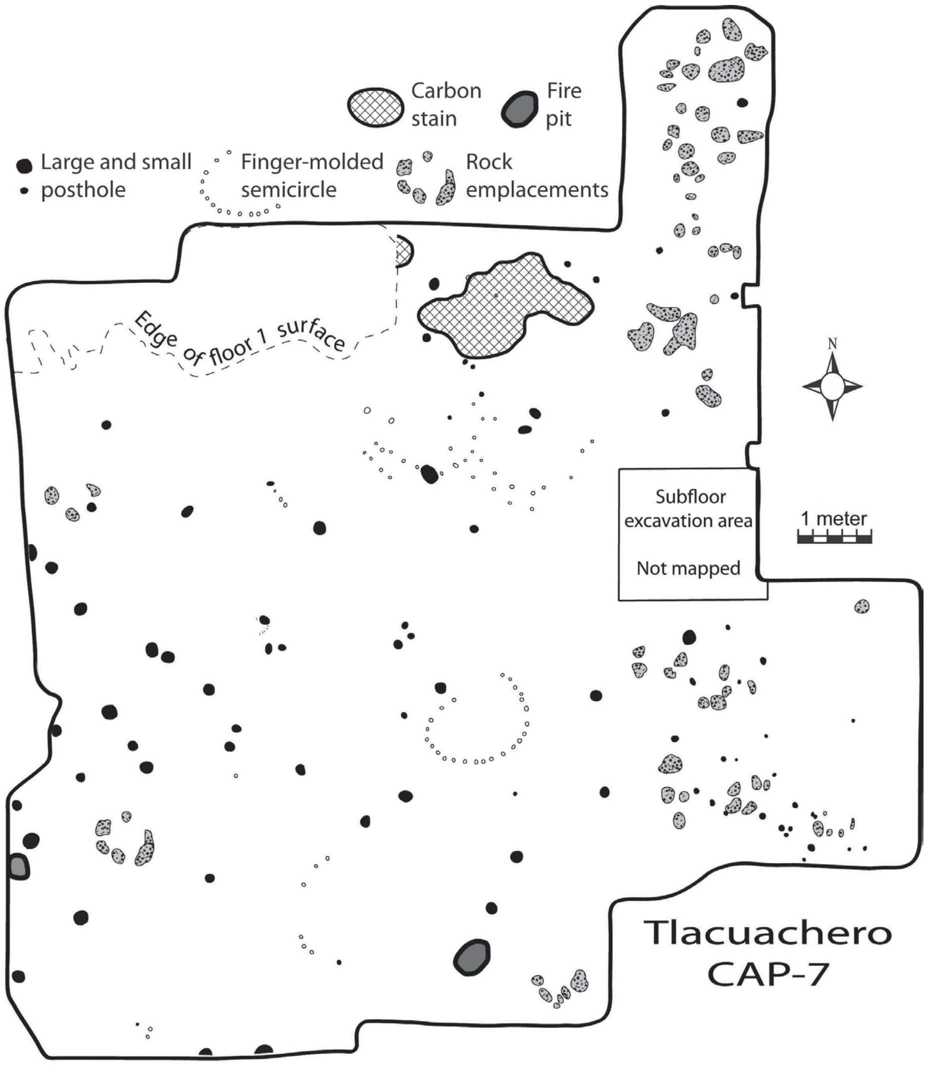


Figure 4.7a. Map of cultural features on the surface of Floor 1 including postholes, finger-molded holes, rock emplacements, fire basins, and carbon stains (illustrations by Heather B. Thakar and Barbara Voorhies).

Unfortunately, a small area located in the middle of this concentration of rock emplacements was not mapped in the original 1973 excavation of Unit N0E2. The unmapped area of Unit N0E2 is clearly indicated in Figure 4.7a and Figure 4.7b. It is unknown whether this area originally exhibited additional emplacements. Only two well-defined clusters of rock emplacements occur near the western side of the excavation. These two features are of similar size and form to the other circular or semicircular rock emplacement features but are associated with the concentration of large postholes. It is possible that these isolated features served a distinctive function; however, additional evidence is necessary to define what this function may have been.

At least seven finger-molded semicircles formed on Floor 1 are concentrated between the postholes and rock emplacements. All but one of these unique features is incompletely preserved. The most complete example, located in the center of the exposed floor surface, may be the most recent iteration or it may have been protected with grass prior to burial (see Chapter 6). It appears that finger-molded semicircles were purposely constructed and reconstructed multiple times in the same general locations. Several sets of these features are partially superimposed in the central northern area of the Floor 1 exposure. Deliberate superimposition

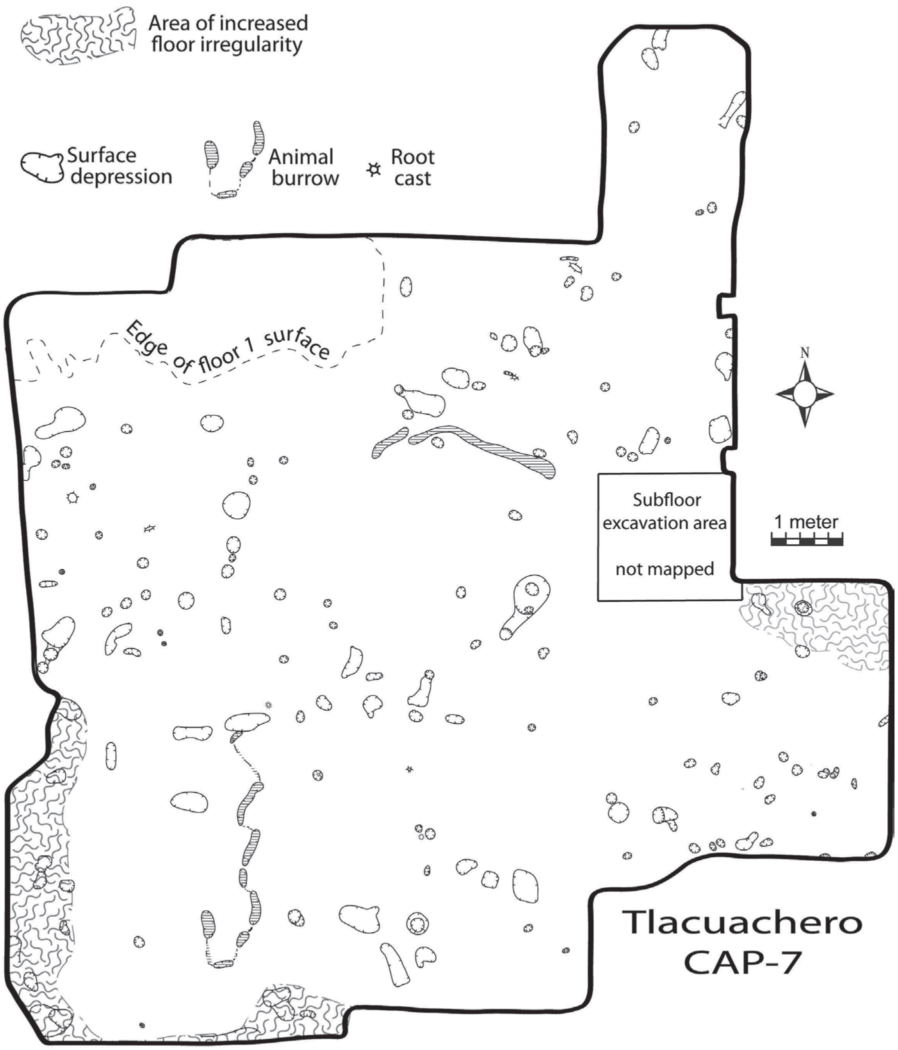


Figure 4.7b. Map of features of unknown or noncultural origins, including surface depressions, animal burrows, and root casts, on the surface of Floor 1 (illustrations by Heather B. Thakar and Barbara Voorhies).

suggests maintenance of structured activity areas through time. However, there is no evident spatial correlation between the location of finger-molded semicircles and any other feature type.

A large (2 x 1 m) irregular carbon stain with charcoal is immediately adjacent to the multiple superimposed finger-molded semicircles in the northern margin of the excavated area of Floor 1. The floor surface in this area is much more irregular than in the rest of the excavation area. This is likely due to substantial accumulation of softer charcoal/ash–laden deposits. As noted by Stahl and Zeidler (1990), thick patchy floor accumulations of similar character are often apparent within the immediate vicinity of heavily used hearths and food-preparation areas. The proximity of this large carbon stain and the superimposed finger-molded semicircles may be a simple product of palimpsest. No other finger-molded semicircles are visibly associated with a high density of charcoal and ash. Nonetheless, the proximity of these unique features is noteworthy.

The only other two, much smaller, charcoal and ash patches encountered on the surface of Floor 1 are distinct from the large irregular patch of charcoal and ash and must be regarded separately from it. These two smaller features clearly are fire basins. Each feature consists of a shallow circular depression, no more than 50 cm in diameter, filled with a high density of charcoal and wood ash. King (2008) found that similar

small burn pits at Río Viejo in Oaxaca were used for small-scale cooking, such as roasting maize kernels or toasting nuts, and were cleaned of ash and charcoal debris on a regular basis. At Tlacuachero both of these small fire basins are located in the southern portion of the excavation exposure, among several subtle surface depressions.

Well over 100 slight surface depressions dimple the otherwise remarkably level surface of Floor 1. Although these features vary greatly in both size and shape, two-thirds are small round pits, not more than 10 cm in diameter. These smaller depressions occur randomly over the entire floor surface. The other third of the surface depressions recorded on Floor 1 are larger and irregular in form. These features are more common in the western portion of the excavated area, away from the rock emplacements and in proximity to the large postholes. In the southwestern corner of the excavation area, several larger surface depressions contribute to a significant increase in floor irregularity. An area of increased surface irregularity extends 20 to 80 cm out from the southern and western walls of Unit S2W1. Five discrete clusters of small fish, bird, and turtle bones were recovered in and around the 15 surface depressions and nine large postholes included within this margin (Table 4.1).

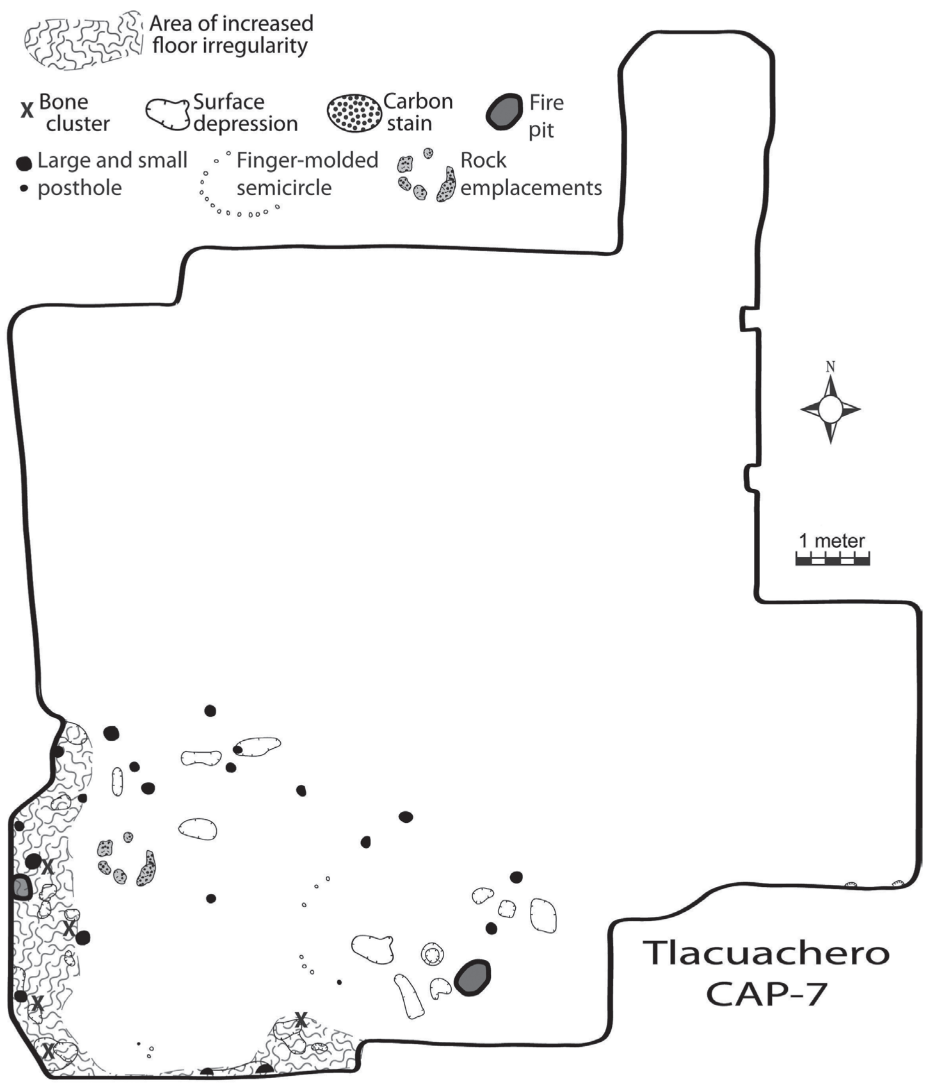


Figure 4.8. Floor 1 features and bone clusters in Unit S2W1 associated with conjectured building. Other features on the floor are not shown (illustration by Heather B. Thakar).

Table 4.1. List of Identified Fauna from Five Discrete Bone Clusters on the Surface of Floor 1 in Unit S2W1 Associated with Large Surface Depressions.

Cluster 1	Cormorant
Cluster 2	Swamp turtle
Cluster 3	Snook
Cluster 4	Alligator gar, sleeper
Cluster 5	Snapper

I suggest that this area of increased floor irregularity and co-occurring clusters of faunal remains (see Figure 4.8) in the southwest corner of the excavation may indicate the margin of a thatched, wall-less building, as described above. Multiple postholes in proximity may represent multiple reconstruction events. There is no clear evidence for distinguishing between postholes constructed during different events on the same prepared floor surface. In the traditional buildings that I examined, the earthen floor surface is typically smooth and compacted in the central area within the building, but the peripheral portions of the roofed floor surface are significantly more irregular. Surface depressions of varying size and depth were abundant around and between postholes, creating a margin of increased floor irregularity that varied in width (Figure 4.3b). Regular maintenance of the central portion of the rancho floor surface sweeps debris outside the structure; however, some items remain trapped by depressions in the peripheral zone rather than exiting the structure altogether (Figure 4.3c). This provides one possible explanation for the association of bone clusters, floor irregularity, and large postholes in the southwestern exposure of Floor 1. Voorhies proposes another possible explanation in Chapter 10.

Postdepositional animal and plant disturbance of Floor 1 is evidenced by two narrow tunnels dug into the floor surface and six root casts that contact the floor surface. The animal tunnels extend approximately 4 m in length but do not exceed 15 cm in width. Neither tunnel negatively affects the preservation of floor features. The six root casts that extend down to the surface of Floor 1 are small, between 5 and 15 cm in thickness. Only the largest root cast penetrates the surface of Floor 1. In all other regards, root-cast features do not have any relationship with or negative effect on the features described above.

Floor 2 Features and Comparison with Features on Floor 1

The 2009 excavations at Tlacuachero exposed approximately 44 m^2 of Floor 2 (Figure 4.1). The feature types observed on Floor 1 were also documented on the surface of this earlier floor (Figure 4.9), with the exception of rock emplacements, which were absent from the area that we exposed in our excavations.

To analyze the spatial arrangement of features on the surface of Floor 2, it is necessary to remove those features originating on Floor 1 and penetrating the underlying Floor 2. For example, of the 40 postholes on the exposed surface of Floor 2, we found that 19 originated in the overlying Floor 1. In other words, only 21 postholes originated on Floor 2. When Floor 1 was constructed over Floor 2, these 21 postholes were filled in and covered over with the Floor 1 material, along with two superimposed finger-molded circles unique to Floor 2. Accordingly, in the following discussion I consider only those features that originated on Floor 2.

Figure 4.9a and Figure 4.9b provide two maps illustrating the location and size of all features that originate at the level of Floor 2. The first map plots the size and location of principal cultural feature types (postholes, finger-molded holes, and carbon stains) and subtle surface depressions of unknown origins. The second map plots these same principal cultural feature types in relation to feature types of noncultural origins (animal burrows and root casts).

Postholes are the most common cultural features documented on the exposed surface of Floor 2. Within this feature type, there are significantly more large postholes than small postholes, and it is noteworthy that the Floor 2 exposure lies beneath the area in Floor 1 with the greatest concentration of large postholes. On Floor 2, the two size categories of postholes are spatially separated, as on Floor 1. Fifteen large postholes are concentrated in the northern portion of the exposed floor surface. All five of the small postholes cluster in the southern portion, in proximity to two superimposed finger-molded circles. These two sets of finger-molded holes are strikingly similar to a series of multiple superimposed finger-molded semicircles documented on the surface of Floor 1 and are located nearly below another set of finger holes on the overlying Floor 1 surface. These patterns suggest the maintenance of structured activity areas carried over between floor formation events. Finger-molded semicircles and postholes are the only feature types of definitive cultural

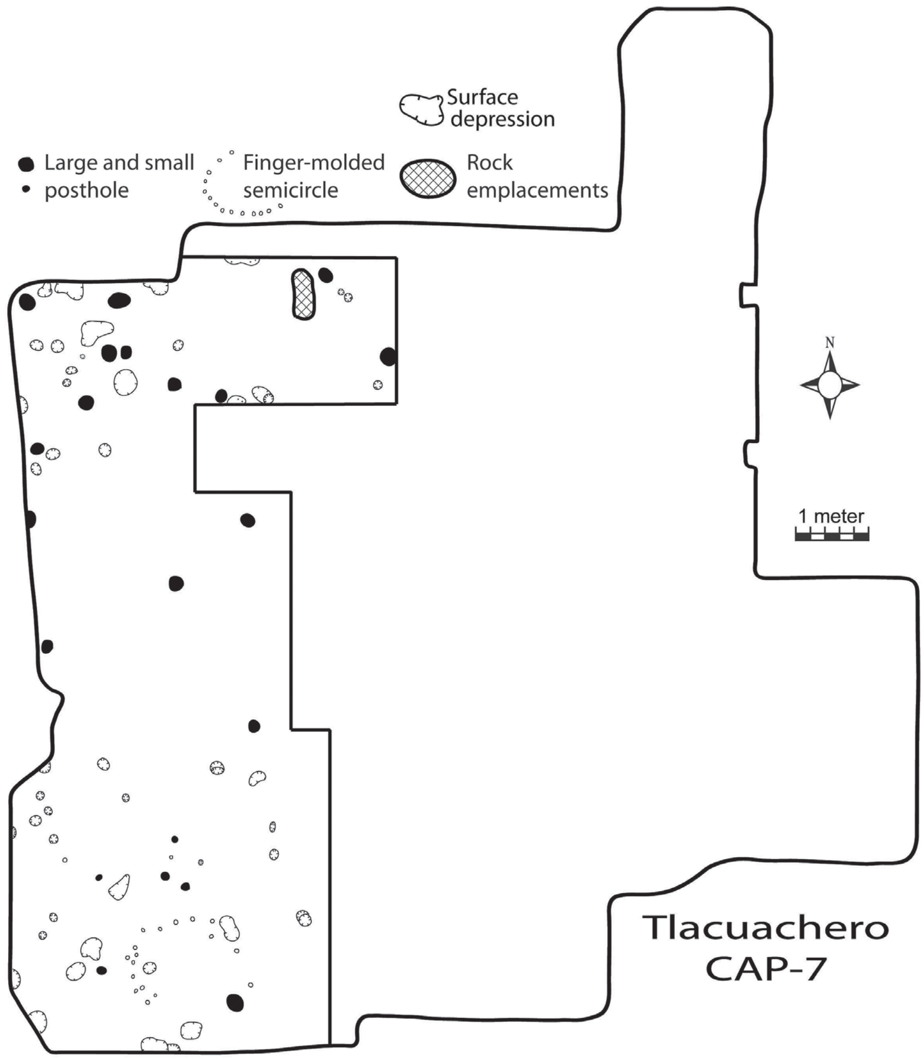


Figure 4.9a. Map of Floor 2 showing cultural features, including postholes, finger-molded holes, and carbon stains, along with surface depressions of unknown origin (illustrations by Heather B. Thakar and Barbara Voorhies).

origin recorded on the exposed surface of Floor 2. As mentioned, rock emplacements are notably absent. Whether this distinction can be attributed to the limited size or location of the excavation area is unclear. The rock emplacements documented on the surface of Floor 1 are concentrated in the eastern margin, away from large postholes and finger-molded semicircles. Therefore it is not surprising that these features were not encountered in the limited excavation exposure of Floor 2, which did not extend into this eastern area of the excavation.

Analogous spatial patterning of features on Floor 2 and Floor 1 surfaces is reflected in the distribution of features of unknown origin. Large irregularly shaped depressions and small circular depressions are concentrated in two discrete clusters among the large postholes in the northern portion of the exposed floor surface and among the small postholes and superimposed finger-molded circles in the southern portion. The zone separating these two areas is curiously devoid of surface depressions. Close association of postholes and large irregular surface depressions is evident on the surface of both floors. Formation processes responsible for the creation of surface depressions were likely consistent between the two floor-formation events. Within the northern cluster of large postholes and slight surface depressions there is a large (70 x 30 cm) ovoid patch of charcoal and ash incorporated into the surface of Floor

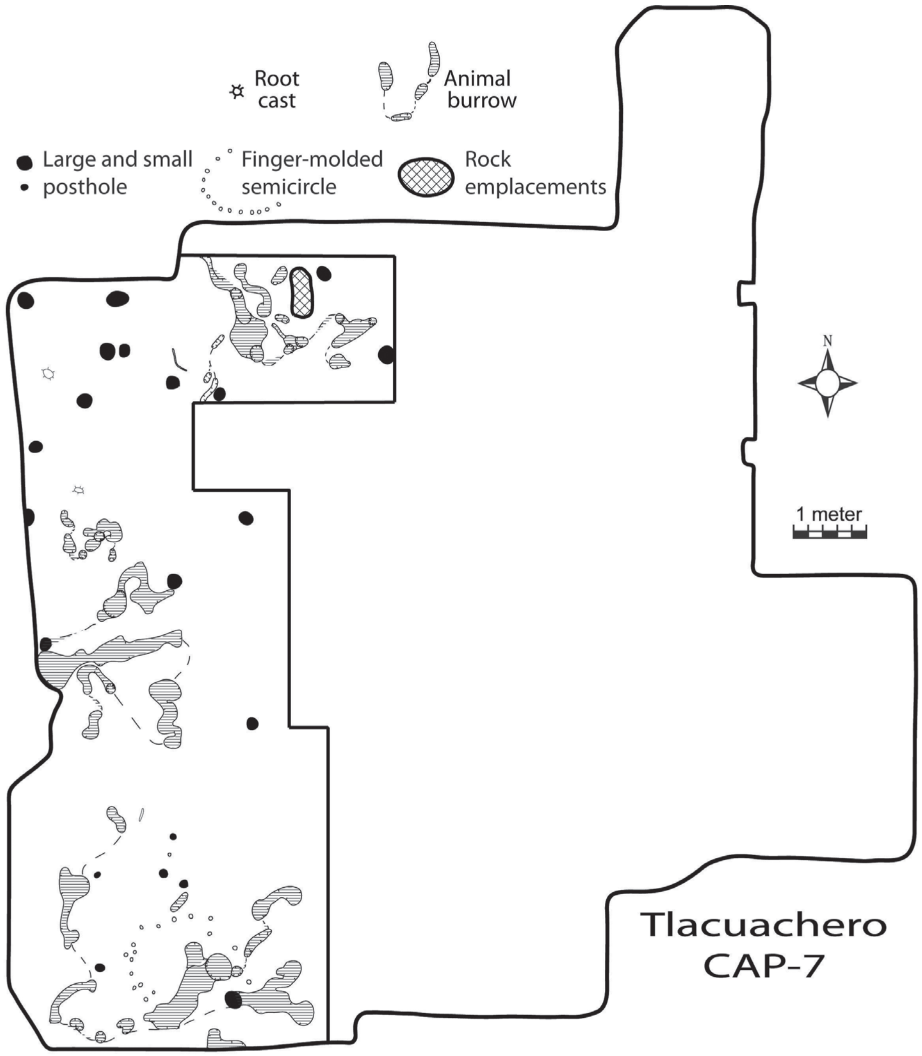


Figure 4.9b. Map of Floor 2 showing cultural features, including postholes, carbon stains, and finger-molded holes, along with features of noncultural origins (animal burrows and root casts) (illustrations by Heather B. Thakar and Barbara Voorhies).

2. This carbon stain is the only feature of this type recorded on the surface of Floor 2 and is incidentally quite close to where a very similar, albeit much larger, feature was located on the surface of overlying Floor 1. Demonstrated similarity in the distribution and association of feature types on both floor surfaces suggests that activities carried out across the floor surfaces were spatially circumscribed and consistent through time.

In contrast, postdepositional processes differentially affected the surface of Floor 1 and Floor 2. Disparity in the degree of animal burrowing may reflect differences in the formation and compaction of these two floors. A veritable maze of expansive animal burrows penetrating the surface of Floor 1 incorporates postholes as access points between the two floor surfaces. There is no evidence that these tunnels deeply penetrated the exceptionally hard surface of Floor 2. Rather, when the burrowing culprits were no longer able to tunnel downward, as they had through Floor 1, they expanded their tunnels horizontally along the surface of Floor 2. Individual tunnel segments reach up to 2 m long and 30 cm in width. Figure 4.9b illustrates the spatial relationship between these features and principal cultural features.

Floor 3 Contents and Features

As I mentioned above, Floor 3 was exposed only in Unit N1W1, which means that only a very small area (4 m^2) is available for study. This contrasts with the larger

Table 4.2. Attributes of Pebbles Recovered in Screen During the Removal of Floor 3 (FS 09-346).

FS 09-346	Weight (g)	Dimensions (cm)	Color
A	7.02	2.8 x 1.7	Dark gray
B	3.06	1.6 x 1.3	Dark gray
C	1.89	2.0 x 1.5	Dark gray
D	1.49	1.6 x 1.0	Dark gray
E	1.13	1.6 x 1.0	Dark gray
F	1.47	1.5 x 1.1	Light gray
G	0.99	1.3 x 0.9	Light gray
H	0.86	1.5 x 1.1	Dark gray
I	1.18	1.2 x 0.9	Light gray
J	1.37	1.4 x 1.0	Dark gray
K	0.87	1.2 x 1.1	Light gray
L	0.83	1.2 x 0.6	Light gray
M	0.57	1.2 x 0.6	Dark gray
N	0.85	0.9 x 0.9	Dark gray
O	0.71	1.5 x 0.8	Light gray
P	0.35	0.9 x 0.6	Dark gray
Q	0.77	1.3 x 0.9	Light gray
R	0.56	1.4 x 0.5	Dark gray
S	0.35	0.9 x 0.7	Dark gray
T	0.07	0.5 x 0.4	Light gray
U	0.16	1.3 x 0.6	Dark gray

areal exposures of the two overlying floors. Despite the large disparity in size of exposures, Floor 3 is strikingly different in several significant ways from the other two floors investigated at Tlacuachero.

One unusual characteristic of Floor 3 is that 21 pebbles were recovered from within the floor during its removal, but no pebbles came from either of the other two floors. People must have transported the pebbles to the site, since there is no viable natural process that would account for their presence there. The 21 pebbles are rounded and subangular in shape and vary in size and color, as may be seen in Table 4.2. They bear no visible evidence of intentional modification. Why were these pebbles brought to the site?

Archaeologists have proposed several explanations for exotic pebbles in archaeological sites, including their use as sling projectiles or pebble hammerstones (discussed in Aldenderfer 1998:95). A further possibility, based on the ethnohistoric and ethnographic evidence summarized elsewhere (Voorhies 2013), is that the pebbles were used as counters for game boards. Additional ideas are that they might have served as pebble parching stones or even analogs to the "power stones" of the Dani in New Guinea (Hampton 1999:198–199). A final idea suggested by an anonymous reviewer is that they may have served as pellets, perhaps for a turtle shell rattle.

However, none of these possible explanations seems particularly compelling in the case of the pebbles from Floor 3. The small size and lack of battering on the Tlacuachero stones eliminates the possibility they were tiny hammerstones, and the fact that there is no apparent selectivity in shape is inconsistent with the proposition that they are slingshot projectiles. The recovered pebbles do seem to fall into two color categories, light gray and dark gray, but these are not highly contrastive, as might be expected for game board counters (see Chapter 10). The possibility that the stones were used for parching may be worth future consideration since I have yet to find any ethnographic description of parching stones to generate useful archaeological expectations for this proposed function. The magico-religious stones maintained especially by Dani women to assure the health and well-being of their families and pigs are uniformly well rounded and similar in size and shape (Hampton 1999:Figure 4.38). As mentioned, this is not the case with the pebbles from Floor 3. Finally, the possibility that the stones might have been incorporated in turtle shell rattles has no additional supporting evidence. There was no evidence of use modification on the turtle shell fragments that the field crew recovered at Tlacuachero (see Chapter 9), despite the fact that the two recovered fishhooks are made of turtle shell. The turtle shell fragments found on Floor 3 are mixed with fish and other food taxa. In short, I have no satisfactory explanation for the pebbles found on Floor 3 at Tlacuachero.

The only cultural features present on the exposed area of Floor 3 are three places with clear evidence of burning. As may be seen on the map of the floor (Figure 4.10), the easternmost one-third of the unit consisted of a large area of burned shell, charcoal, and

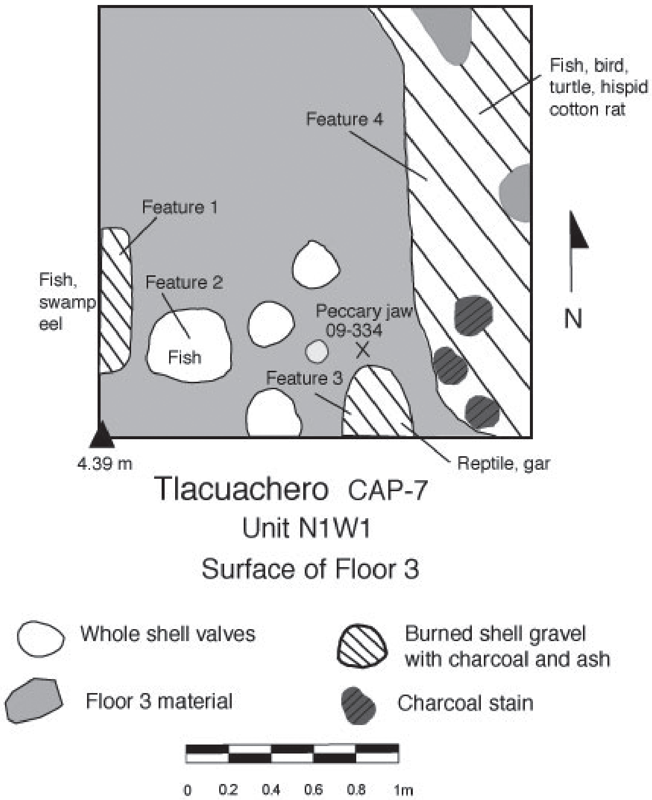


Figure 4.10. Map of Floor 3 showing locations of burned areas, bone clusters, and patches of whole clamshells (illustration by Barbara Voorhies).

ash. Smaller concentrations of burned shell gravel with ash and dispersed charcoal occur at the southern and western sides of the unit. In the field, these three fire features were labeled Feature 4, Feature 3, and Feature 1, respectively. All three of the informal fire features extend beyond the limits of the excavation unit. Other types of cultural features present on the overlying floors, such as postholes, rock emplacements, and finger-molded holes, are not present in the existing exposure of Floor 3. However, in the middle of the southern half of the unit are several places where the floor is very thin and the underlying whole shells protrude through the fine-grained sediment of the floor. The largest of these is designated Feature 2.

Moreover, in stark contrast to the other two floors, many chipped stone objects (n = 19) were present on the surface of Floor 3 (Chapter 8). Some of these are whole and the others are fragments. All the flakes are ignimbrite, a material obtained from the nearby Tajumulco source (Table 8.4). Floor 3 had by far the highest horizontal concentration of chipped stone, at 4.75 pieces per square meter, compared to 0.21 pieces per square meter on Floor 1 and zero pieces per square meter on Floor 2.

Abundant vertebrate faunal remains were on the surface of Floor 3, both within the specific features and elsewhere on the floor surface. Again, this is in strong

Figure 4.11. Three small fragments of polished bone from Floor 3. From left to right: stingray spine, bird, and medium mammal (photograph by Barbara Voorhies).

Figure 4.12. Photograph of floor sampling technique. Archaeologist Heather B. Thakar takes samples of Floor 1 at 1-m intervals along a tape measure. She is assisted by Luis Angel de los Santos Ovalle (photograph by Barbara Voorhies).

contrast to most areas on floors 1 and 2. In general, these bones on Floor 3 come from a fairly wide variety of animals, but fish bones are the most prevalent. In the features, as well as on the surface of the floor generally, the bone assemblages contain a mixture of animals rather than only one or two species. Table 4.3 lists the common names of animals identified in the faunal assemblages for each of the bone-cluster features shown in Figure 4.10. The jaw of a peccary was found at the southern end of the unit at the location of the X in Figure 4.10.

Finally, in strong contrast to the situation on the two upper floor exposures, three small polished bone fragments were found on Floor 3: a worked stingray spine fragment, a polished bird bone fragment, and a polished medium mammal bone fragment (Figure 4.11). Although these fragments are all too small to hazard a guess about the nature of the whole artifacts, these are the only samples of polished bone recovered during the 2009 field season.

In summary, the small area of the surface of Floor 3 available for study has evidence of fire features, plentiful chipped-stone flakes, abundant vertebrate faunal remains from a variety of animals, and three small fragments of worked bone. Taken together, they provide very convincing evidence that our excavation unit uncovered an activity area where the ancient Chantuto people butchered and cooked a variety of fish and game, as well as conducted other activities.

Summary of Floor Features

Spatial analysis of the distribution of primary cultural features and features of unknown origins reveals consistent associations in distinct feature types on the surface of both Floor 1 and Floor 2. Many large postholes are concentrated in the western portion of the exposed floor surfaces. These postholes consistently co-occur with large irregular surface depressions. Small postholes are concentrated in the southeastern portion of the exposed surface of Floor 1 and co-occur with a concentration of rock emplacements in this area. Overall, rock emplacements are concentrated on the eastern portion of the exposed surface of Floor 1. However, the northern cluster of rock emplacements does not co-occur with large quantities of small postholes. This might suggest functional differences between the two dense clusters of circular stone features, but it may also be due to different activities in the two areas at different points in time. Overlapping iterations of finger-molded semicircles on the surfaces of Floor 1 and Floor 2 provide the most direct evidence for the deliberate superimposition of features and the maintenance of structured activity areas on these floors.

Documentation of consistent structured use of the floor surfaces is an important key to understanding the people who formed the floor surfaces. However, the spatial patterns and feature associations are not sufficient to distinguish between the construction of wall-less thatched buildings, *tapesco*-like fish racks, or even crib-like elevated storage structures. Indeed, all proposed feature functions must be evaluated with

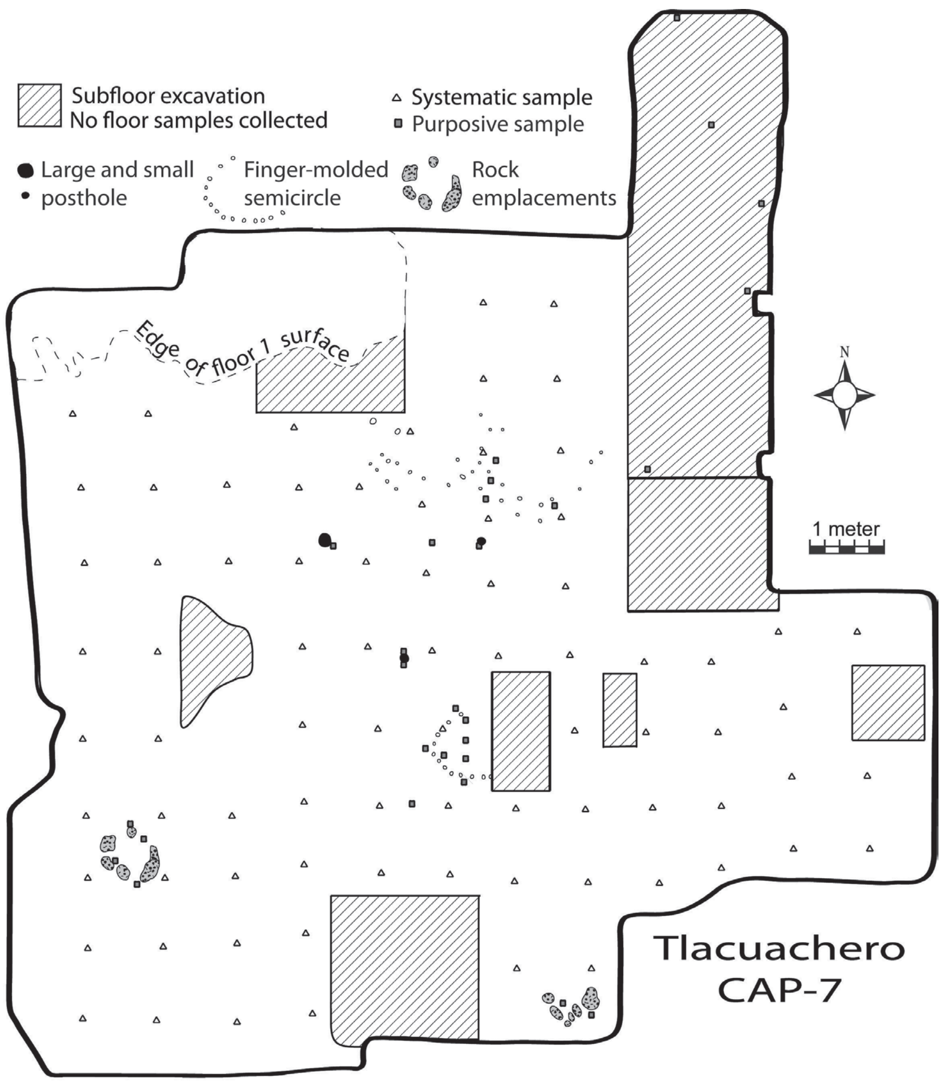


Figure 4.13a. Map of Floor 1 showing random and purposive sample locations relative to selected features (illustrations by Heather B. Thakar and Barbara Voorhies).

relationship to additional data sets to determine their use and purpose. This will be done in the penultimate chapter. Elucidating the function of these features is key to understanding the purpose of the floors themselves.

Sampling Procedures

The dearth of artifacts or other macroremains on the surfaces of the two upper floors severely inhibits the possibility of determining what activities were once carried out there, and by extension why the floors were formed. Analysis of microscopic and chemical constituents of the floor matrices affords an additional opportunity to elucidate the nature of human activities and other taphonomic processes that occurred on the surface of constructed floors at Tlacuachero. To accomplish this, we collected samples of floor sediment matrix from Floor 1 and Floor 2 using both random and nonrandom procedures (Figure 4.12).

Sampling methods were extensive rather than intensive. We collected systematic samples at the nodes of 1-m grids across the entire excavation exposures of Floor 1 and Floor 2 (Figure 4.13). In addition, we

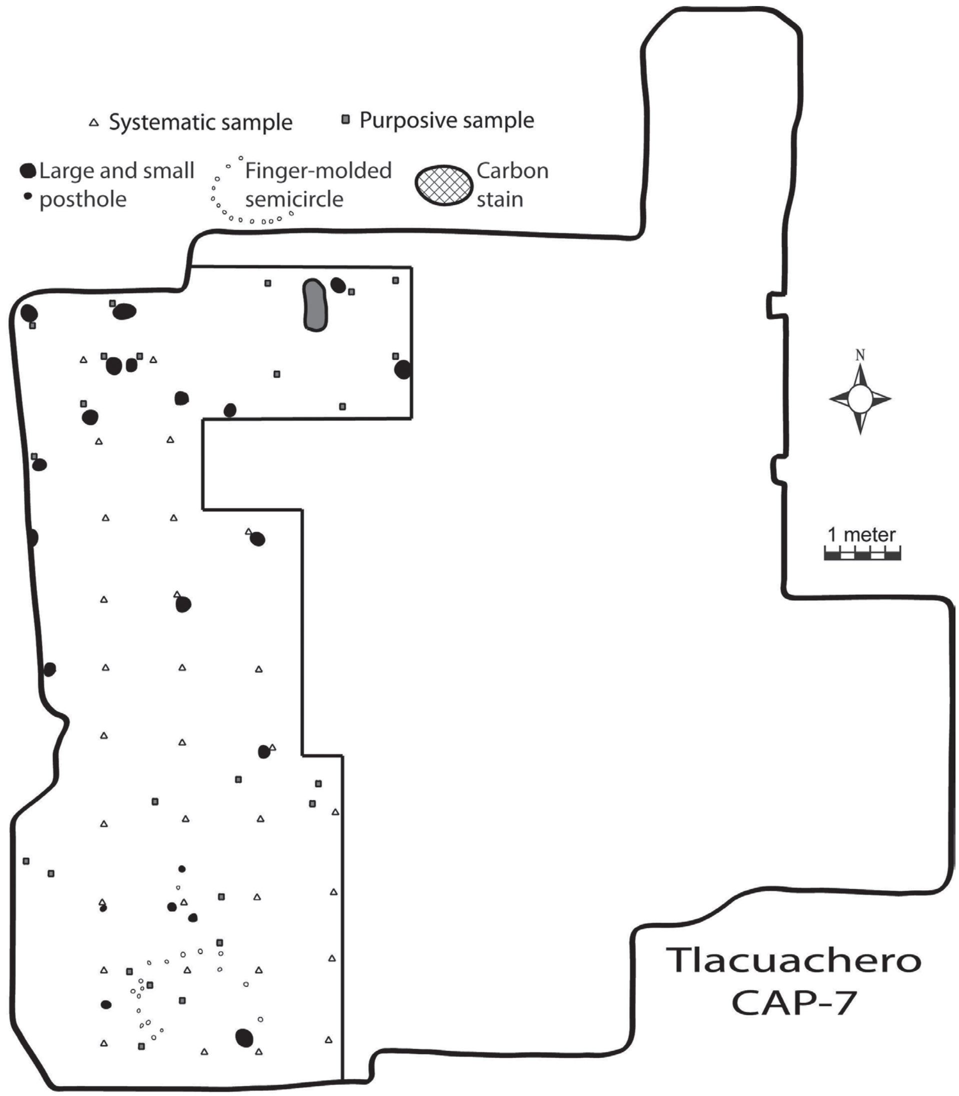


Figure 4.13b. Map of Floor 2 showing random and purposive sample locations relative to selected features (illustrations by Heather B. Thakar and Barbara Voorhies).

collected nonrandom, purposive samples in and around selected cultural features on each of the two floors. This sampling procedure facilitates analysis of spatial variation across the entire excavation area, such as differences between hypothesized structure interiors, activity areas, and feature functions.

At each sampling location, the floor surface was lightly scraped and then brushed clean to ensure uncontaminated collection of the floor sediment. The upper 2 to 3 cm of intact floor matrix, including all embedded materials, was removed by trowel within a 10 cm x 10 cm area and immediately placed in a labeled plastic bag. Following these procedures, 100 samples were collected from Floor 1 and 50 samples were collected from Floor 2.

The sediment samples were dried and then separated into four size classes by passing them through a set of nested geologic sieves in graduated mesh sizes (4 mm, 2 mm, 1 mm), with the finest material collected in a pan. This was done to facilitate hand sorting of the material for microrefuse analysis and to isolate fine sediment to be used for color, chemical, and phytolith analysis. Microrefuse analysis was carried out on the material caught in the three nested sieves with the

largest mesh sizes, which collectively we refer to as the coarse fraction of the total sample.

The finest material, which passed through all the sieves and was collected in the pan, could not be hand sorted, as the sediment is too fine. This sediment, referred to as the fine-fraction, was divided into smaller subsamples to be distributed to collaborators for specific analyses. Subsamples of fine-fraction sediment from each sample were sent to Hector Neff for geochemical analysis (Chapter 5) and to Doug Drake for phytolith analysis (Chapter 7). The results of their studies are reported here in separate chapters. I conducted spatial analysis of color variation on the remaining fine-fraction from each sample retained by Voorhies at University of California–Santa Barbara, as reported in Chapter 6.

Conclusions

In this chapter I have introduced the floors at Tlacuachero, which were the principal focus of the 2009 investigations at the site. I have discussed the cultural and noncultural features present on the floors and speculated about what may have caused them. In addition, I have discussed methods the archaeologists used to sample the floors in order to perform various laboratory analyses on their contents. The results of these analyses are presented in subsequent chapters.

The consideration of the spatial organization of archaeological features indicates the spatial separation of different human activities once carried out on the surfaces of floors 1 and 2 at Tlacuachero. On Floor 1 the large postholes are concentrated in the western sector of the excavation; rock emplacements occur primarily in the eastern half of the Floor 1 exposure; and the finger-molded semicircles are in the middle of the excavated area. Similar spatial layout on the surface of Floor 2 indicates continuity in the spatial organization of activities over time. We also know that the observed feature patterns do not represent a single moment of time on either floor but must be considered palimpsests, where features become superimposed over time. Clear evidence of this phenomenon is the superimposed finger-molded semicircles found on both floors 1 and 2.

References Cited

Aldenderfer, Mark S.

1998 *Montane Foragers: Asana and the South-Central Andean Archaic*. University of Iowa Press, Iowa City.

Barba, Luis

2007 Chemical Residues in Lime-Plastered Archaeological Floors. *Geoarchaeology* 22:439–452.

Binford, Lewis R.

1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.

Hampton, O. W. "Bud"

1999 *Culture of Stone: Sacred and Profane Uses of Stone Among the Dani*. Texas A&M University Press, College Station.

King, Stacie M.

2008 The Spatial Organization of Food Sharing in Early Postclassic Households: An Application of Soil Chemistry in Ancient Oaxaca, Mexico. *Journal of Archaeological Science* 35:1224–1239.

Smyth, Michael P.

1990 Maize Storage Among the Puuc Maya: The Development of an Archaeological Method. *Ancient Mesoamerica* 1:51–69.

Stahl, Peter W., and James A. Zeidler

1990 Differential Bone-Refuse Accumulation in Food-Preparation and Traffic Areas on an Early Ecuadorian House Floor. *Latin American Antiquity* 1:150–169.

Voorhies, Barbara

1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico.* Papers of the New World Archaeological Foundation, No. 41. Brigham Young University, Provo, Utah.

2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University of Florida Press, Gainesville.

2013 The Deep Prehistory of Indian Gaming: Possible Late Archaic Gameboards at the Tlacuachero Shellmound, Chiapas, Mexico. *Latin American Antiquity* 24:98–115.

Wauchope, Robert

1938 *Modern Maya Houses: A Study of Their Archaeological Significance*. Carnegie Institution of Washington Publication 502. Carnegie Institution, Washington, D.C.

Chapter 5

Geochemistry of the Tlacuachero Floors

Hector Neff, Paul Burger, and Isabela Kott

The "clay floors" entombed in the Tlacuachero shellmound (Voorhies 1976, 2004) apparently were used over a period of about 500 years during the Late Archaic period (Kennett et al. 2011; Chapter 2, this volume). During such extended use, a living surface would accumulate residue by-products of the activities carried out on it. These residues, when incorporated into the floor substrate, would be expected to alter the elemental composition of that substrate. Areas of greatest organic by-product accumulation would be expected to show the greatest alteration. If so, variation in the altered element's concentration across the surface should constitute a record of variation in the intensity of activities carried out on the floor.

Elemental characterization for the identification of activity areas has been demonstrated by a number of studies, especially during the past 10 years. Soil phosphate analysis has long been used to prospect for midden locations (e.g., Sjoberg 1976), and rapid means of soil phosphate analysis have been published recently (Rypkema et al. 2007). With the availability of rapid, affordable, multielement characterization techniques, archaeological soil and sediment characterization can be extended to include a wider range of elements that potentially may be enriched or depleted by human activities. Not surprisingly, a number of studies over the last decade have demonstrated that past occupation surfaces show elemental concentration variability that is plausibly attributed to variation in activities carried out on those surfaces (e.g., Barba 2007; Dahlin et al. 2007; Hutson and Terry 2006; Wells et al. 2007; Wells and Terry 2007).

What activities might have been carried out on the Tlacuachero floors and what effects might they have had on sediment chemistry? Based on the arrangements of features and presence of small bones discussed elsewhere in this volume (Chapter 6), our main hypothesis is that a variety of foods were processed and consumed on the stabilized surfaces. Such foods may have included shellfish, which obviously were procured and processed both before and after the occupation of the floors and remains of which are incorporated into the floors. Fish, crustaceans, mammals, reptiles, birds, and plants, including maize, might also have contributed by-product residues. Beyond processing, one would also expect that human consumption of food and subsequent elimination of bodily waste might have taken place on the stabilized surfaces.

Residues from food processing dropped on a stabilized surface would have affected the sediment chemistry, enriching elements common in foods

while diluting elements not present in the residues. Phosphorus is a component of crucial biological molecules, including DNA, and metals such as zinc, manganese, and iron are involved in a variety of metabolic pathways and therefore are found in tissues of virtually all organisms. Calcium and strontium, of course, are key components of bone and shells that might have been dropped on the surface, and lime is also used in the preparation of maize flour. Thus phosphorus, zinc, manganese, calcium, strontium, and iron potentially would be enriched by organic residues, but the precise effect would have depended on the starting composition of the sediment. If the starting material was clay (hydrated alumino-silicate), all of these elements, perhaps with the exception of manganese and iron, would have been enriched by food processing and elimination, while aluminum and silicon would have been slightly depleted. If, on the other hand, the starting material was powdered shell or some other carbonate material, calcium and strontium might have been slightly diluted while the other elements were enriched.

Methods

Here, laser ablation ICP-MS (LA-ICP-MS) and x-ray fluorescence (XRF) are used for elemental characterization of samples from the Tlacuachero floors, while Fourier-transform infrared spectroscopy (FTIR) is used to gain some insight into their mineralogical makeup. All analyses were conducted at the Institute for Integrated Research in Materials, Environments, and Society, California State University–Long Beach, under the direction of the senior author.

The goal is to test the hypotheses outlined above about what activities might have been carried out on the floors and to explore whether there is spatial variation across the floor in the elemental indices of these activities.

Preparation of the sediment samples for elemental analysis involved homogenization, infusion with an internal standard (indium), and consolidation with an XRF binder. An internal standard is necessary for the ICP-MS analysis because signal intensities vary over time, with fluctuations in laser power and with depth of the crater created by the laser. The 40-ppm indium added as the internal standard has no effect on the XRF spectra.

LA-ICP-MS analysis was undertaken using a GBC Optimass 8000 time-of-flight ICP-MS connected to a New Wave UP213 laser ablation system. Signals of a wide range of major, minor, and trace elements were monitored as the laser ablated along a line on the pressed pellets. Since the material was originally assumed to be clayey sediment, the standards used were those normally used in analysis of sediments and pottery: NIST-standard glasses SRM612 and SRM610, NIST brick clay, SRM679, and Ohio Red Clay. Very high calcium concentrations in the floor samples made calibration problematic using the infused indium internal standard, so aluminum was instead used as the internal standard, the signal intensities then being calibrated to concentrations by summing to 100 percent oxides, as suggested by Gratuze (1999; Neff 2012). Our assumption that the floor was clayey sediment also led us to omit phosphorus from the analysis, but this is an inconsequential omission because phosphorus was easily detectable by the XRF analysis.

The Bruker Tracer portable XRF instrument used in this study allows variable x-ray tube settings and beam filtering in order to optimize signal-to-noise ratios for elements of interest. Elements from magnesium to niobium were determined from K-alpha lines, with some L-alpha lines in this spectral region measured as well. Each sample was analyzed twice. K-alpha lines from magnesium to iron were determined with the high voltage set at 15 kV and the anode current at 15 microamps, with no filter, and with the detector chamber evacuated. K-alpha lines from iron to niobium were determined using a filter consisting of thin foils of aluminum, titanium, and copper; 40 kV high voltage; and 15 microamps anode current. The L-alpha line for barium was measured on the first analysis, and the L-alpha lines for lead and thorium were measured on the second analysis. Quantification of the data involved calculating peak areas for all detectable elements in the sample. Direct analysis of signal intensities reduces noise that can be introduced through calibration based on standards and provides a better basis for examining spatial variation in elemental concentrations.

The FTIR analyses were undertaken on a Bruker Alpha portable FTIR spectrometer equipped with an attenuated total reflectance (ATR) crystal. The ATR crystal permits IR absorbance to be measured on

powdered samples with no sample preparation beyond slight grinding to produce the powder.

All the analytical techniques used here yield multivariate data, and although it is often useful to examine variation of single variables, multivariate pattern recognition techniques offer a more powerful means for examining interobject clustering and intervariable covariation. Here, principal components analysis (PCA) is used to extract the largest axes of variation from the various data sets and to identify which of the original variables contribute most strongly to the major axes.

Results

In this section we present the results of each of the three analyses that we conducted.

LA-ICP-MS Analysis

Initial perusal of the LA-ICP-MS results made it immediately clear that the floor samples were very far from the expected composition of a clay floor. Both silicon and aluminum are far below 1 percent in all samples, the averages being 0.3 percent for aluminum and 0.1 percent for silicon. If the floor material included clay (hydrated alumino-silicate) in any quantity, concentrations of aluminum should have been 5 percent or more, and concentrations of silicon should have been 15 percent or more. In marked contrast to the extremely low aluminum and silicon concentrations, calcium averages around 39 percent. Although LA-ICP-MS calcium determinations may be slightly inflated due to the omission of phosphorus from the summation to 100 percent oxide concentration, calcium, presumably as calcium carbonate, is clearly the major component of the sediments making up the floor.

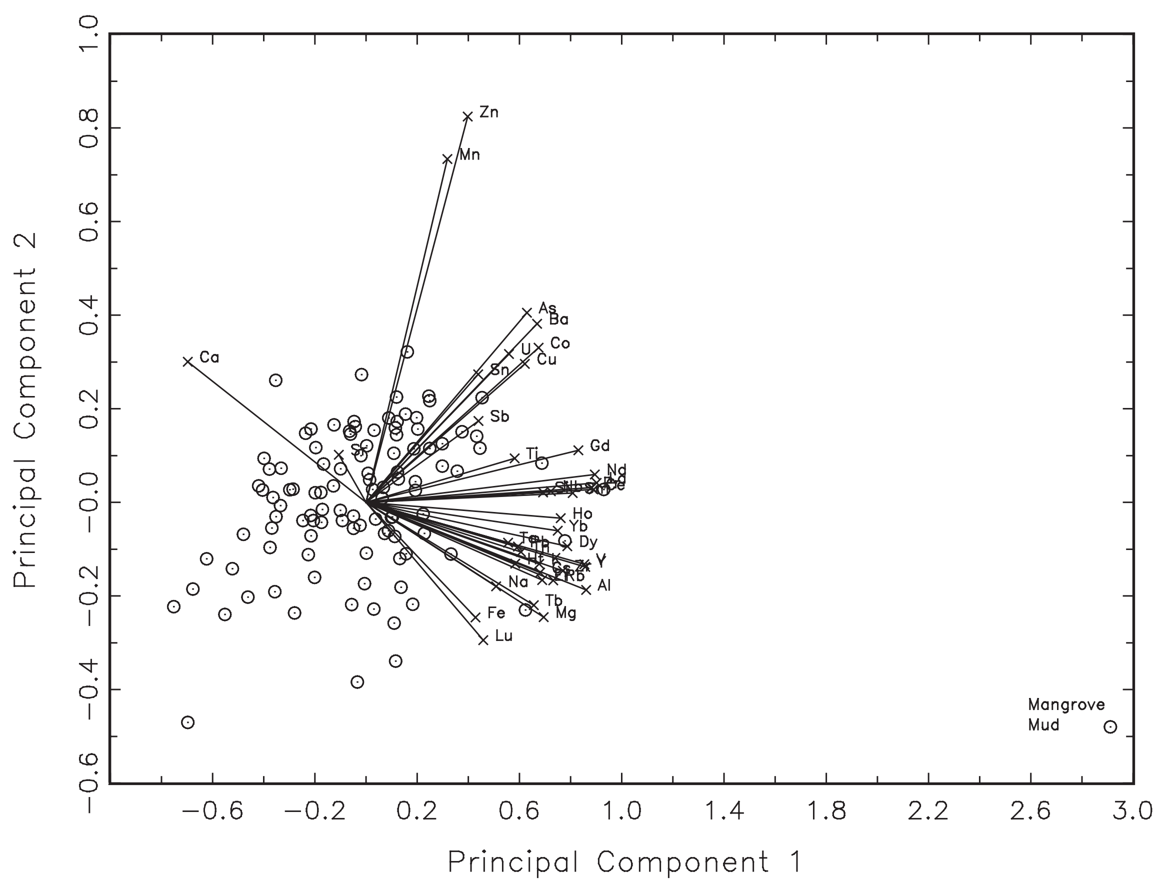


Figure 5.1. Biplot derived from PCA of the correlation matrix of LA-ICP-MS data on samples from Tlacuachero Floor 1. Vectors from the origin indicate the direction of each element's contribution to the configuration of the sediment samples on these two principal components (illustration by Hector Neff).

A biplot derived from principal components analysis of the LA-ICP-MS data (Figure 5.1) shows that calcium and strontium vary inversely with aluminum, silicon, iron, titanium, rare earth elements, and other trace elements. Strontium has the same valence-electron configuration as calcium and substitutes for it in calcite and other minerals, so the positive correlation of the two elements is expected. The inversely correlated elements clearly act together as impurities, slightly diluting calcium and strontium concentrations in the matrix. Zinc and manganese, two elements found in plant and animal tissues, are the most important contributors to variation on PC2, and, as the configuration of variable coordinates in Figure 5.1 shows, they are uncorrelated with calcium and strontium on the one hand and with the impurity metals and rare earths on the other hand. Overall then, PC1 of the LA-ICP-MS data seems to monitor purity of the calcareous matrix material while PC2 monitors contributions from biologically important elements, specifically manganese and zinc.

The LA-ICP-MS results allow us to reject an implicit hypothesis that has guided research at Tlacuachero for over 30 years (Voorhies 1976, 2004)—namely, that the floors consist of some kind of clay-rich sediment. The major element composition of all analyzed floor samples is entirely incompatible with the characterization *clay* and instead fits the elemental composition of some kind of powdered calcareous material. The extremely divergent position of the mangrove mud sample in Figure 5.1 highlights the distinctiveness of the floor material relative to noncalcareous sediments of the Acapetahua Estuary region. In addition, the observation that biologically important elements (manganese and zinc) govern the second-largest axis of variation in the data (PC2) supports the hypothesis that residue by-products from the processing of foods modified the original composition of the floor sediments and created the observed pattern of elemental variation.

X-Ray Fluorescence Analysis

Although XRF determines far fewer elements with less sensitivity than LA-ICP-MS, it has some important advantages over the LA-ICP-MS analyses in the present study. For one thing, the data can be examined without calibration, which eliminates the standardization problems discussed above and provides a more reliable indication of relative concentration differences from place to place across the floor. Second, possible sources of residues left on the floor, such as fish, shrimp, and *pozol* (maize flour), could be analyzed to assess their potential to have contributed to observed elemental variation. Samples of lagoon-bottom sediment and mud from the mangrove forest floor adjacent to Tlacuachero were also included as background reference samples. Third, phosphorus, which was omitted from the LA-ICP-MS analysis, could be determined post hoc from the x-ray spectra once it became clear that the "clay floor" was something other than clay and that other biologically important elements (zinc and manganese) contributed to elemental variation.

Figure 5.2 shows four XRF spectra, all obtained using the same instrument settings. At the top of the figure, spectra from mangrove mud and lagoon-bottom sediments are overlain and normalized to each other. Salient characteristics of these local sediments include high iron, high silicon (especially in the lagoon-bottom sediment), presence of an aluminum peak as a bulge on the left side of the silicon peak, a relatively small calcium peak, and undetectable phosphorus and zinc peaks. In the bottom of Figure 5.2, a sample from the floor is shown together with a sample of mammal bone, again with the two spectra normalized to each other. Salient characteristics of these two spectra are absence of silicon and aluminum peaks, a prominent phosphorus peak, a very prominent calcium peak, a small iron peak, and a detectable zinc peak, despite high background in this region. These qualitative results strongly reinforce the main conclusion of the LA-ICP-MS analysis—namely, that the floor material is very distinct from clayey sediments, including off-site sediments sampled in the immediate vicinity of Tlacuachero. In addition, the XRF spectra demonstrate the presence of phosphorus in the floor and show that the relative concentrations of phosphorus and calcium are roughly the same in the floor as in the bone. The last observations point to a viable hypothesis about the nature of the floor material—namely, that it is the mineral equivalent of bone— that is, hydroxylapatite. This hypothesis is examined in more detail later on, in the discussion of FTIR results.

As noted previously, statistical analysis of the floor data was carried out on the net intensities data without

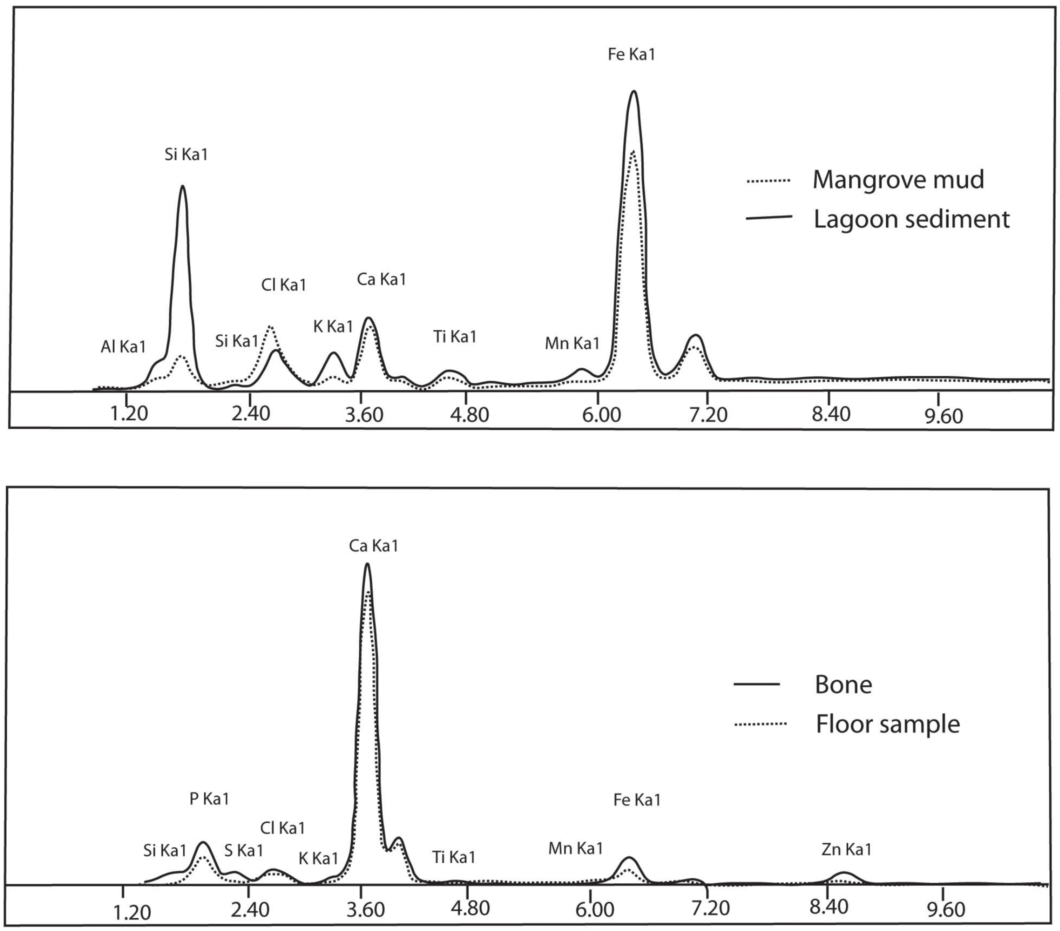


Figure 5.2. Top: XRF spectra from mangrove mud (dotted line) and lagoon-bottom sediment (solid line). Bottom: XRF spectrum from bone (solid line) together with one of the Tlacuachero floor samples (dotted line). All spectra were taken with accelerating voltage of 15 kV and 15 microamps beam current, with no filter and with the detector chamber evacuated (illustration by Hector Neff).

the intervening step of calibration to elemental concentrations. XRF analyses were undertaken on both Floor 1 and Floor 2 samples. These samples are all of a relatively uniform matrix, so there should be little matrix-related variation in sensitivity for the various elements. The potential residue sources (fish, shrimp, shell, and *pozol*) are obviously different matrices, but the relative peak intensities should nonetheless show the *direction* (if not the specific magnitude) of their compositional effects.

As with the LA-ICP-MS data, principal components analysis (PCA) was used to identify the major axes of elemental variation in the data. Due to the smaller suite of determined elements and the inclusion of samples not analyzed by LA-ICP-MS (Floor 2), the major axes of variation in the XRF data differ somewhat from those in the LA-ICP-MS data. As shown in Figure 5.3, PC1 subsumes a strong negative correlation between calcium on one hand and, on the other hand, the biologically important elements phosphorus, zinc, and manganese. PC2, meanwhile, expresses enrichment of iron, silicon, titanium, and cobalt. Projection of the shell, mangrove mud, and food items into the PCA space indicates that shrimp, fish, and *pozol* would all contribute to lower scores on PC1, whereas shell (near pure calcite or aragonite) contributes to higher scores. Floor 2 samples overlap Floor 1 samples but form a much tighter cluster toward the low end of PC1 (that is, enriched in manganese, zinc, and phosphorus). The mangrove mud, being much higher in silicon and metals, differs dramatically from all floor samples and from the analyzed foods.

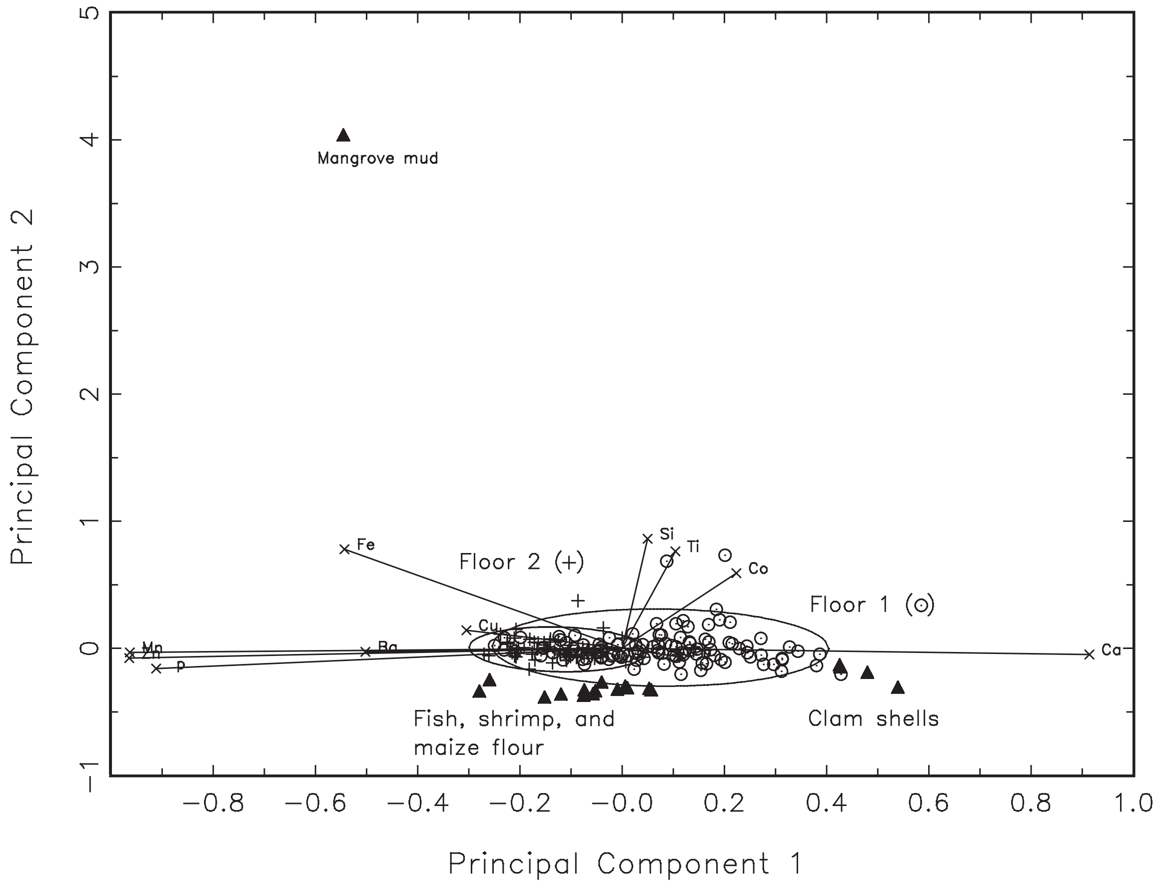


Figure 5.3. Biplot derived from PCA of the correlation matrix of XRF peak-intensities data from Tlacuachero Floor 1 (circles) and Floor 2 (crosses) samples. Comparisons (triangles) of food samples, clamshells, and mangrove mud are projected into the PCA space (illustration by Hector Neff).

Bivariate plots of the net intensities data further clarify patterns of enrichment and dilution in the XRF data. As detected by the PCA, calcium is negatively correlated with several elements, including phosphorus. A bivariate calcium-phosphorus plot (Figure 5.4) makes it clear that, assuming the starting floor material was powdered calcium carbonate similar in composition to shell, residues from fish and shrimp could create intermediate compositional profiles within the range of variation of the floor compositions.

A bivariate plot of zinc and phosphorus (Figure 5.5) shows the strong positive correlation of these elements and confirms that zinc, like phosphorus, is enriched relative to calcium carbonate, the likely starting composition of the floor. Residues from biological tissues are likely sources of this positively correlated enrichment. For instance, as Figure 5.5 shows, zinc enrichment is plausibly due to processing of shrimp and/or fish on the floor.

In summary, the XRF data for floors 1 and 2, together with the analysis of possible residue sources, reinforce and extend the conclusions based on the LA-ICP-MS study of Floor 1. First, the XRF data are completely incompatible with the characterization of the Tlacuachero surfaces as "clay floors." Instead, the proportions of calcium and phosphorus indicate that the surfaces are hydroxylapatite, a common form of which is bone. The only recognizable bone fragments in the floor, however, are small fish bones (as discussed by Thakar in Chapter 6, this volume), and it is difficult to imagine that the fine powdered material that makes up the bulk of the floor came from ground-up bone; one would expect to see partially ground bone pieces if this were the case. Moreover, phosphorus-to-calcium ratios are not constant, as would be expected if the floor were ground-up bone, but rather higher levels of phosphorus are associated with lower levels of calcium

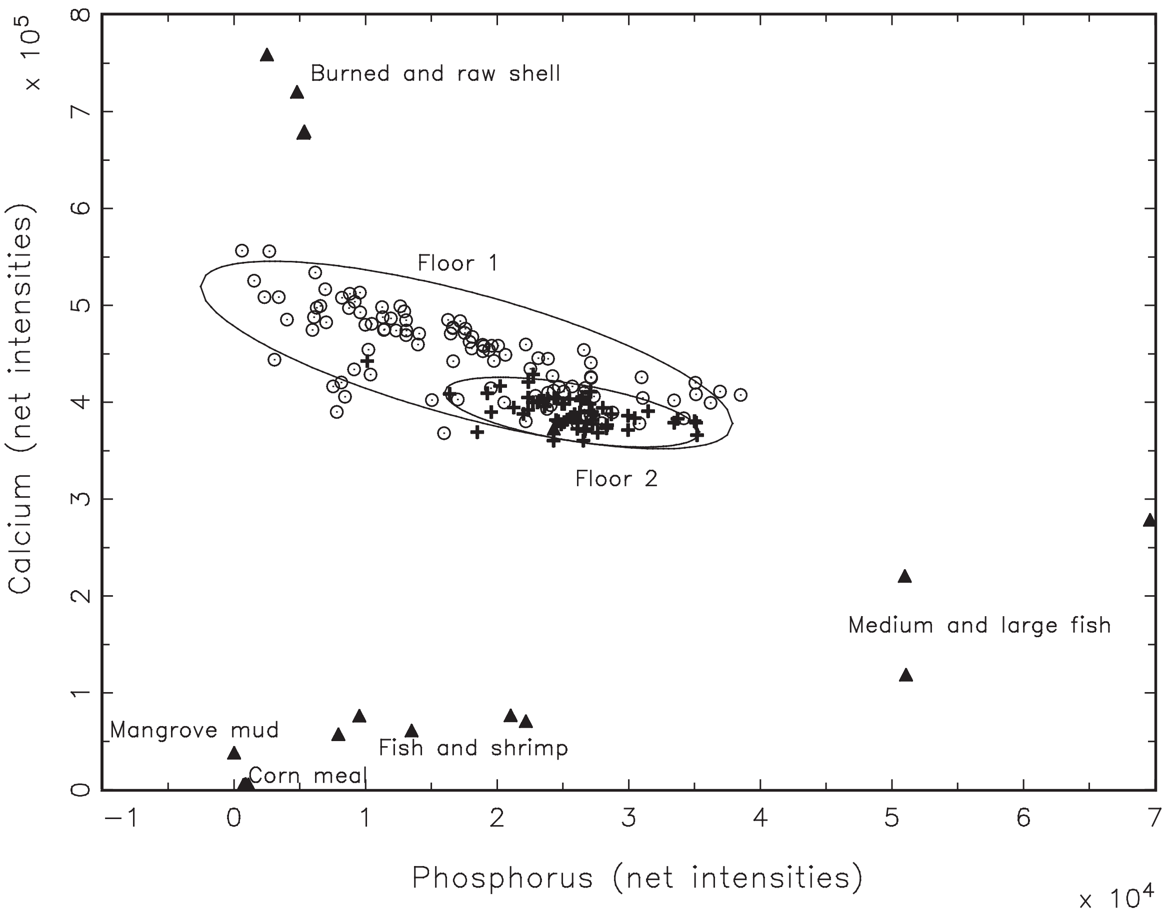


Figure 5.4. Bivariate plot of phosphorus and calcium net intensities in Tlacuachero floor samples and samples of fish, shrimp, shell, pozol, and mangrove mud also analyzed by XRF. Floor 1 = circles; Floor 2 = crosses; comparisons = triangles (illustration by Hector Neff).

(Figure 5.4) and higher levels of zinc, another biologically important element (Figure 5.5). Such a pattern of elemental variation is plausibly attributed to deposition of residues from the processing of marine and estuarine animals for consumption on top of a surface that started out as calcium carbonate. In short, the hypothesis that emerges from the elemental studies is that the floors are diagenetic hydroxylapatites formed when phosphates from organic residues reacted with carbonates that were present initially.

FTIR Analysis

FTIR analysis offers a means to evaluate the foregoing hypothesis about the molecular state of elements present in the floor sediments. Absorbance of infrared radiation occurs when the frequency of impinging radiation matches the frequency at which molecular bonds in the material vibrate. The output of the FTIR spectrometer is a spectrum indicating how much IR radiation the material absorbs at different wavelengths (usually expressed as cm^{-1} or wavenumber). Peaks on the output spectra indicate the presence of various types of molecular bonds. Weiner (2010:Chapter 12) provides a comprehensive guide to the use of FTIR in the analysis of various archaeological materials, including carbonates and apatites, which are of greatest interest here.

Figure 5.6 shows a typical FTIR spectrum from the floor together with a spectrum from mammal bone. From left to right, absorbance peaks include 1412 cm^{-1} (carbonate), 1012 cm^{-1} (phosphate), 872 cm^{-1} (carbonate), 712 cm^{-1} (carbonate), 603 cm^{-1} (phosphate), 564 cm^{-1} (phosphate), and 465 cm^{-1} (phosphate). Heights of these peaks in the floor sediment spectra were calculated to quantify calcite versus carbonate hydroxylapatite.

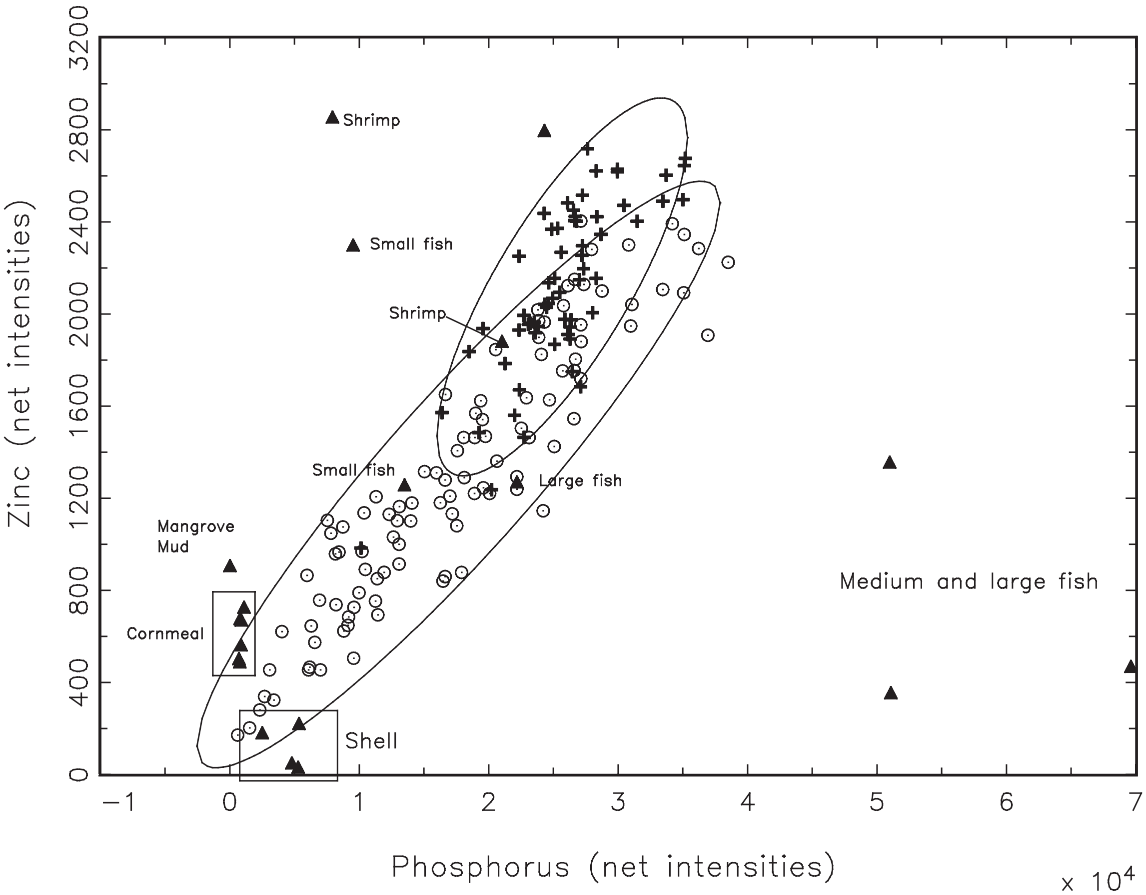


Figure 5.5. Bivariate plot of phosphorus and zinc net intensities in Tlacuachero floor samples and samples of fish, shrimp, shell, pozol, and mangrove mud also analyzed by XRF. Floor 1 = circles; Floor 2 = crosses; comparisons = triangles (illustration by Hector Neff).

Sample FS 09-433 represents one extreme of the range of FTIR spectra obtained from Floor 1 (Figure 5.7). In this spectrum, the carbonate peaks at 1401, 872, and 712 are prominent, while the phosphate peaks are minor. FS 09-433 is very similar to ash calcite, a spectrum of which is shown in the bottom part of Figure 5.7. Geogenic and biogenic calcites (not shown) are also very similar to FS 09-433. Under the diagenetic hypothesis outlined above, this nearly pure calcium carbonate is from a part of the floor that was minimally altered by deposition of organic residues and subsequent combination of phosphates with the original carbonate material of the floor.

PCA was undertaken on the peak-height data for seven phosphate and calcite peaks extracted from the Floor 1 and Floor 2 samples and from natural comparison materials. A biplot of the resulting variable and object coordinates (Figure 5.8) shows that PC1, the largest axis of variation in the data, subsumes variation from an extreme of near-pure calcium carbonate to an opposite extreme that is strongly determined by phosphate absorbance peaks. Importantly, bone hydroxylapatite (the mammal bone data at the top of Figure 5.8) does not fall at the opposite extreme from calcium carbonate; this is consistent with the inference that the floor material is not some kind of ground-up bone but rather a diagenetically created carbonate hydroxylapatite. FTIR spectra from the majority of the floor samples (for example, Figure 5.6, bottom) show all of the main features mentioned by Weiner (2010:286–297) as characteristic of carbonate hydroxylapatite. Again, the near-pure calcium carbonate samples, such as FS 09-433 (Figure 5.7, top), are exceptions. PC1 of the IR absorbance data (Figure 5.8) thus appears to represent a continuum from near-pure calcium carbonate, the inferred

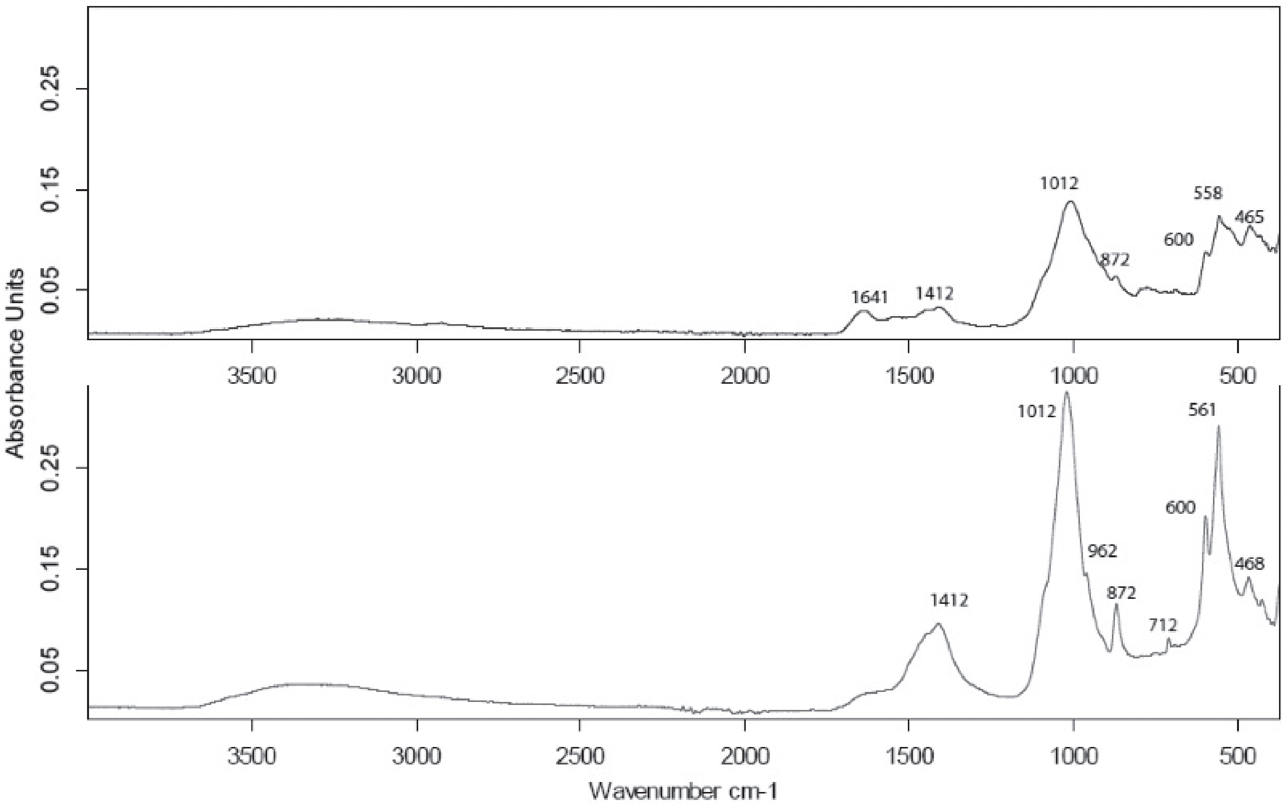


Figure 5.6. FTIR spectra for powdered mammal bone (top) and Floor 1 sample FS 09-416 (bottom). Numbers near peaks indicate wavenumber of maximum absorbance (illustration by Hector Neff).

starting material of the floor, to highly altered carbonate hydroxylapatite with prominent phosphate IR absorbance peaks.

Figure 5.9 is a bivariate plot of the raw peak-height data for the 603 cm^{-1} peak and the 712 cm^{-1} peak, the former being unique for carbonate hydroxylapatite and the latter being unique for calcite. There is a strong negative correlation between the peak heights, with one extreme (high 712 cm^{-1} and low 603 cm^{-1}) representing near-pure calcite and the other extreme representing highly altered carbonate hydroxylapatite. Both the ash calcite sample and the geological calcite plot at the calcite extreme, as expected, along with several near-pure calcite samples from the floor. Most Floor 1 samples and virtually all Floor 2 samples show significant alteration to diagenetic carbonate hydroxylapatite.

Analysis of the FTIR spectra obtained from floor sediments strongly supports the hypothesis that the floor was affected by deposition of variable amounts of organic residues, phosphates from which later reacted with the original calcium-carbonate matrix to form carbonate hydroxylapatite. The reaction of carbonates and phosphates would have taken place as microbial breakdown of organic material lowered pH, allowing carbonate hydroxylapatite to form. Although carbonate hydroxylapatite is relatively soluble (Karkanas et al. 2000; Weiner 2010: 296–297), the strongly alkaline calcium-carbonate matrix of the floor itself and the underlying shell deposits prevented pH from dropping to the point where carbonate hydroxylapatite would transform into less-soluble authigenic phosphate minerals.

Spatial Variation in the Elemental and FTIR Data

If organic residues from food processing transformed an original calcium carbonate matrix into carbonate hydroxylapatite, one would expect spatial patterning in the deposition of residues to have created

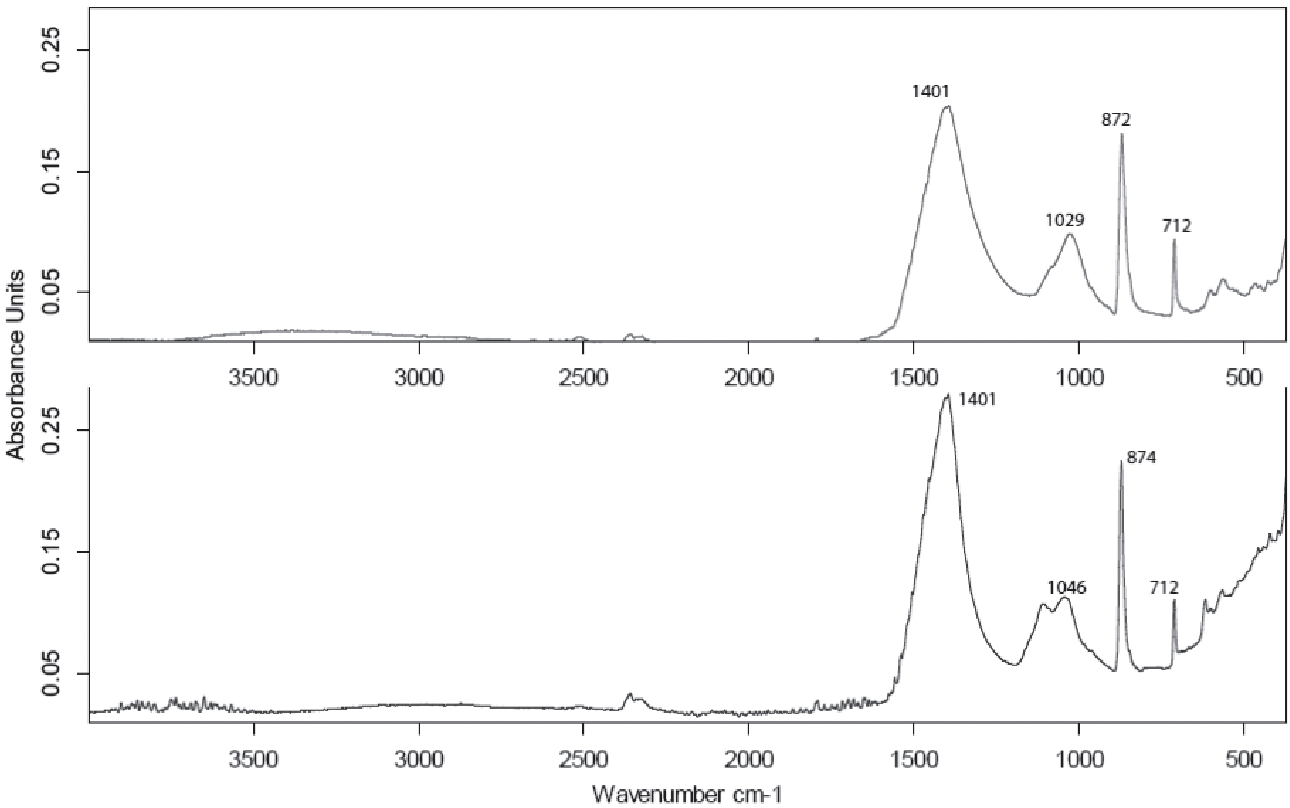


Figure 5.7. FTIR spectra for Floor 1 sample FS 09-433 (top) and a ground sample of wood ash calcite (bottom). Numbers attached to peaks indicate wavenumber of maximum absorbance (llustration by Hector Neff).

spatial patterning in the elemental and mineralogical makeup of the floor. One spatial pattern is already clear: average zinc and phosphorus levels in Floor 2 are substantially higher than Floor 1, and the range of values is smaller (Figure 5.4 and Figure 5.5). Similarly, the transformation of calcium carbonate to carbonate hydroxylapatite has generally been more complete on Floor 2 than on Floor 1 (Figure 5.8 and Figure 5.9).

Figures 5.10 through 15.19 are maps of variation in the elemental and FTIR data across the two sampled Tlacuachero floors. With the exception of figures 5.10 and 5.15, dark gray on these maps represents elevated values, whereas light gray represents depressed values. The scale in figures 5.10 and 5.15 is reversed because PC1 of the XRF data, the food residue dimension, has zinc and phosphorus contributing negatively and calcium contributing positively. Each map is superimposed over the floor base map, so that associations between observed features on the floors and patterns of elemental enrichment or IR absorbance are apparent.

The Floor 1 elemental maps (figures 5.10–5.12) show that PC1, phosphorus/calcium, and zinc/calcium have strikingly similar spatial trends across the floor. The area of rock impressions in the northeast corner of the exposed floor is highly enriched in elements associated with food residues, as are the areas associated with finger-molded holes extending southwest from these rock impressions. The southeast corner and the western side of the exposed area, meanwhile, are lower in all three indices of residue effects.

The map of PC1 scores from the FTIR data (Figure 5.13) shows almost the same pattern as observed in the elemental data. High PC1 scores (indicating predominance of carbonate hydroxylapatite relative to unaffected calcium carbonate) occur in the same sections of the floor where high

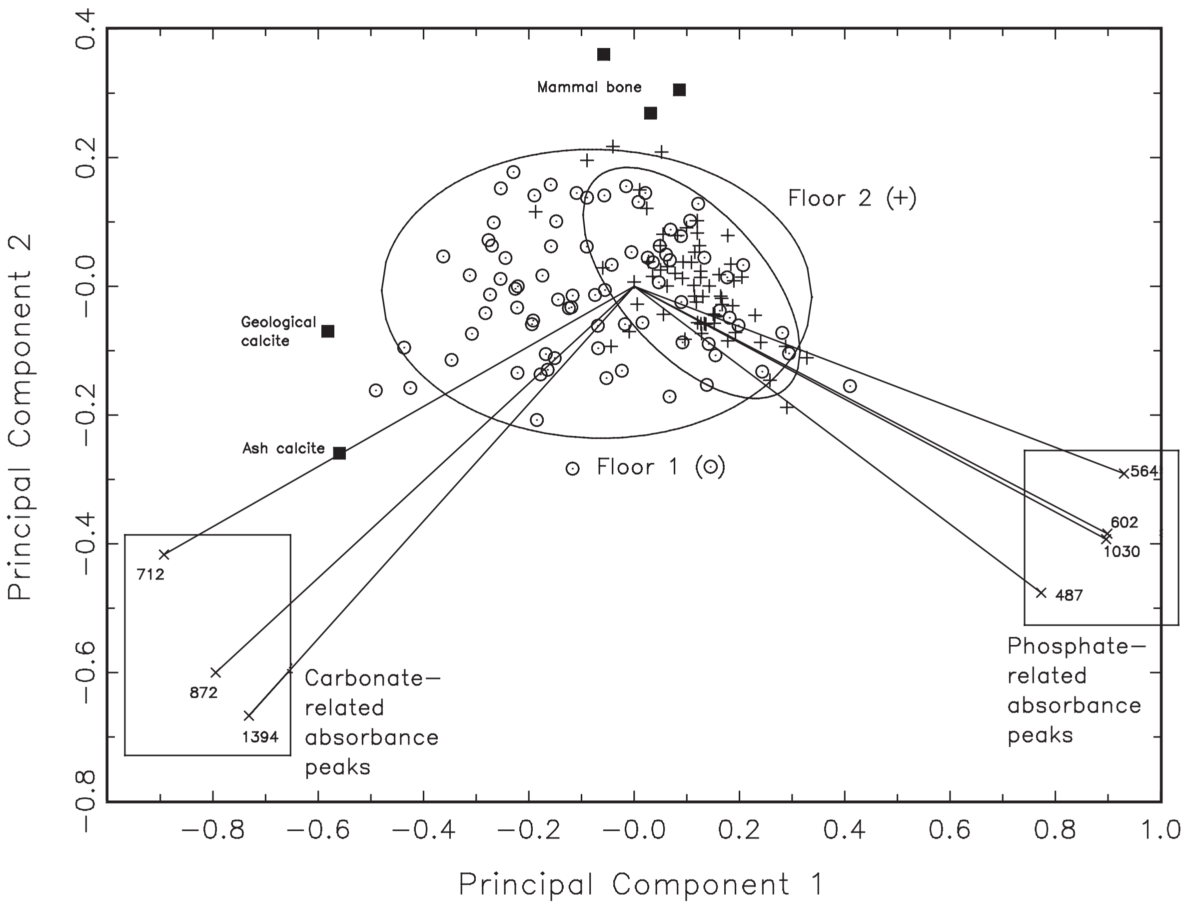


Figure 5.8. Biplot derived from PCA of the correlation matrix for seven absorbance peaks extracted from FTIR spectra for the floor samples. Figures 5.6 and 5.7 illustrate how heights of the seven peaks were measured in the raw FTIR spectra. Numbers at the ends of the variable vectors indicate wavenumbers of the measured absorbance peaks. Floor 1 = circles; Floor 2 = crosses; comparisons = rectangles (illustration by Hector Neff).

phosphorus/calcium and high zinc/calcium are observed in the elemental data. Similarly, the map of the 603 cm^{-1} to 712 cm^{-1} ratio data (Figure 5.14) demonstrates that prominence of diagenetic alteration (high 603 cm^{-1}) in the same locations that show high zinc and high phosphorus. These observations provide strong support for the hypothesis that diagenetic alteration of calcite following deposition of phosphorus-enriched organic residues on top of the floor created the carbonate hydroxylapatite material that currently makes up the floor and left evidence of where organic-residue deposition was most concentrated. As noted, residue effects seem to be concentrated in the areas of rock emplacements and circular patterns of finger-molded holes. The spatial contrast of unaltered versus altered areas is perhaps most clearly visible on the 603 cm^{-1} to 712 cm^{-1} ratio map (Figure 5.14).

Similar spatial patterns in the elemental and FTIR data are also evident on Floor 2 (figures 5.15– 5.19). As noted previously, phosphorus and zinc enrichment are generally higher on Floor 2 compared to Floor 1, and this shows up clearly on the phosphorus/calcium and zinc/calcium maps (figures 5.16 and 5.17). Diagenetic carbonate hydroxylapatite also predominates over the calcium carbonate background over a larger proportion of Floor 2 (figures 5.18–5.19). As on Floor 1, the indicators of elemental enrichment and diagenetic formation of carbonate hydroxylapatite coincide, and all indicators are high in the vicinity of a circular arrangement of finger-molded holes in the southern part of the area

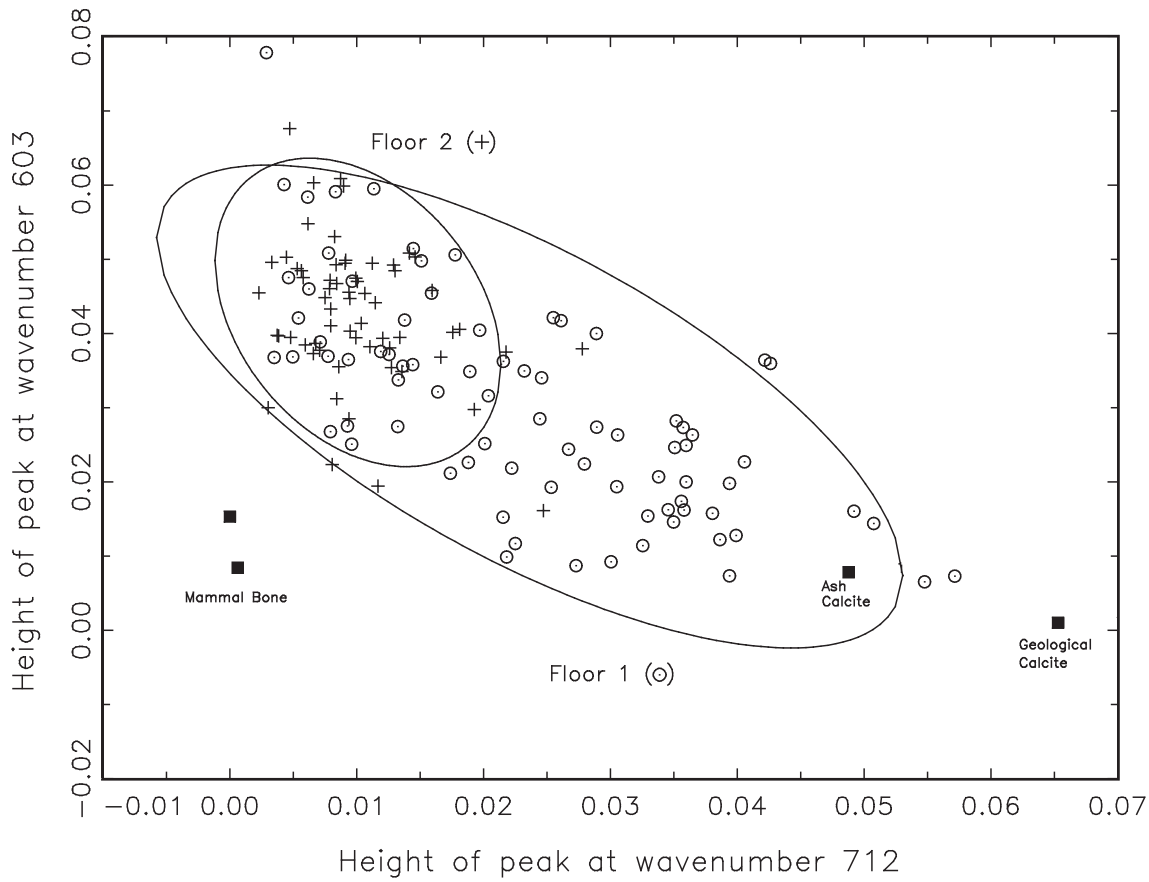


Figure 5.9. Bivariate plot based on measured height of peaks at wavenumber 603 and 712 FTIR spectra from Floor 1 and Floor 2, together with some natural materials, which are labeled. The 603 cm^{-1} peak uniquely indicates the presence of carbonate hydroxylapatite, while the 712 cm^{-1} peak uniquely indicates the presence of calcite. Floor 1 = circles; Floor 2 = crosses; comparisons = rectangles (illustration by Hector Neff).

mapped. Interestingly, however, there is a depression of all diagenetic indicators within the semicircular feature defined by the finger holes, while peak diagenetic alteration occurs immediately outside this feature. An area of large postholes at the northern end of the mapped area also has enriched residue elements and predominance of carbonate hydroxylapatite.

The main finding of the spatial analysis is that elemental (XRF) and mineralogical (FTIR) indicators show very similar patterns of variation across both Floor 1 and Floor 2. This finding is consistent with the hypothesis that residues from decomposition of organic remains reacted with the original calcium carbonate matrix material to produce the carbonate hydroxylapatite material that currently makes up the floor feature.

Conclusions

Geochemically, the Tlacuachero floors are carbonate hydroxylapatite. The patterns of elemental and IR-absorbance variation (figures 5.1, 5.3, 5.4, 5.5, 5.8, and 5.9) are incompatible with any other interpretation. Elementally, the floors differ from the underlying shell matrix in the enrichment of elements associated most closely with animal tissue (zinc and phosphorus), and they also differ from natural fine-grained silicate sediments, such as the mangrove mud and lagoon-bottom sediments sampled locally. Mineralogically, one extreme of the range of FTIR spectra from the floor approximates calcite, but the vast majority of spectra have absorbance peaks found most commonly in diagenetic carbonate hydroxylapatites (Weiner 2010:295–297). Originally, the floor

must have been pyrogenic (ash) or biogenic (shell) calcite. Deposition of organic remains, presumably from food processing, followed by microbial breakdown then added phosphorus and zinc and lowered the pH, favoring the reaction of calcite with phosphates from the organic matter.

Based on these results, the Tlacuachero floors were surfaces on which people processed or consumed foods, most probably including fish and other animals whose tissues are enriched in phosphorus and zinc. Certain locations on the floors, especially those associated with the enigmatic finger-molded holes, were more heavily utilized for these activities than others. It is possible that the postholes represent components of perishable structures and that the more versus less heavily used areas correspond to interior and exterior spaces of buildings, but unfortunately the configuration of postholes does not clearly indicate what might have been interior and what might have been exterior space. The phytolith study (Chapter 7 in this volume) does not seem to support the idea that heavily used areas were interiors.

At some point, people covered up Floor 2 with Floor 1. By the time this happened, Floor 2 was more heavily affected by by-product residues than Floor 1 ever was. This suggests that residue-deposition and diagenetic alteration of Floor 2 took place over a longer period of time than in the case of Floor 1. In addition, the fact that people exerted the effort to cover Floor 2 with a fresh layer of calcium carbonate may indicate that the accumulation of residues made the surface less desirable as a living and/or food-processing surface.

The inference that the Tlacuachero floors became less desirable as they accumulated residues brings up another possible source of organic residues mentioned in the introduction but not addressed explicitly in the analysis. Humans processing and consuming foods implies humans eliminating the bodily waste products from food consumption. Any stay at island Tlacuachero of more than a few hours would have resulted in humans contributing to the chemical environment in this way. The areas of high phosphorus, high zinc that we infer to be areas of high accumulation of residues from food processing might also have served as latrines during some part of the floors' use-history.

What was the origin of the calcium carbonate matrix that made up the inferred starting material of the floors? With local lagoon and mangrove sediments ruled out, the two most obvious possibilities are shell and wood ash. Mollusk shell dominates the layers above and below the floors, and many of the layers show evidence of burning. Bulk samples from the floors consist of macroscopic shell fragments in a brown powder matrix, which implies that both ash and shell served as sources of the starting material. But if the same basic processes (accumulation of shell and burning of wood fires) account for the formation of the floors and the underlying and overlying layers, why do the floors have such a visually distinctive, fine-grained matrix?

One possible explanation for the visual distinctiveness of the floor strata is that they represent periods of much more intensive use than do the underlying and overlying shell strata. While the shell strata may have accumulated as a result of occasional visits by people harvesting marsh clams and sometimes having clambakes, the floor layers may have resulted from near-continuous occupation by people who kept fires burning and carried out other domestic activities over extended periods of time. There are a few features identified as hearths on the floors themselves, but more such features might have been obliterated by people cleaning up the living area and raking the ash into uniform layers, which we currently recognize as floors. Intensive use over long periods of time is also consistent with the advanced state of diagenetic alteration of the calcium-carbonate matrix documented here. And finally, the high-precision radiocarbon dates reported by Kennett et al. (2011 and this volume) from the Tlacuachero stratigraphic sequence are consistent with long-term, intensive use, since the dates indicate that the less than 50 cm of Floor 1–through–Floor 3 deposits accumulated over a period of more than 500 years while the deep overlying and underlying shell layers accumulated much more rapidly.

Acknowledgments. Funding from National Science Foundation (BCS0321361, BCS0917702, and BCS1115361) supported parts of this work. We are also grateful to Jessica Jaynes, Scott Bigney, and Richard George for carrying out much of the sample preparation and for running analyses reported here.

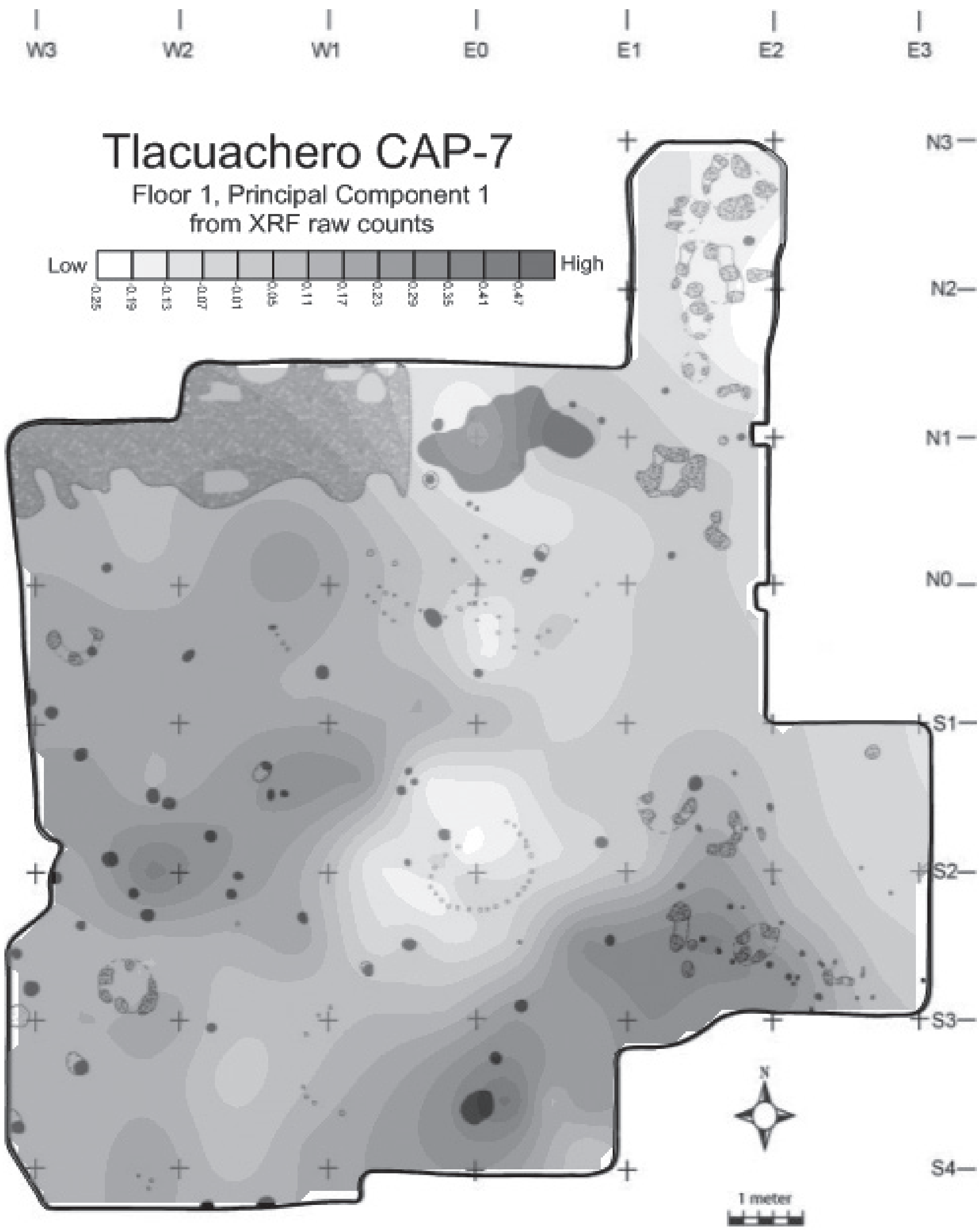


Figure 5.10. Map of scores for principal component 1 of XRF data (see Figure 5.3) across Tlacuachero Floor 1. As explained in the text and illustrated in Figure 5.3, low PC1 scores indicate enrichment of phosphorus and zinc together with dilution of calcium (illustration by Hector Neff and Aric Monts-Homkey).

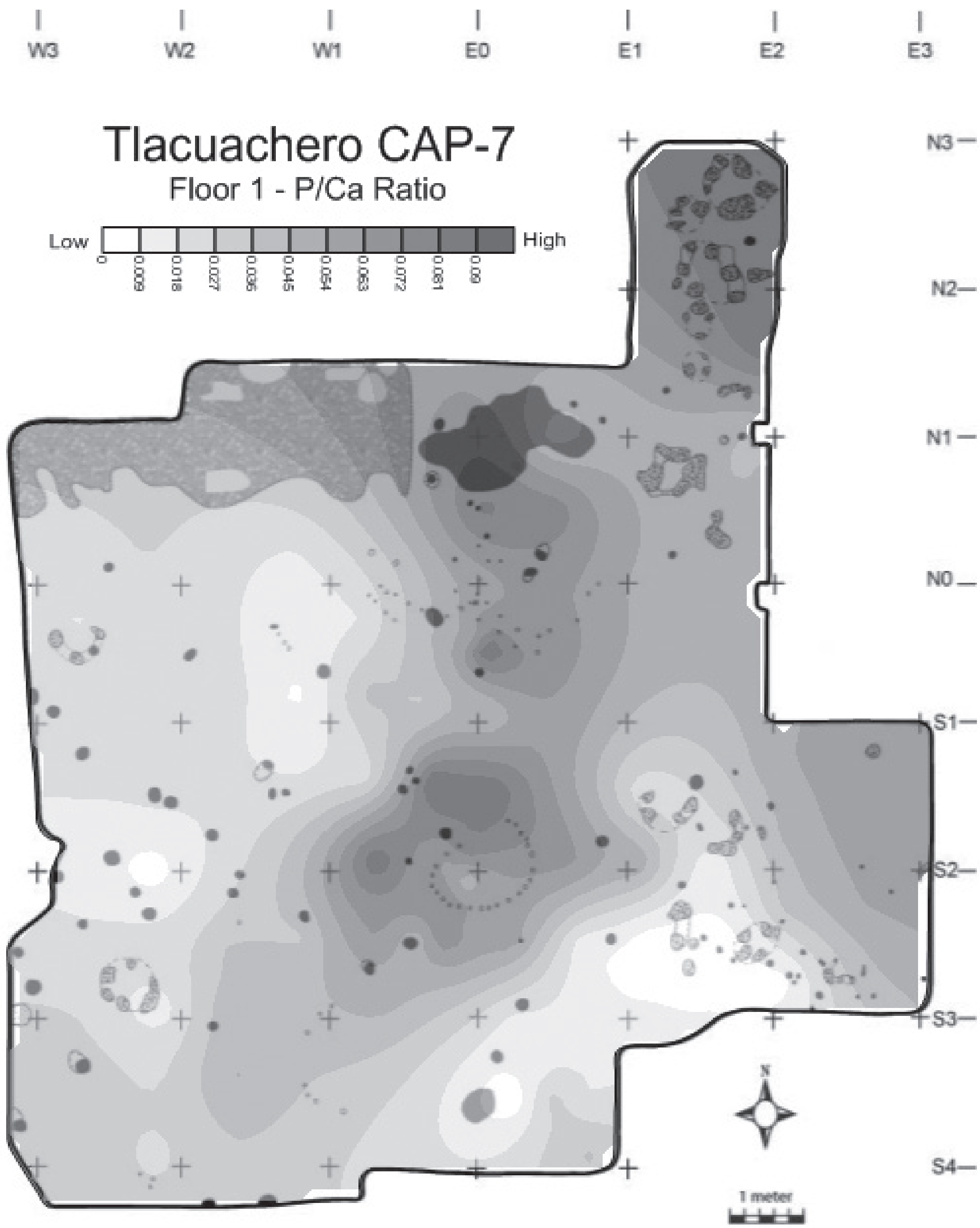


Figure 5.11. Map of phosphorus/calcium ratios obtained from XRF net intensities data across Tlacuachero Floor 1. Dark grays indicate high values; light grays indicate low values (illustration by Hector Neff and Aric Monts-Homkey).

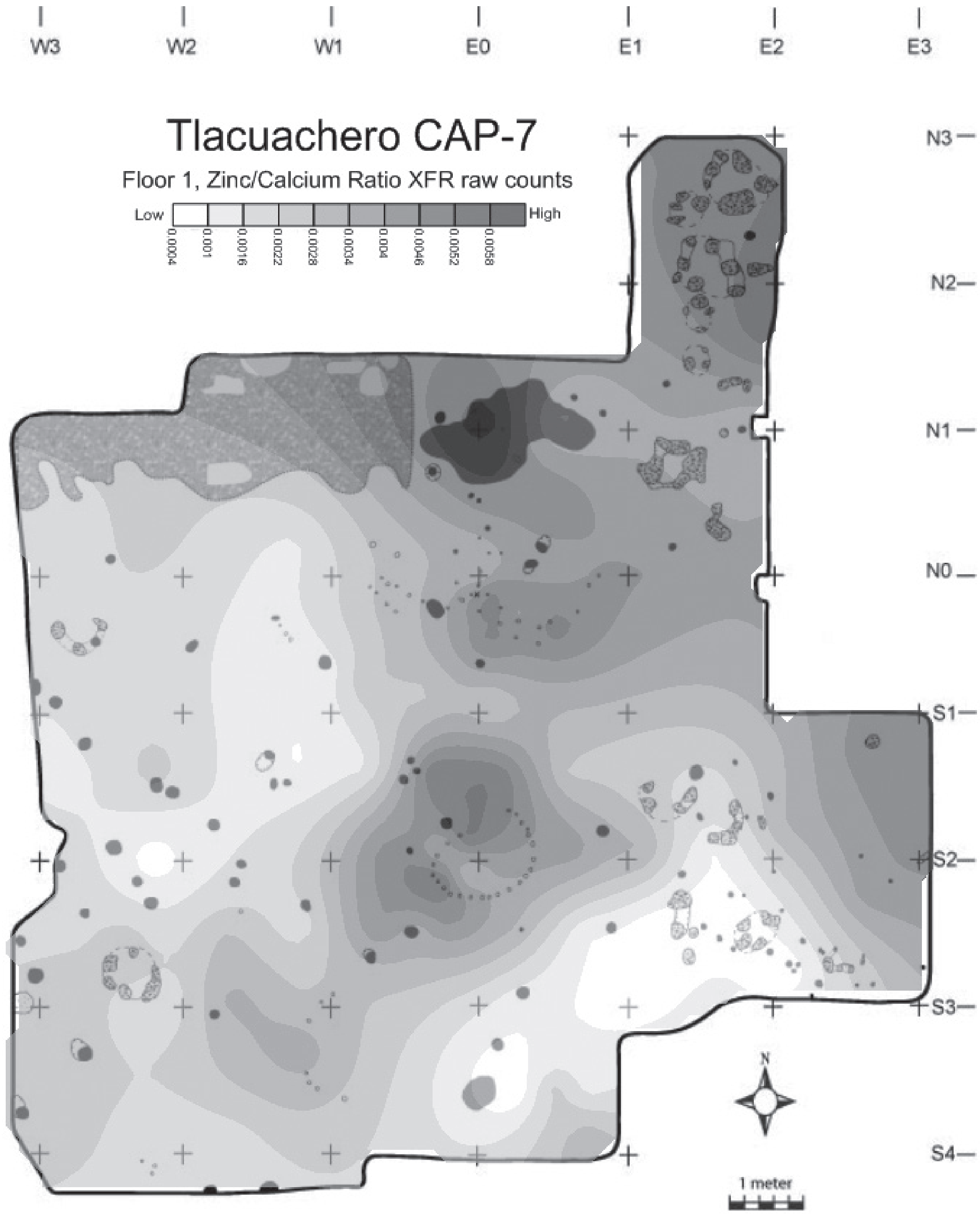


Figure 5.12. Map of zinc/calcium ratios obtained from XRF net intensities data across Tlacuachero Floor 1. Dark grays indicate high values; light grays indicate low values (llustration by Hector Neff and Aric Monts-Homkey).

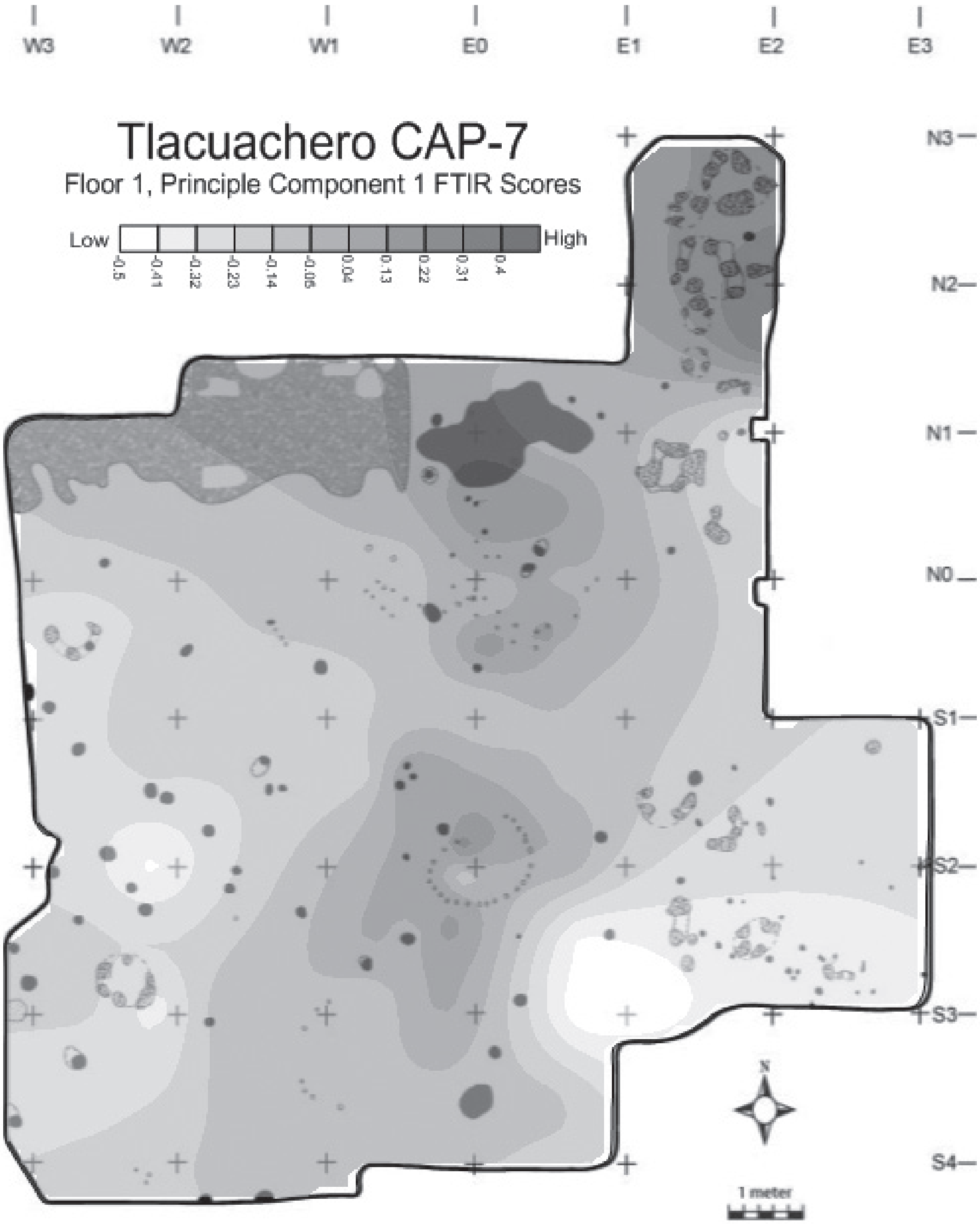


Figure 5.13. Map of scores on principal component 1 of FTIR absorbance peak data (see Figure 5.8) across Tlacuachero Floor 1. Dark grays indicate high values while light grays indicate low values. As discussed in the text and illustrated in Figure 5.8, low values on PC1 indicate near-pure calcite while high values indicate areas strongly affected by phosphate absorbance peaks resulting from diagenetic formation of carbonate hydroxylapatite. Note that data are missing in the eastern projection of this map between S1 and S3, which accounts for the difference in this area compared to the elemental concentration maps (illustration by Hector Neff and Aric Monts-Homkey).

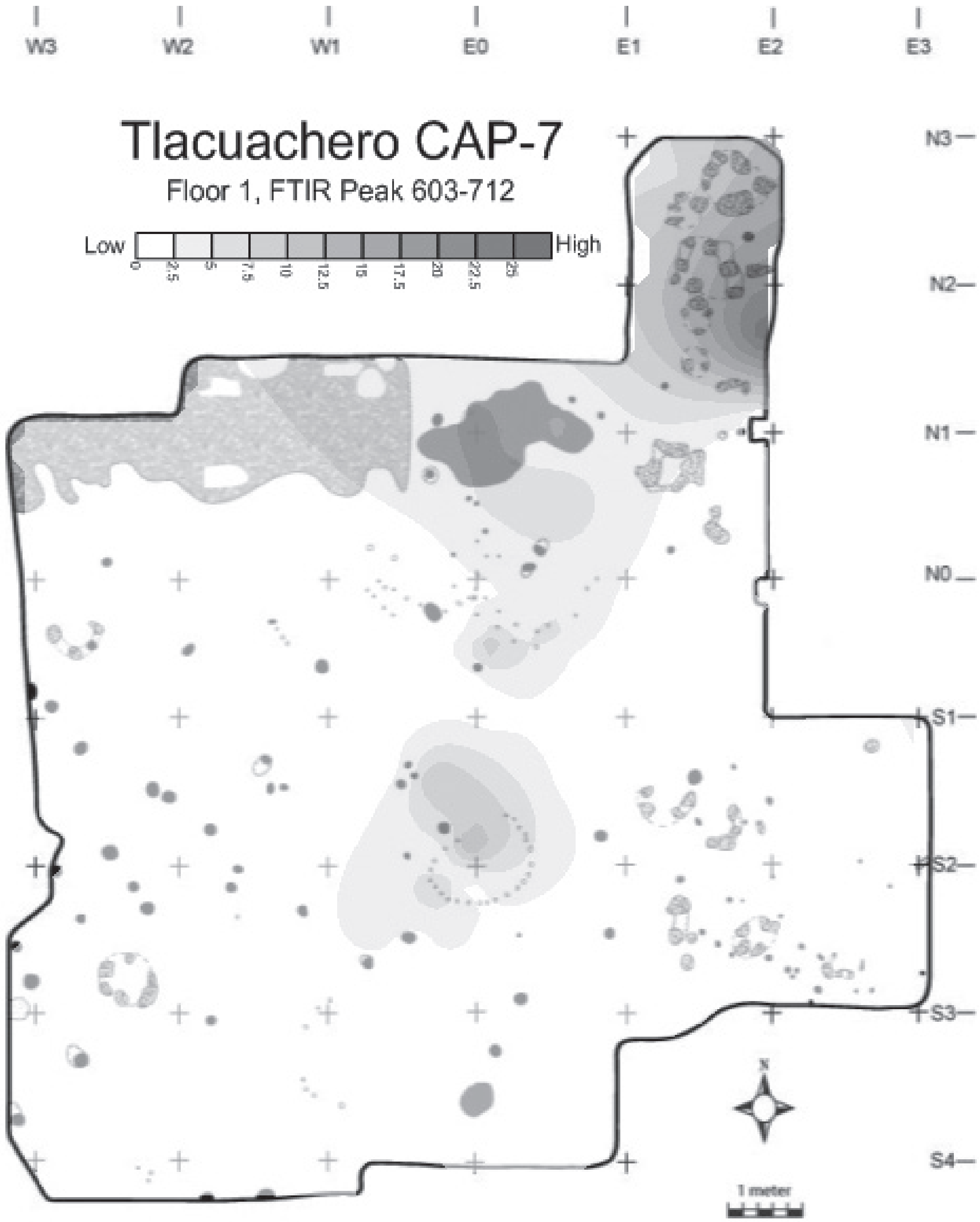


Figure 5.14. Map of the ratio of the 603 cm^{-1} peak on the IR absorbance data to the 712 cm^{-1} peak. The former is unique for carbonate hydroxylapatite while the latter is unique for calcite. High values (dark grays) therefore indicate areas most dramatically affected by diagenetic conversion of calcite to carbonate hydroxylapatite (illustration by Hector Neff and Aric Monts-Homkey).

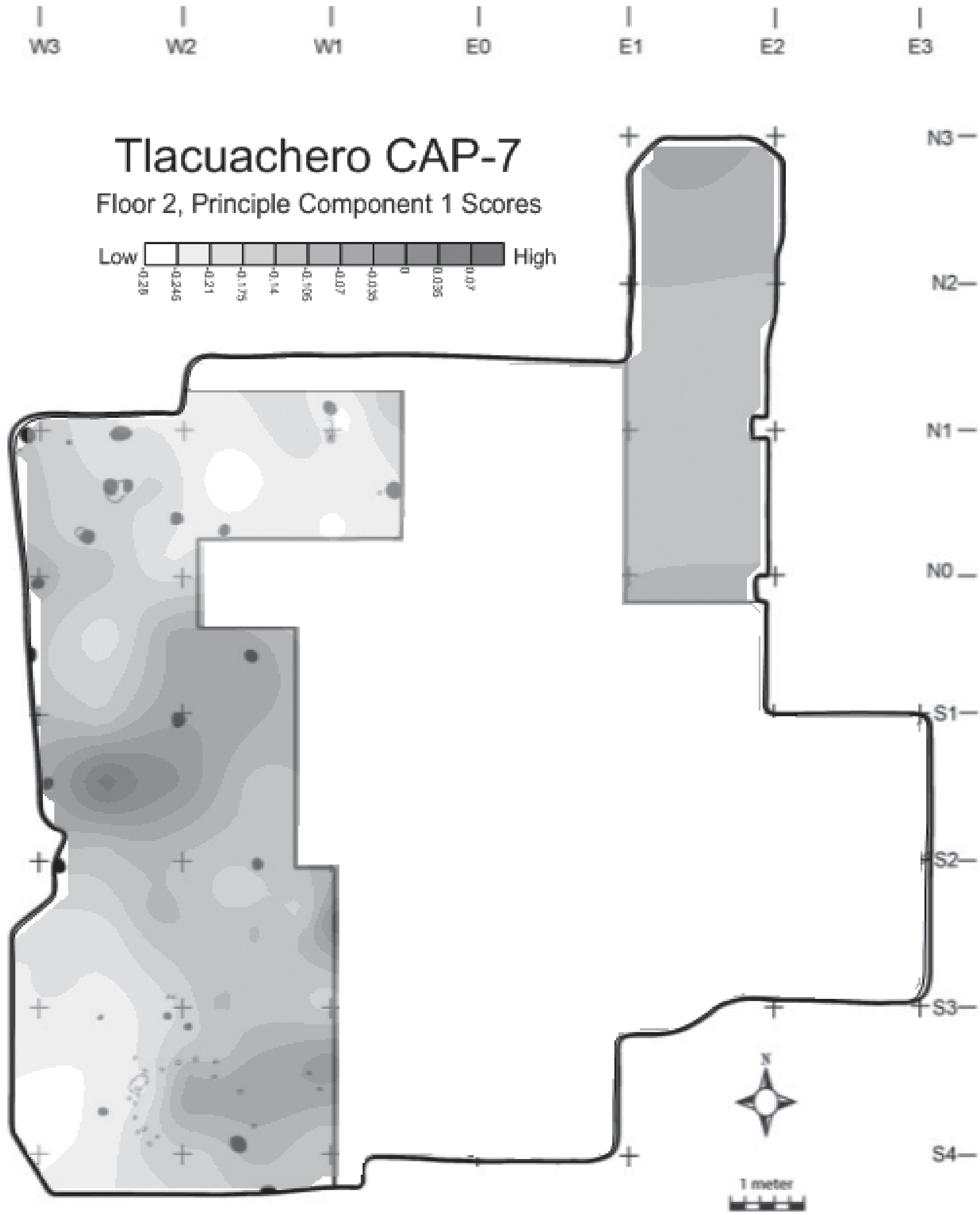


Figure 5.15. Map of scores on principal component 1 of XRF net intensities data across the exposed area of Floor 2 (illustration by Hector Neff and Aric Monts-Homkey).

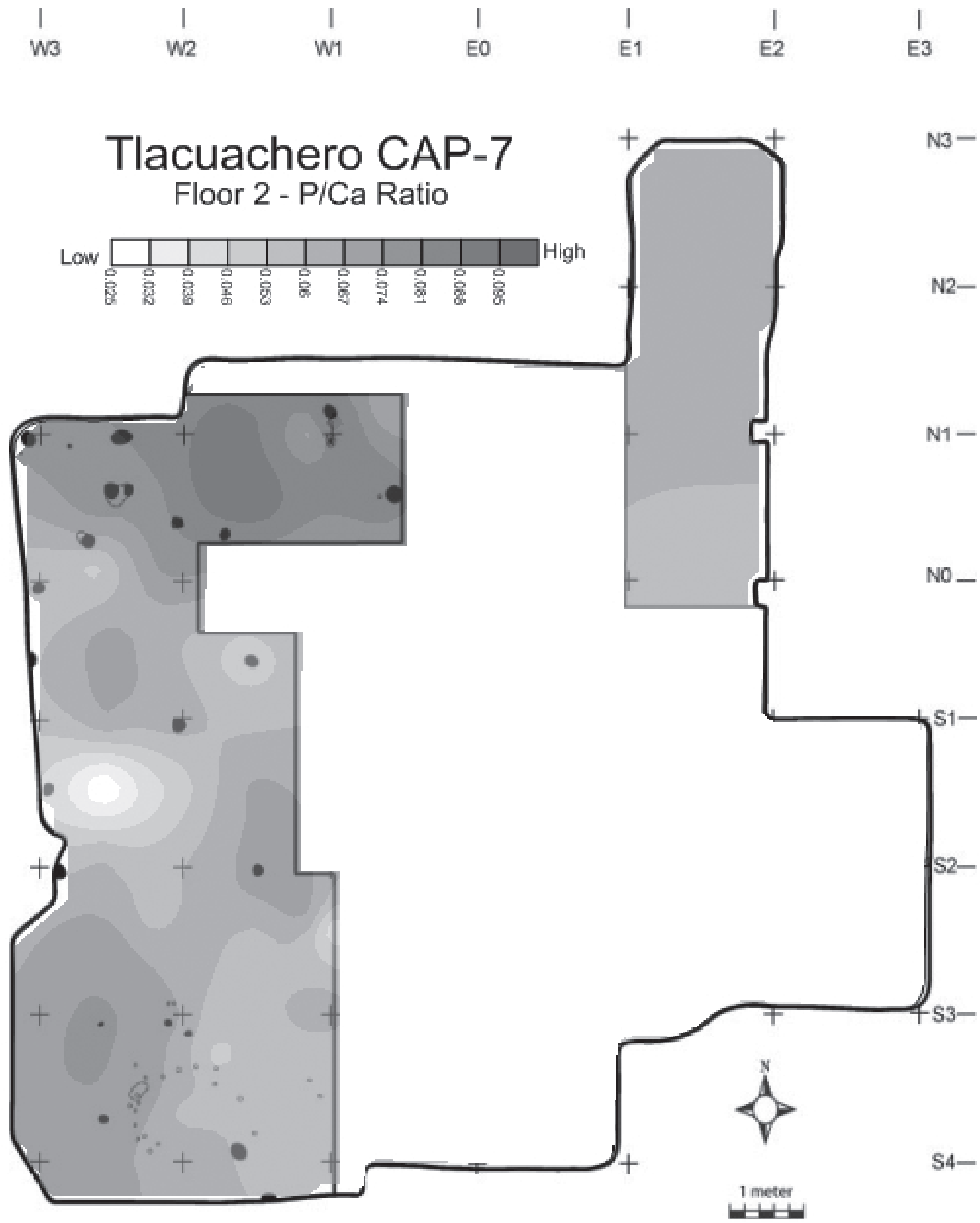


Figure 5.16. Map of phosphorus/calcium ratios obtained from XRF net intensities data across exposed area of Tlacuachero Floor 2 (illustration by Hector Neff and Aric Monts-Homkey).

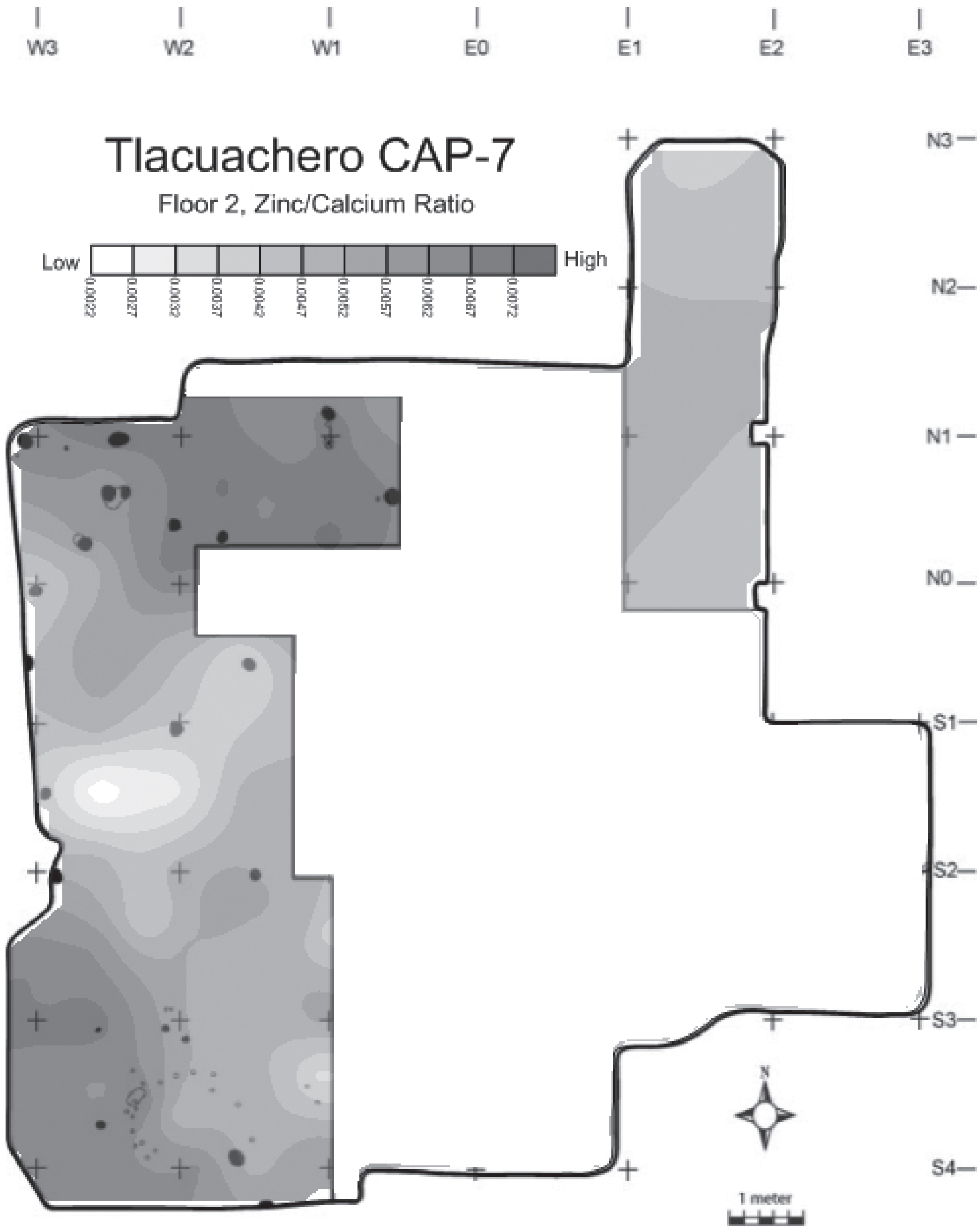


Figure 5.17. Map of zinc/calcium ratios obtained from XRF net intensities data across the exposed area of Tlacuachero Floor 2 (illustration by Hector Neff and Aric Monts-Homkey).

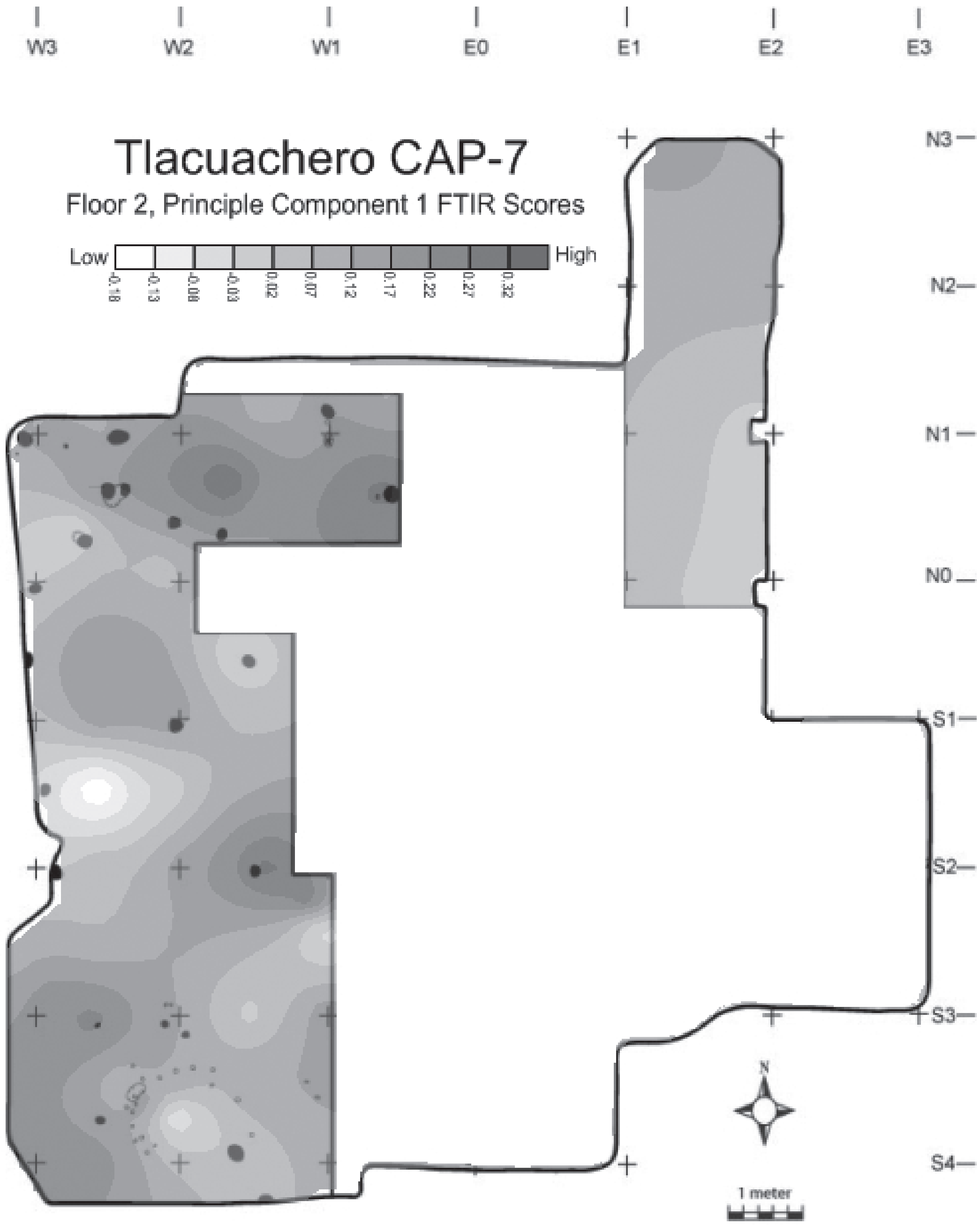


Figure 5.18. Map of scores on principal component 1 of FTIR absorbance peak data (see Figure 5.8) across the exposed area of Tlacuachero Floor 2. Dark grays indicate high values while light grays indicate low values (illustration by Hector Neff and Aric Monts-Homkey).

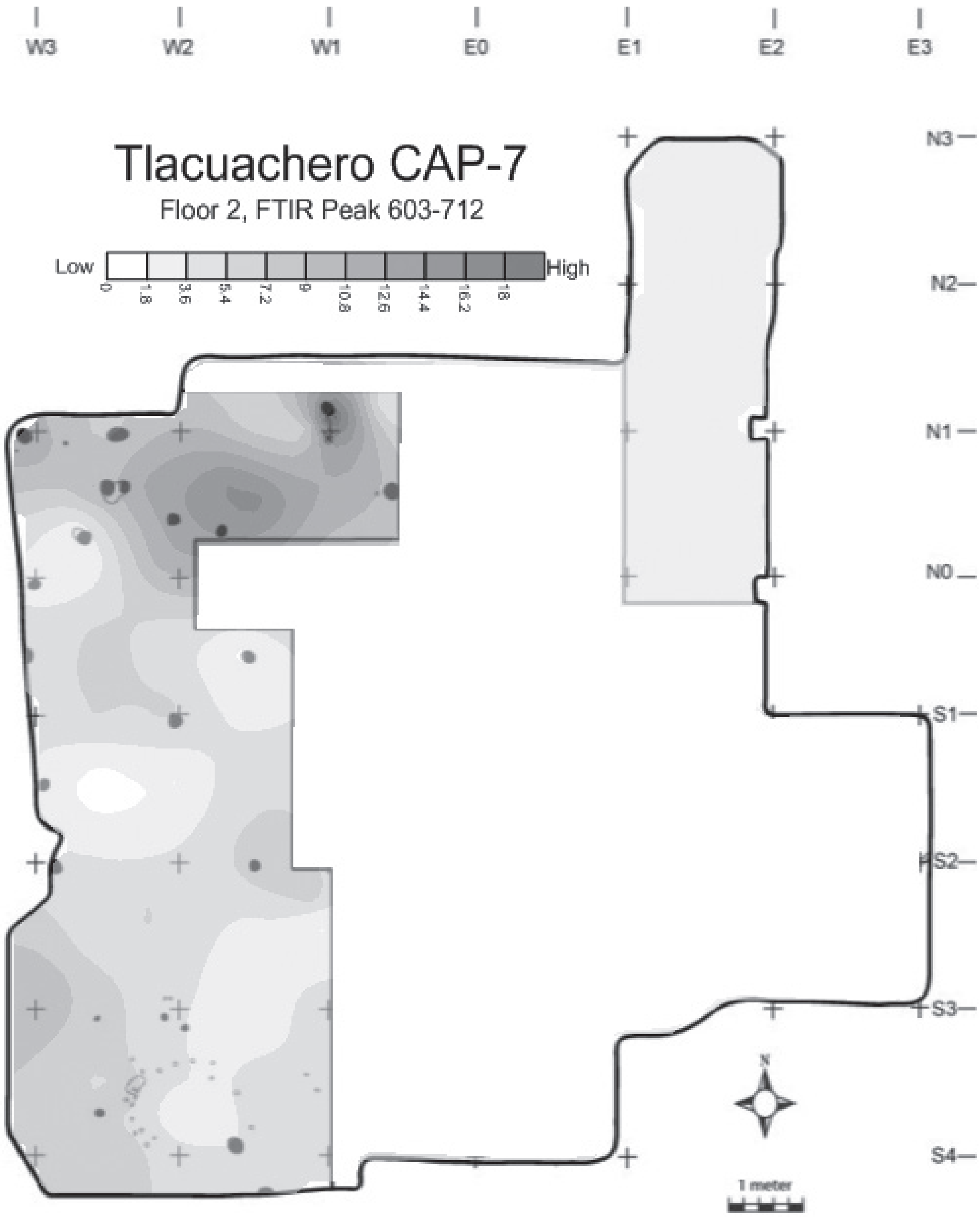


Figure 5.19. Map of the ratio of the 603 cm^{-1} peak on the IR absorbance data to the 712 cm^{-1} peak on the exposed area of Floor 2. The 603 peak is unique for carbonate hydroxylapatite while the 712 peak is unique for calcite. High values (darker grays) therefore indicate areas most dramatically affected by diagenetic conversion of calcite to carbonate hydroxylapatite. The scale is identical to Figure 5.14, so the greater predominance of high values indicates more extensive diagenetic alteration on Floor 2 compared to Floor 1 (illustration by Hector Neff and Aric Monts-Homkey).

References Cited

Barba, Luis
2007 Chemical Residues in Lime-Plastered Archaeological Floors. *Geoarchaeology* 22:439–452.

Dahlin, Bruce H., Christopher T. Jensen, Richard E. Terry, David R. Wright, and Timothy Beach
2007 In Search of an Ancient Maya Market. *Latin American Antiquity* 18:363–384.

Gratuze, Bernard
1999 Obsidian Characterization by Laser Ablation ICP-MS and Its Application to Prehistoric Trade in the Mediterranean and Near East: Sources and Distribution of Obsidian Within the Aegean and Anatolia. *Journal of Archaeological Science* 26:869–881.

Hutson, Scott R., and Richard E. Terry
2006 Recovering Social and Cultural Dynamics from Plaster Floors: Chemical Analyses of Ancient Chunchucmil, Yucatan, Mexico. *Journal of Archaeological Science* 33:391–404.

Karkanas, Panagiotis, Ofer Bar-Yosef, Paul Goldberg, and Steve Weiner
2000 Diagenesis in Prehistoric Caves: The Use of Minerals That Form in Situ to Assess the Completeness of the Archaeological Record. *Journal of Archaeological Science* 2000:915–929.

Kennett, Douglas J., Brendan J. Culleton, Barbara Voorhies, and John R. Southon
2011 Bayesian Analysis of High-Precision AMS 14C dates from a Prehistoric Mexican Shellmound. *Radiocarbon* 53:245–259.

Neff, Hector
2012 Laser Ablation-ICP-MS in Archaeology. In *Handbook of Mass Spectrometry*, edited by Mike S. Lee, pp. 829–843. John Wiley and Sons, New York.

Rypkema, Heather A., Wayne E. Lee, Michael L. Galaty, and Jonathan Haws
2007 Rapid, In-Stride Soil Phosphate Measurement in Archaeological Survey: A New Method Tested in Loudown County, Virginia. *Journal of Archaeological Science* 34:1859–1867.

Sjoberg, A.
1976 Phosphate Analysis of Anthropic Soils. *Journal of Field Archaeology* 3:447–454.

Voorhies, Barbara
1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico*. Papers of the New World Archaeological Foundation, No. 41. Brigham Young University, Provo, Utah.
2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

Wells, E. Christian, Claire Novotny, and James R. Hawken
2007 Quantitative Modeling of Soil Chemical Data from Inductively Coupled Plasma—Optical Emission Spectroscopy Reveals Evidence for Cooking and Eating in Ancient Mesoamerican Plazas. In *Archaeological Chemistry: Analytical Technique and Archaeological Interpretation*, edited by Michael D. Glascock, Robert J. Speakman, and Rachel S. Popelka-Filcoff, pp. 210–230. American Chemical Society, Washington, D.C.

Wells, E. Christian, and Richard E. Terry
2007 Introduction to the Special Issue: Advances in Geoarchaeological Approaches to Anthrosol Chemistry, Part II: Activity Area Analysis. *Geoarchaeology: An International Journal* 22:387–390.

Weiner, Stephen
2010 *Microarchaeology: Beyond the Visible Archaeological Record*. Cambridge University Press, Cambridge.

Chapter 6

Spatial Analysis of Microrefuse and Floor Color Variations

Heather B. Thakar

In this chapter I examine spatial patterning of microrefuse and color variation across Floor 1 and Floor 2. For each of these topics I discuss the methods of data collection and the results, after which I discuss how the results compare spatially to the cultural and noncultural features present on Floor 1 and Floor 2. The concluding section of this paper synthesizes these results and provides a summary of the formational pathways that affected the distribution of and relationships between these three categories of material remains as a means of understanding the organizational structure of activities and their spatial usage on the surface of floors at Tlacuachero.

Microrefuse Analysis

I begin by discussing the spatial analysis of bone microrefuse accumulation relative to archaeological features on the floors at Tlacuachero. The goal of the analysis presented here is to identify and interpret patterns within the embedded microrefuse assemblage to provide insight into the activities once carried out on the floor surfaces at Tlacuachero. To this end, I consider the results of our analysis in light of archaeological and ethnoarchaeological taphonomic studies of floor contexts.

Analytical Framework

Earthen floors are a natural trap for all manner of cultural debris (Janes 1989:852). A significant amount of archaeological research in recent decades has focused on elucidating the processes that influence the spatial structure of botanical, faunal, and lithic microrefuse accumulation (Fladmark 1982; Hull 1987; Janes 1983; Metcalfe and Heath 1990; Rosen 1989; Schiffer 1983; Simms and Heath 1990; Stahl and Zeidler 1990). These studies have demonstrated that distributional patterns of artifacts may be expected to vary differentially as a function of their relative size susceptibility to various redistributive processes. Very small archaeological materials of all classes tend to escape routine maintenance activities, such as sweeping, and remain close to primary depositional contexts (Simms and Heath 1990). Spatial patterning of microrefuse embedded within floors is more likely to be structured by consistent, patterned use (Metcalfe and Heath 1990:786). Thus recovery and analysis of microrefuse embedded in use surfaces is widely accepted as an effective means of identifying intrasite spatial organization of prehistoric activities, particularly in those cases where it may be the only means of doing so (Metcalfe and Heath 1990:792). Wendt (2005:449) argues that refuse patterning can

be used to infer architecture in societies that build perishable structures or, by extension, at sites like Tlacuachero where all suprafloor construction materials either were removed at the time of abandonment or did not preserve. With reference to this analytical framework, the following analysis of spatial patterning in the density of microbone refuse embedded in the floors at Tlacuachero provides a means by which it may be possible to elucidate the nature of human activities that once occurred on the surface of the floors at Tlacuachero.

Laboratory Procedures

The analytical procedures were relatively simple but extraordinarily time-consuming. Microrefuse analysis was conducted with the aid of student volunteers working in a laboratory in the Department of Anthropology, University of California–Santa Barbara. As described in Chapter 4 under the heading "Sampling Procedures," each sample of floor matrix was weighed and then passed through a set of nested geologic sieves with mesh sizes 4 mm, 2 mm, and 1 mm. Students separately sorted material retained in each of the three sieves to increase the accuracy of the sorting process, because it is easier to separate items when they are the same size than when various sizes are mixed. The purpose of hand sorting this material was to retrieve any artifacts or unusual ecofacts that might be present. The sorters frequently used magnifying glasses when sorting the smallest size category of material. Shell from marsh clams constituted the bulk of the material from the three largest size categories (that is, material caught by the three sieves). The students were instructed to separate all items from the shell particles. Fish bones were collected in abundance, although their frequency varied. Not a single fragment of cryptocrystalline or noncrystalline rocks was found in the analyzed samples, confirming that lithic tool production was not an activity carried out on these floors. Volunteer sorters were so effective that they even recovered occasional sand-size grains of clear quartz, but these do not aid in the interpretation of how people used the floors. In addition, small shells from mollusks other than clams were found in the samples, but these co-occur in the same habitat as the clams and we assume that they came to the site along with loads of clams. Thus the following analysis is necessarily restricted to bone microrefuse, the only type of microrefuse that we believe is directly related to human activity once carried out on the floors at Tlacuachero.

After sorting was complete for each sample, we calculated the ratio of weight of recovered bone per total weight of analyzed sample. Because the floor samples were not exactly the same size, the results were standardized using the formula bone weight/total sample weight times a constant value. Results of these calculations were plotted using Surfer version 9.0 (Golden Software Inc.) mapping software to display density contour plots. Smooth contour lines were generated using ordinary point kriging to interpolate densities between the collected sample locations while honoring the measured densities at the collected sample locations. The resulting density map contains isopleths that connect density values of equal value and is read in the same way as a topographic map. Figure 6.1 displays general trends within the distribution of the microbone refuse of Floor 1 and Floor 2 relative to primary cultural features.

Results

Analysis of floor samples from Floor 1 reveals two notable spatial patterns where microbone density is higher than elsewhere (Figure 6.1). There is a large primary concentration of embedded microbone refuse in the northern margin of the excavation area. The largest and densest area is the area associated with a large irregular feature of charcoal and ash. A secondary area of higher microbone density is associated with several rock emplacement features in the northeast 1988 excavation trench.

The second notable pattern of increased microbone density is associated with finger-molded semicircles in two locations on the Floor 1 exposure. In the center of the exposure there is elevated microbone density both to the east and west of the intact semicircle formed of finger-molded holes. Likewise, elevated microbone density surrounds the cluster of superimposed finger-molded features in the north-central part of the Floor 1 exposure.

Floor matrix samples derived from the western, southern, and southeastern margins of Floor 1 are almost devoid of bone microrefuse. Moreover, the change in density is relatively abrupt, and the contrast

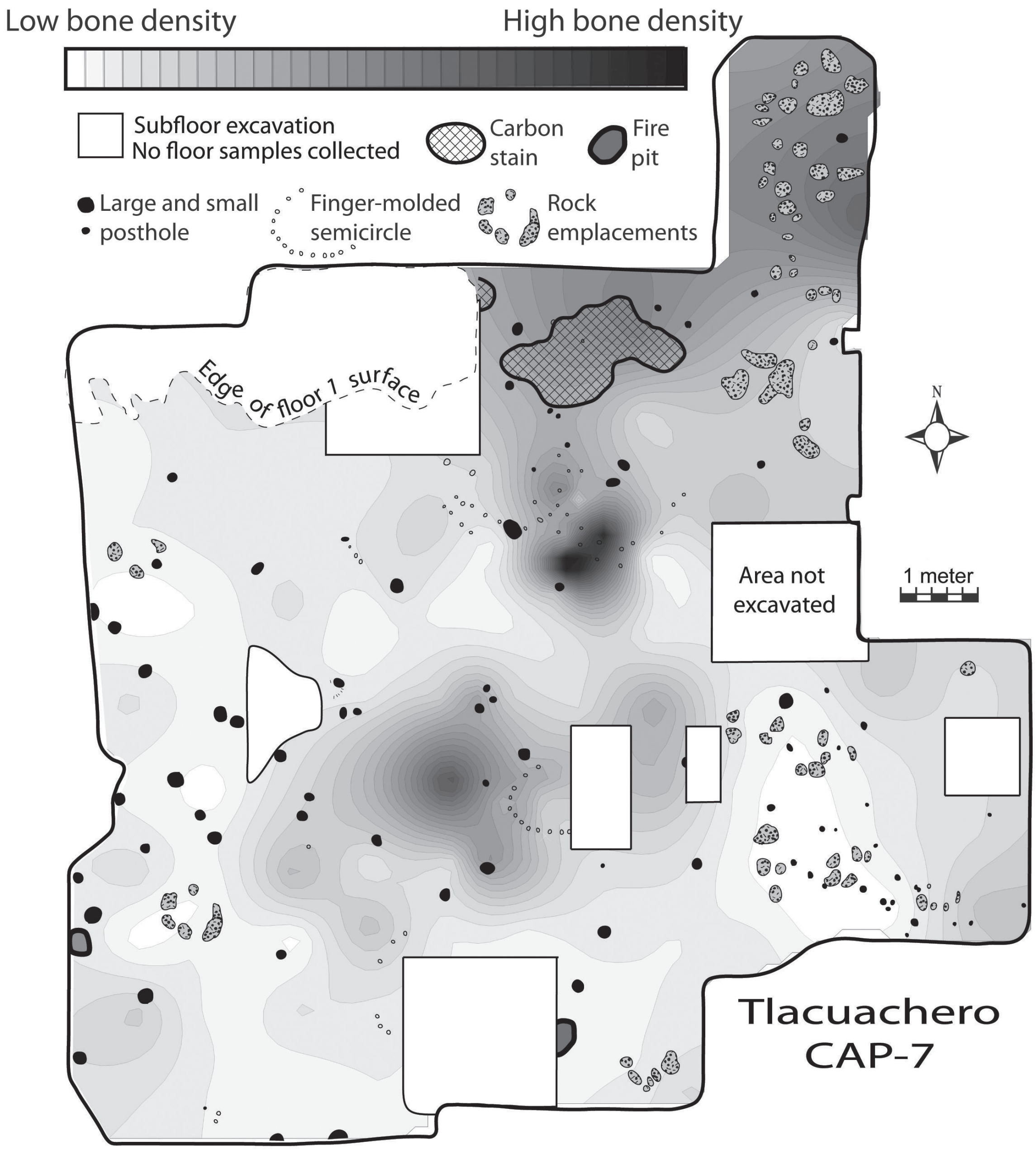


Figure 6.1a. Map of embedded microbone density across Floor 1 surface relative to primary cultural features (illustration by Heather B. Thakar).

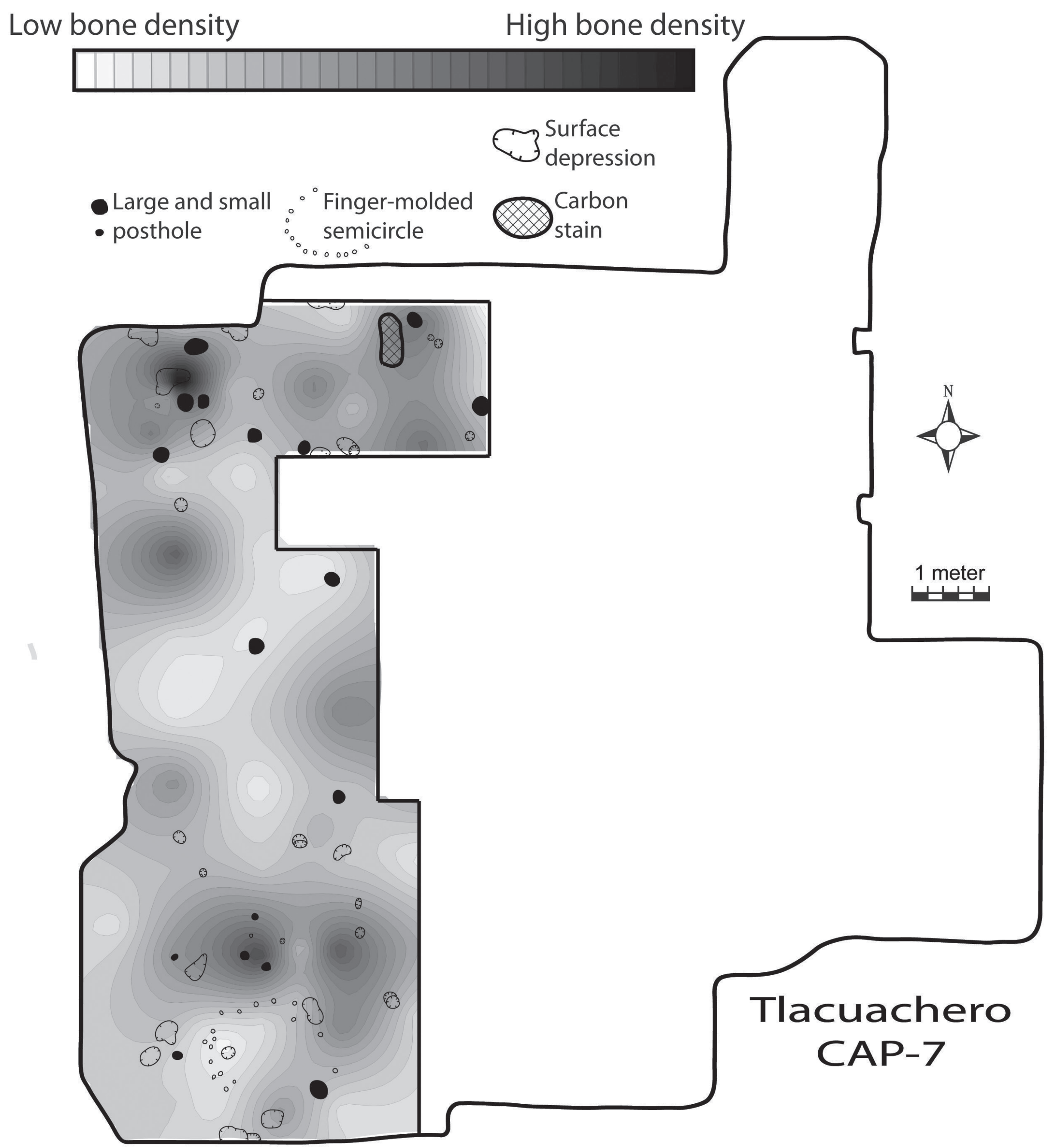


Figure 6.1b. Map of embedded microbone density across Floor 2 surface relative to primary cultural features (illustration by Heather B. Thakar).

between portions of the exposed Floor 1 surface is striking. The vast majority of large postholes clustered in the central-western portion of the excavated area and small postholes clustered in the southeastern portion of the excavated area are associated with minimal microbone refuse embedded in the floor surface. Given the very high density of microrefuse embedded in the northern portions of the excavation area, the lack of materials associated with the western, southern, and southeastern margins suggests very different patterned use of these adjacent spaces.

The density of microbone refuse embedded in Floor 2 is strikingly greater than that of Floor 1 (Figure 6.1). Analysis of floor matrix samples from Floor 2 reveals quite a few high-density concentrations of microbone refuse. Samples from the entire northern margin of the excavation area had the highest bone frequency. Within this area it is possible to identify two distinct hot spots. The highest concentration is in immediate association with several large postholes in the northwest corner of the floor exposure. It is unclear how or if this hot spot is related to the high-density area just a few meters east, in the northeast corner of the floor exposure, an area with large postholes, a large irregularly shaped carbon stain, and a darkened floor surface. It is not possible to distinguish the relationship between these two areas at this time. However, it is certain that floor matrix samples from the entire northern margin of the Floor 2 exposure include a particularly high quantity of microbone fragments. The second clearly identifiable concentration of microbone refuse is located in the southern portion of the excavation exposure, in association with four small postholes, immediately north of two superimposed finger-molded semicircles. This patch appears to be part of a pattern of higher microbone density encircling much of the area of the finger-molded holes.

There are no distinctive sections of Floor 2 completely devoid of embedded microbone refuse, unlike the situation on Floor 1. However, the overlapping high-density concentrations of microbone refuse are separated by a relatively narrow transitional zone within which the amount of embedded microbone refuse is quite low. This long, narrow, S-shaped area runs from south to north across the exposed floor surface, skirting alongside several large postholes. This zone is characterized by very low quantities of embedded microbone refuse and a complete lack of slight surface depressions that are otherwise a common feature in the surface of Floor 2. Given the high density of microrefuse embedded in Floor 2 throughout the excavation area, the lack of materials associated with this area suggests distinctive use patterns.

Discussion

The density maps in Figure 6.1a and Figure 6.1b show strong patterning in the distribution of microbone refuse embedded in the floors at Tlacuachero. This basic observation has far-reaching implications. Studies among modern hunter-gatherers suggest that structures impose spatial constraints conducive to activity segregation, especially among groups where bulk processing and food storage are important, effectively increasing the likelihood of discovering spatial patterning in various types of microrefuse (Binford 1987; O'Connell 1987; O'Connell et al. 1991). In contrast, clear patterning in microrefuse is rare when site occupation is brief and/or when the performance of activities is not spatially circumscribed by structures (O'Connell 1987; O'Connell et al. 1991). Therefore the initial observation of this study strongly implies extended occupational periods and the presence of structures that circumscribed activity areas across the floor surfaces at Tlacuachero. However, the nature of the hypothetical structures is unknown. Rather than buildings, the constraint might derive from other kinds of structures, such as fish racks, clusters of elevation stones, or simply areas of flooring alone. In Chapter 10 Voorhies revisits this issue.

Color Variation Analysis

In this section I describe the spatial distribution of sediment colors and feature associations identified in the analysis of color variation based on the fine-fraction of floor matrix samples from Floor 1 and Floor 2. Field excavators were readily able to distinguish Floor 1, with its light tan color, from Floor 2, which is a dark orange-red. In addition, we surmise that color variations on both floor surfaces at Tlacuachero were produced by human activities or other taphonomic processes, resulting in alteration of the original floor matrix color. In other words, the color of sediment is derived from its sediment source (primary), postdepositional alteration (secondary), or both.

At this time the original or primary floor matrix color is not known, although it is likely to be light because it is the color of wood ash and lime plaster, both of which might have been the originating material (Chapter 5), and of hydroxylapatite, the diagenetic substance, when it occurs in its pure state.

Laboratory Procedures

Munsell color charts were used to characterize the color of each floor matrix sample. I made all the color determinations on the dry fine-fraction of the floor samples. This procedure of using a single analyst reduces inconsistency. Sediment samples from the floors at Tlacuachero were primarily attributed to hue 10YR, with some additional attributions to 7.5YR or 5YR. The complete color code and the fixed color name, which overlap significantly among the three hues, were recorded for each sample. To produce meaningful, yet easy to interpret, maps that related color variation to spatial features on the floor surfaces, I ranked the Munsell colors on a single continuous scale from 1 (light) to 13 (very dark) for each of the two floors, based on the associated Munsell fixed color names. This scale provided a relative color-density value that could be represented graphically using the Surfer mapping software. It is important to note that this analysis obviates the overall variation in hue (reddish or yellowish) in order to focus on the greater variation in saturation (dark or light). The resulting gradient map does not directly correlate with the original Munsell soil color attributions; nor is it intended to represent them. Rather Figure 6.2a and Figure 6.2b present broad patterns in sediment color saturation from light to dark relative to feature locations on the surface of the floors at Tlacuachero.

Results

Three color regimes (dark, light, and very light) characterize the range of sediment color variation evident in the fine-fraction samples floors at Tlacuachero. The description "dark" refers to floor matrix samples identified as dark brown, dark grayish brown, dark reddish brown, dark yellowish brown, or very dark grayish brown using Munsell color chart labels. These samples are notably darker than the shades of brown that generally characterize the color of the floor matrices. Ethnoarchaeological investigation and archaeological excavations in Mesoamerica document dark floor stains in association with discrete sectors for food production and consumption (Manzanilla and Barba 1990:46). "Dark" floor matrix color is likely to represent secondary color alteration in areas of regular food processing, preparation, or consumption.

Floor matrix samples from Floor 1 and Floor 2 were most commonly attributed to a "light" color category that included Munsell color names: pale brown, brown, grayish brown, reddish brown, or yellowish brown. This category correlates well with the overall floor color noted in the field for both Floor 1 and Floor 2 and may represent the primary color of the original floor materials. However, this assertion is not definitive; the original color of the floor surface may have been lighter. "Light" floor matrix may simply characterize areas that were neither directly exposed to nor protected from regular food processing, preparation, or consumption.

The description "very light" refers to floor matrix samples identified as light gray, light grayish brown, or gray using Munsell color chart labels. These samples are markedly lighter, or rather grayer, than most other floor matrix samples. "Very light" floor matrix color may represent the original floor surface color in areas exposed to little food-related activity, greater initial contribution of burned shell to the sediment matrix, or secondary color alteration in areas where postformation fires contributed ash to the floor matrix. However, we do not have independent verification of high ash content in these samples. Thus it is necessary to consider that the original floor color may have been very light in comparison to portions of the floor surface darkened by exposure to food processing, preparation, or consumption. Below I briefly outline the location and spatial association of distinct areas of dark, light, and very light floor matrix for both Floor 1 and Floor 2 (Figure 6.2a and Figure 6.2b).

Floor 1. For Floor 1, I identify three principal areas of dark floor matrix. The very darkest fine-fraction samples are derived from the north-central portion of the 2009 excavation exposure, in close association with the large irregular patch of charcoal and ash recorded as a fire feature. Distinctive sediment darkening associated with this large carbon stain is noticeable in the fine-fraction over a much larger area than is recorded for the surface feature. Sediment

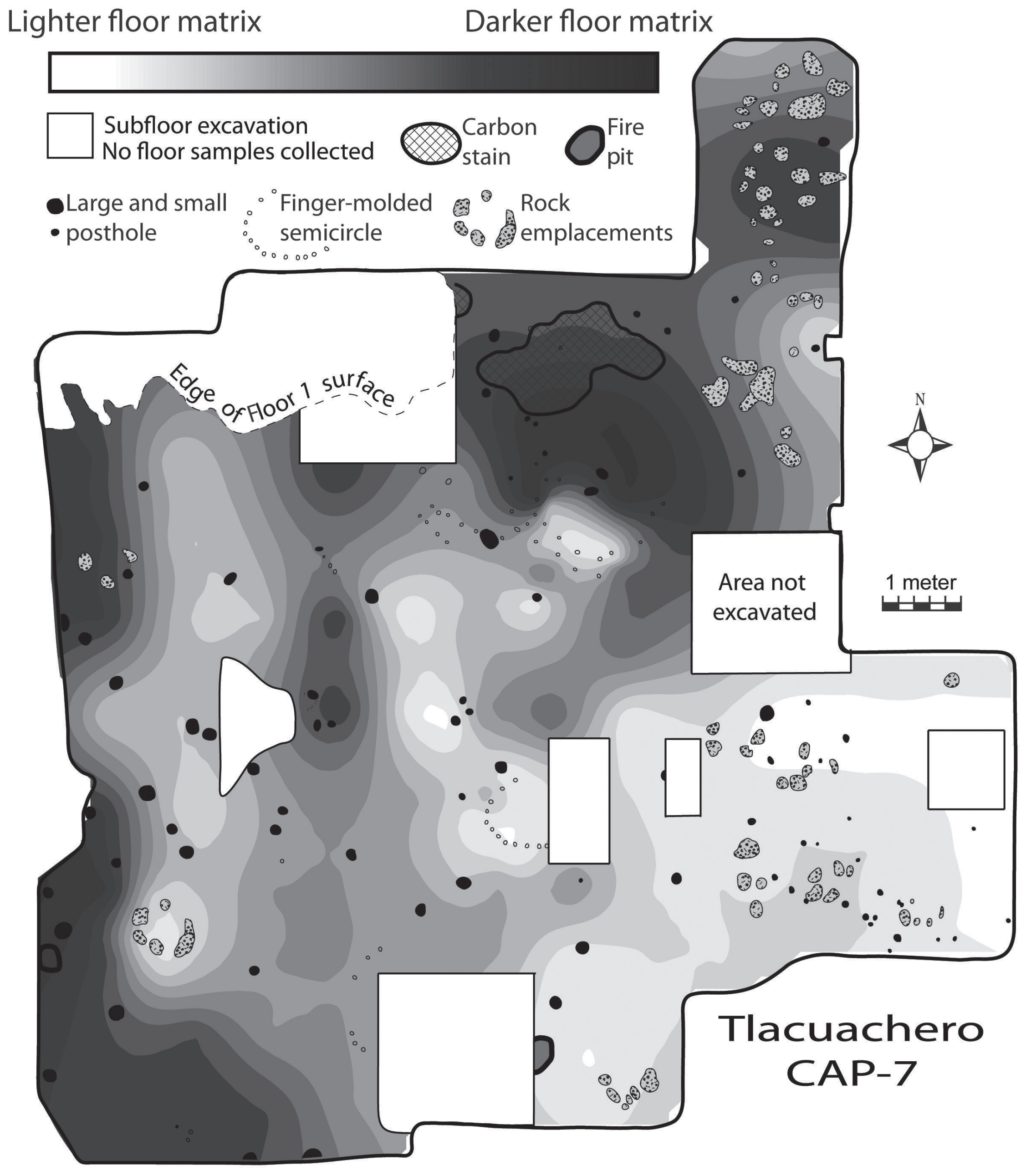


Figure 6.2a. Map of color variation across the surface of Floor 1 relative to primary cultural features (illustration by Heather B. Thakar).

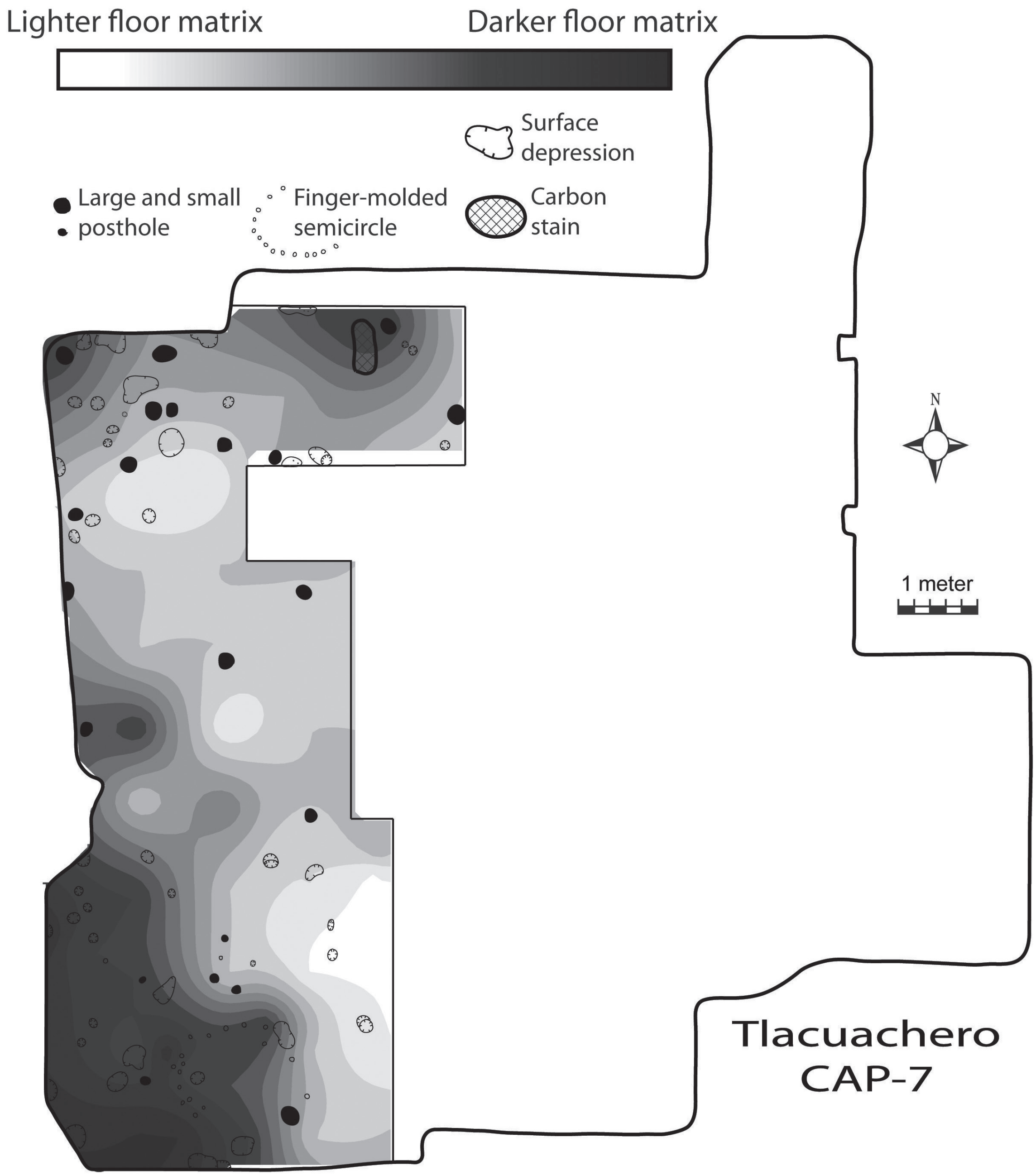


Figure 6.2b. Map of color variation across the surface of Floor 2 relative to primary cultural features. Note that the color variation for each map is unique to the individual data set; for this reason the maps in Figure 6.2 do not portray the fact that the colors are darker overall on Floor 2 compared to Floor 1 (illustration by Heather B. Thakar).

darkening is also noted northeast of the carbon stain feature, throughout the northern portion of the 1988 excavation trench. Color alteration throughout this area may be related to the same activities responsible for the large associated carbon stain. Another distinctive area of dark floor matrix is evident in the southwestern portion of the floor exposure. Samples derived from the area of increased surface unevenness that extends out from the southern and western walls of Unit S2W1 are markedly darker in color than samples derived from the rest of the excavation area. It is unclear whether the third principal area of dark floor matrix in the northwestern margin of the excavation area is related to either of the prior areas described. There are also no clear feature associations with this area. Interestingly, all bone clusters recovered from the floor surface during the course of excavation occurred in areas of dark floor matrix. I also note that large surface depressions appear to occur in higher frequency in areas with dark floor matrix.

For Floor 1 I identify one primary area and several smaller patches of very light floor matrix. Most of the fine-fraction samples attributed to light (grayish) sediments are derived from the southeastern portion of the excavation area. There appears to be a strong spatial correlation between very light floor matrix color and small postholes, both of which are highly restricted to the southeastern corner of the excavation area. As noted above, a scattering of smaller rock emplacements and small surface depressions also accompany this dense cluster of small postholes. Only a few other discrete patches of lighter-colored sediment matrix occur in other portions of Floor 1. Two of these patches appear to be directly related to well-defined circular rock emplacement features: one documented on the surface of Floor 1 in Unit S2W1 near the western limit of the excavation area, and the other in the southeastern corner of the excavation area. Distinctive patches of light-colored sediment also occur, associated spatially with two areas of finger-molded semicircles on the surface of Floor 1.

Floor 2. For Floor 2, I identify two principal areas of dark floor matrix associated with the Munsell soil colors dark brown, dark grayish brown, dark reddish brown, dark yellowish brown, or very dark grayish brown. The fine-fraction samples from the southwest corner and the northern margin of the excavation area appear to be significantly darker than the fine-fraction samples from the rest of the excavation area. It is worth noting that in these same two regions we also collected significantly darker matrix samples from Floor 1. This suggests that human activities or taphonomic processes that resulted in floor darkening were governed by similar spatial patterns during the use of both floors. As noted for Floor 1, color alteration in the northern margin of the excavation is adjacent to irregular patches of charcoal and ash and is the product of similar human activities. Sediment darkening associated with these carbon stains is noticeable in the fine-fraction over larger areas than is recorded for the surface features. The second principal area of dark floor matrix is evident in the southwestern portion of the floor exposure. The very darkest fine-fraction samples from Floor 2 pertain to this region. However, this area does not have any clear artifact or feature associations other than several larger surface depressions. As noted for Floor 1, large surface depressions appear to occur in greater frequency in areas of dark floor matrix. This correlation is more clearly evidenced for Floor 2.

I identify three distinct patches of very light floor matrix across the exposed surface of Floor 2. The color of sediment samples derived from each of these patches was identified as light gray, light grayish brown, gray, or grayish brown using Munsell color chart labels. There are no clear artifact or feature associations with these three patches of very light floor matrix.

Discussion

My systematic laboratory analysis of color variation across the floor surfaces at Tlacuachero confirms the qualitative in-field assessment that human activities or taphonomic processes affected discrete portions of floor surfaces, resulting in alteration of the original floor matrix color. This study affirms the previous assertion, based on spatial distribution of feature locations, that spatially restricted activity areas at Tlacuachero were maintained through time and reproduced across construction events. Furthermore, secondary color alteration of sediments used to construct the floors at Tlacuachero contribute to understanding the specific nature of restricted activity areas and elucidate the function of discrete feature types.

Analysis of color variation across the surface of these floors indicates that the original floor sediment

color was significantly darkened in the northern and western exposure of both Floor 1 and Floor 2. This suggests that food processing, preparation, or consumption occurred regularly in these discrete portions of the floor surfaces. This interpretation is further supported by the association between dark floor matrix in the northern portion of both floor surfaces and large irregular carbon stains, and the co-occurrence of dark floor matrix and several isolated bone clusters on the surface of Floor 1. In an ethnoarchaeological study of Achuar dwellings in tropical Ecuador, Stahl and Zeidler (1990) document similar irregular, patchy accumulations of carbon and debris around hearth areas. Demonstrated similarity in the location of dark floor matrix and consistent association with large irregular carbon stains on the surface of both floor surfaces strongly suggest that food-processing and food-consumption activities were spatially circumscribed and maintained through time.

In contrast to secondary darkening of floor sediment color, analysis of color variation across the surface of these floors suggests a light or very light original floor matrix color. Significantly lighter, grayer floor matrix is highly restricted to the location of three distinct feature types: finger-molded semicircles, rock emplacements, and small postholes. This pattern is most evident in association with a high density of small postholes and a cluster of circular rock emplacements in the eastern portion of the excavated area of Floor 1, hypothesized to be a storage area. In an ethnoarchaeological study of the Puuc Maya in the Yucatán, Smyth (1990:67) documents the use of small smoke-producing fires built underneath and around storage facilities to kill or drive out insects. Frequent use of this method could contribute significant quantities of ash to the floor matrix around storage areas, producing distinctive lightening of the sediments. However, light floor matrix color also consistently co-occurs with finger-molded semicircles that appear to have special significance, such as being game boards as proposed by Voorhies (2013 and Chapter 10).

I suggest that areas generally protected or separated from food-related activities remain light in color saturation and close to the original color of the floor matrix. The hypothesized activities (food processing, food consumption, and food storage) may have resulted in either darkening or lightening of the original floor matrix color.

Interpretation of Spatial Patterns

There is a notable spatial correspondence between the density of microbone refuse embedded in the floor surfaces and the color of the floor matrix sediment. Higher bone density is associated with darkened sediment and lower bone density is associated with lighter sediment color across the surface of Floor 1 and Floor 2. Darkened floor matrix and large irregular carbon stains often represent food-processing and food-consumption activities (see color variation analysis above). Stahl and Zeidler (1990) document the rapid incorporation of food debris and residues into the floor surface around hearths. They attribute this increase in accumulation to a greater amount of traffic in and around this area of food preparation. This resonates strongly with the microbone refuse and sediment color patterning documented at Tlacuachero and suggests that locations where high microbone density and dark floor matrix color co-occur are linked to food processing and/or consumption. Thus I infer the presence of discrete food-processing activities in the northernmost exposure of both floor surfaces. If this is correct, then the prehistoric inhabitants of Tlacuachero produced large irregular carbon stains by consistently preparing food and cooking in the same area of the floor surfaces. Based on comparisons with ethnographically described households in Mesoamerica, it is likely that such food processing and household activities would have been located in outdoor areas (Robin 2002; Robin and Rothschild 2002).

There is a clear difference between the cluster of rock emplacements in the northeastern portion of the Floor 1 excavation exposure and the cluster of rock emplacements in the southeastern portion of the excavation area. The cluster of rock emplacements in the northeastern portion of the excavation area is associated with very few postholes, large or small; a darkened floor matrix; and a very high density of embedded microbone refuse, whereas the cluster of rock emplacements in the southeastern portion of the excavation area is associated with an abundance of small postholes and a lighter floor matrix and is practically devoid of embedded microbone refuse. This sharp distinction suggests that these two discrete areas of circular stone features were used for very different purposes. Here I consider whether either of these two areas could be related to food-processing or food-storage activities.

Smyth (1990:67) indicates that storage itself is often a segregated and independent activity, producing spatially differentiated and materially distinctive remains. The southeastern cluster of circular stone features is clearly segregated from adjacent areas in the distribution of microbone refuse, floor matrix color, and associated small postholes. These distinctive patterns are strongly correlated and spatially restricted. Thus I suggest that this cluster of rock emplacements documented in the southeastern corner of the Floor 1 excavation exposure may indeed be related to food storage activities that incorporated elevating stones and possibly small shelters.

In contrast, the northeastern cluster of circular stone features is adjacent to a proposed location of outdoor food-processing activities. The high microbone density and dark floor matrix color that characterize this food-processing area also extend throughout the adjacent eastern cluster of circular stone features. There is no evidence of spatial segregation in the distribution of microbone refuse or floor matrix color between the proposed food-processing area and the northeastern cluster of rock emplacement features, as I noted for the southeastern cluster of stone imprints. Therefore I suggest that either the northeastern cluster of rock emplacements was related to food-processing rather than food storage, or the observed pattern is a result of the palimpsest factor.

The density of microbone refuse embedded in the floor surfaces and the color of the floor matrix sediment do not co-vary in all portions of the excavation area or in association with all feature types. Microbone refuse density is generally lower in the vicinity of large postholes on the floor surfaces. This pattern is particularly evident across the entire surface of Floor 1 and in association with the long, narrow, S-shaped area previously discussed on Floor 2. However, floor color matrix is not consistently lighter or darker in association with this feature type. Stahl and Zeidler (1990:165) document increased densities of fishbone fragments embedded in high-traffic areas of earthen floors. Decreased density of microbone refuse embedded into floor surfaces around postholes may be attributed to lower-frequency traffic in and around large supporting posts of structures. The distinct function of different structures represented by postholes may account for the lack of congruent spatial patterning between floor color alteration and embedded microrefuse density.

This synthesis of spatial patterning within three main categories of archaeological remains for Floor 1 and Floor 2—(a) feature patterning, (b) refuse patterning, and (c) sediment color characteristics—provides support for human activities responsible for large irregular carbon stains and identifies possible functions for clusters of rock emplacements. However, this synthesis is unable to elucidate the specific function of large postholes or finger-molded semicircles created on the surface of floors at Tlacuachero. Chapter 10 integrates these two analyses with chemical and microbotanical analyses of the floor matrices to provide further insight into the activities once carried out on the floor surfaces at Tlacuachero.

References Cited

Binford, Lewis R.

1987 Researching Ambiguity: Frames of Reference and Site Structure. In *Method and Theory for Activity Area Research: An Ethnoarchaeological Approach*, edited by Susan Kent, pp. 449–512. Columbia University Press, New York.

Fladmark, K. R.

1982 Microdebitage Analysis: Initial Considerations. *Journal of Archaeological Science* 9:205–220.

Hull, Kathleen L.

1987 Identification of Cultural Site Formation Processes Through Microdebitage Analysis. *American Antiquity* 52:772–783.

Janes, Robert R.

1983 *Archaeological Ethnography Among the Mackenzie Basin Dene, Canada*. Arctic Institute of North America, Technical Paper 28. University of Calgary, Calgary.

1989 A Comment on Microdebitage Analyses and Cultural Site-Formation Processes Among Tipi Dwellers. *American Antiquity* 54(4):851–855.

Manzanilla, Linda, and Luis Barba

1990 The Study of Activities in Classic Households: Two Case Studies from Coba and Teotihuacan. *Ancient Mesoamerica* 1:41–49.

Metcalfe, Duncan, and Kathleen M. Heath

1990 Microrefuse and Site Structure: The Hearths and Floors of the Heartbreak Hotel. *American Antiquity* 55(4):781–796.

O'Connell, James F.
1987 Alyawara Site Structure and Its Archaeological Implications. *American Antiquity* 52:74–108.

O'Connell, James F., Kristen Hawkes, and Nicholas B. Jones
1991 Distribution of Refuse-Producing Activities at Hadza Residential Base Camps: Implications for Analyses of Archaeological Site Structure. In *The Interpretation of Archaeological Spatial Patterning*, edited by Ellen M. Kroll and T. Douglas Price, pp. 61–75. Plenum Press, New York.

Robin, Nan A.
2002 Outside of Houses the Practices of Everyday Life at Chan Nòohol, Belize. *Journal of Social Archaeology* 2(2):245–268.

Robin, Nan A., and Cynthia Rothschild
2002 Archaeological Ethnographies Social Dynamics of Outdoor Space. *Journal of Social Archaeology* 2:159–172.

Rosen, Arlene Miller
1989 Ancient Town and City Sites: A View from the Microscope. *American Antiquity* 54:564–578.

Schiffer, Michael B.
1983 Toward the Identification of Formation Processes. *American Antiquity* 48:675–706.

Simms, Steven R., and Kathleen M. Heath
1990 Site Structure of the Orbit Inn: An Application of Ethnoarchaeology. *American Antiquity* 55:797–813.

Smyth, Michael P.
1990 Maize Storage Among the Puuc Maya: The Development of an Archaeological Method. *Ancient Mesoamerica* 1:51–69.

Stahl, Peter W., and James A. Zeidler
1990 Differential Bone-Refuse Accumulation in Food-Preparation and Traffic Areas on an Early Ecuadorian House Floor. *Latin American Antiquity* 1:150–169.

Voorhies, Barbara
2013 The Deep Prehistory of Indian Gaming: Possible Late Archaic Gameboards at the Tlacuachero Shellmound, Chiapas, Mexico. *Latin American Antiquity* 24:98–115.

Wendt, Carl J.
2005 Using Refuse Disposal Patterns to Infer Olmec Site Structure in the San Lorenzo Region, Veracruz, Mexico. *Latin American Antiquity* 16:449–466.

Chapter 7

A Spatial Analysis of Phytoliths at Tlacuachero

Doug H. Drake

The Chantuto people, known primarily from a series of shellmounds, lived on the southern Pacific coast of Mexico during the Middle and Late Archaic periods. The shellmounds and their creators have garnered interest following the discovery of the Chantuto site (Figure 7.1) by Drucker (1948) and the subsequent discoveries of Campón, El Chorro, Tlacuachero, Zapotillo, and Cerro de las Conchas (Clark 1994; Lorenzo 1955; Voorhies 1976, 2004:29). Previous investigations have provided many insights into the phytolith record of the area. However, there is still much to learn about the use of plants during the Archaic period (Jones and Voorhies 2004; Kennett et al. 2010; Michaels and Voorhies 1995; Neff et al. 2006; Voorhies et al. 2002). This chapter expands the available record through an additional examination of the phytolith evidence at Tlacuachero, a shellmound dating to the Late Archaic period.

In contrast to most phytolith studies, I examined the phytoliths at the Tlacuachero site along a horizontal plane rather than stratigraphically. Examining the phytoliths from a horizontal plane should provide a source of phytolith data that will complement existing phytolith studies from the site. Whereas Jones and Voorhies (2004) provided an overview of the phytolith record over time, this study is designed to provide more specific information on how phytolith-producing plants were being used during the formation and use of Floor 1 atop the Tlacuachero shellmound during a pivotal moment in its occupational history. Although others, such as Sullivan and Kealhofer (2004), have examined large-scale distributions of phytoliths, analysis of the small-scale differential distribution of phytoliths from a horizontal plane has been previously attempted only rarely. Here, a series of 38 samples from Floor 1 has been analyzed, along with four additional samples from Floor 2. Because the analyzed samples were taken from a horizontal plane, distributional patterns of phytoliths across the floors at Tlacuachero can be examined. These distributional patterns may document the use areas of different phytolith-producing plants and may allow for a determination of how these different taxa were being used. Although Floor 2 has been less extensively sampled than Floor 1, a comparison of taxa recovered from the two floors may permit insights into how vegetation at the site was used through time.

Floor 1 at Tlacuachero marks an important point in the history of the site and region. Research by Jones and Voorhies (2004) demonstrated that phytoliths diagnostic of maize are found only in sediments contemporaneous with and younger than this floor at Tlacuachero. Thus the formation and use of Floor 1 may reflect changes that took place during the local introduction

of domesticates such as maize. Kennett and Voorhies (1996) demonstrated that the seasons when the site was used changed through the Late Archaic period. It could also be argued that the formation of the floors themselves implies that those living at the site were departing from their previous subsistence strategies. Below the floors, the mound completely consists of shells from the marsh clam *Polymesoda* sp. In the previous use of the site, floors were not formed. Why then, around 4415–4320 cal B.P., did the people present at this site create a floor atop the shellmound? The answer to this question hinges on whether Floor 1 and by extension the other floors were intentionally constructed or formed as a consequence of intense surface activity, an unsolved problem at the present time (see Chapter 5 and Chapter 10). Whatever the case, this change in site use is supported by Kennett and Voorhies's (1996) suggestion that farther inland, during the time frame Floor 1 was in use, there was a reorientation toward greater reliance on domesticated plants such as maize.

The shift away from hunting and gathering toward a greater dependence on agriculture has been a focus of archaeological research for many years, providing many answers as to when and where domesticates first spread. Insights into the domestication and spread of agricultural practices have typically used microbotanical and genetic analytical techniques. Based upon microfossil evidence, it is most likely that maize was domesticated in the Balsas River valley in Mexico as early as 6700 cal BCE and had spread to the Gulf Coast by around 5200 cal BCE (Piperno et al. 2009; Pope et al. 2001). Additionally, it is now recognized that maize was likely domesticated in a single instance from an ancestral species of the wild grass, teosinte (Matsuoka et al. 2002). Although there have been many breakthroughs in the chronological and spatial understanding of the origin and spread of agriculture, the explanation of why people chose to practice such intensive land use strategies has been more elusive.

The importance of understanding the transition to agriculture cannot be overstated. It has become clear that this change often accompanies other important processes, such as increasing sociopolitical complexity and social stratification (Cowgill 1996; Feinman 1995; Price and Brown 1985). Although the use of domesticates and agricultural practices may not be a strict prerequisite for social complexity and hereditary inequality, they are often a prerequisite for attaining the high population densities and generation of surplus that are the hallmark of more complex societies.

If archaeologists have any hope of untangling the web of interaction between adoption of agricultural practices and social complexity, then the conditions prior to and during the transition to reliance on agriculture must be more comprehensively understood. Circumstances surrounding the formation and use of Floor 1 at Tlacuachero present a unique opportunity to focus on this important transition. Although pollen and macrobotanical remains have not been preserved at Tlacuachero, likely due to the local sediment having a high oxidation potential, there is an excellent record of phytoliths that can provide a glimpse into plant use at the site. An analysis of the phytolith types present and their distribution across Floor 1 may shed light on the way the site's inhabitants used different phytolith-producing plants. Although all plants do not produce phytoliths, phytoliths can provide a limited understanding of the way plants were being used at the site. Ultimately, the Chantuto people's relationship with plants during the formation and use of Floor 1 is of utmost importance in understanding the ultimate trajectory of development in Chiapas and the greater region. A detailed analysis of the phytolith types present on Floor 1 may allow new insights into how plants were used during the time period when the transition toward increasing dependence on domesticated plants was being undertaken in the region.

Background

To set the stage for my findings about plant use during the time the floors were in use at Tlacuachero, I first review some relevant previous studies: the findings of prior studies of phytoliths at Tlacuachero; the results of phytolith studies at other locations in coastal Chiapas; and horizontal studies of microbotanical remains as a research tool.

Prior Phytolith Analyses at Tlacuachero

Previous investigations by Jones and Voorhies (2004) into the paleoecology at Tlacuachero have examined the phytolith record at the site and have provided insight into changes in the vegetation over time. Phytoliths present included grasses (bilobate, short cell, small cross, *Chusquea*, and *Zea mays* types), Chrysobalanaceae,

Heliconia, Marantaceae, *Sabal*-type palm, *Stromanthes*, Bulliform-type, Cyperaceae, and unidentified elongate types (Jones and Voorhies 2004:Figure 3). The data obtained have suggested that the vegetational record at the site can be roughly divided into two main zones corresponding to the unconsolidated shell deposits below and above Floor 1.[1] The first (oldest) zone extends from approximately the 7-m level to the 4.5-m (Floor 1) level and is marked by higher percentages of forest elements such as Chrysobalanaceae and *Sabal*-type phytoliths and is lower in disturbance indicators such as grasses. This suggests the surrounding environment was mainly intact tropical evergreen forest. Domesticates are also notably lacking in this basal zone. The second zone identified extends from immediately above Floor 1 upward on the stratigraphic section to 0.75 m, the top of the Archaic period formation at this particular location. This upper zone contains evidence of domesticates such as *Zea mays* and higher frequencies of disturbance-indicating taxa such as grasses (Jones and Voorhies 2004:320). This has been interpreted as suggesting that compared to the lower zone, the natural vegetation at the site was more disturbed but that periodic abandonment allowed the repeated invasion of grasses (Jones and Voorhies 2004:322).

Jones and Voorhies (2004:323) also analyzed three phytolith samples from Floor 1, yielding preliminary insights into the phytolith composition of the floor that are expanded in this study. Their data showed that the phytolith assemblage was dominated primarily by Chrysobalanaceae (a family of tropical flowering trees) and *Sabal* types (a subset of the palm family). The remainder of the phytolith assemblage identified on Floor 1 was made up of mainly various Poacaeae (grass family) and Marantaceae (arrowroot family) phytoliths. Ultimately, the differences among the different samples's taxa representation were not deemed sufficient, given the sample size, to be interpreted as representing different use areas for the plants that produced them.

Prior Phytolith Analyses on the Chiapas Coast

Jones and Voorhies (2004) conducted phytolith research at Cerro de las Conchas, a Middle Archaic period shellmound approximately 30 km to the southeast of Tlacuachero (Figure 7.1). From the lower extent of the vertical series of analyzed samples (6.3 m, 6720–6550 cal B.P.) to 3.4 m below datum (5650–5590 cal B.P.), phytoliths representing forest elements, such as Chrysobalanaceae and *Sabal* sp., dominated the assemblage. The investigators also found a conspicuous lack of cultigens. At 3.4 m below datum, however, a shift is found toward a higher level of disturbance indicators, such as grass. This shift is interpreted as possible encroachment of a grassland savanna into the forest near the site (Jones and Voorhies 2004:306). Phytoliths representing cultigens such as maize appear in the sediments at 1 m in depth, in the zone above the Middle Archaic deposits.

Jones and Voorhies (2004; Voorhies et al. 2002) also investigated the phytolith record from Vuelta Limón, an inland open-air site located approximately 17 km north of Tlacuachero (Figure 7.1). The lowest zone of phytoliths in the vertical series of samples (2.7–1.9 m) is dominated by forest forms representing the Chrysobalanaceae and Marantaceae families. This zone encompasses the Late Archaic and Early Formative periods based on the presence—and absence—of ceramics found in the strata represented. As the phytoliths representing forest forms are replaced by those signaling disturbance, such as the grasses, domesticates such as *Zea mays* (maize) and *Curcurbita* sp. (squash) are found. The uppermost extent of the series, less than 1 m below datum, records a period where disturbance taxa become less common and are replaced by forest elements again (Jones and Voorhies 2004:329).

At Vuelta Limón, Jones and Voorhies (2004) also examined the spatial patterning of phytoliths across the occupational surface designated Stratum E (2.5–2.6 m), an aceramic sediment containing fire-cracked rocks, worn cobbles, and stone tools that dates to the Late Archaic period. Overall, the representation of taxa was very similar to the corresponding depth in the vertical series discussed above. The investigators compared the representation of taxa associated with a concentration of rock (fire-cracked rock and stone tools) against those taxa away from the rock cluster. They found increases in *Sabal* sp., Marantaceae, and palmlike forms associated with the rock cluster. In the samples farther from the rock cluster, they found increased levels of *Heliconia* sp. phytoliths. This led them to interpret the rock cluster as a discard area and to explain the peripheral prevalence of *Heliconia* sp. phytoliths as resulting from its position as a gap colonizing plant (Jones and Voorhies 2004:334). *Zea mays* phytoliths were present but did not exhibit higher frequencies in association with the rock concentration compared to elsewhere.

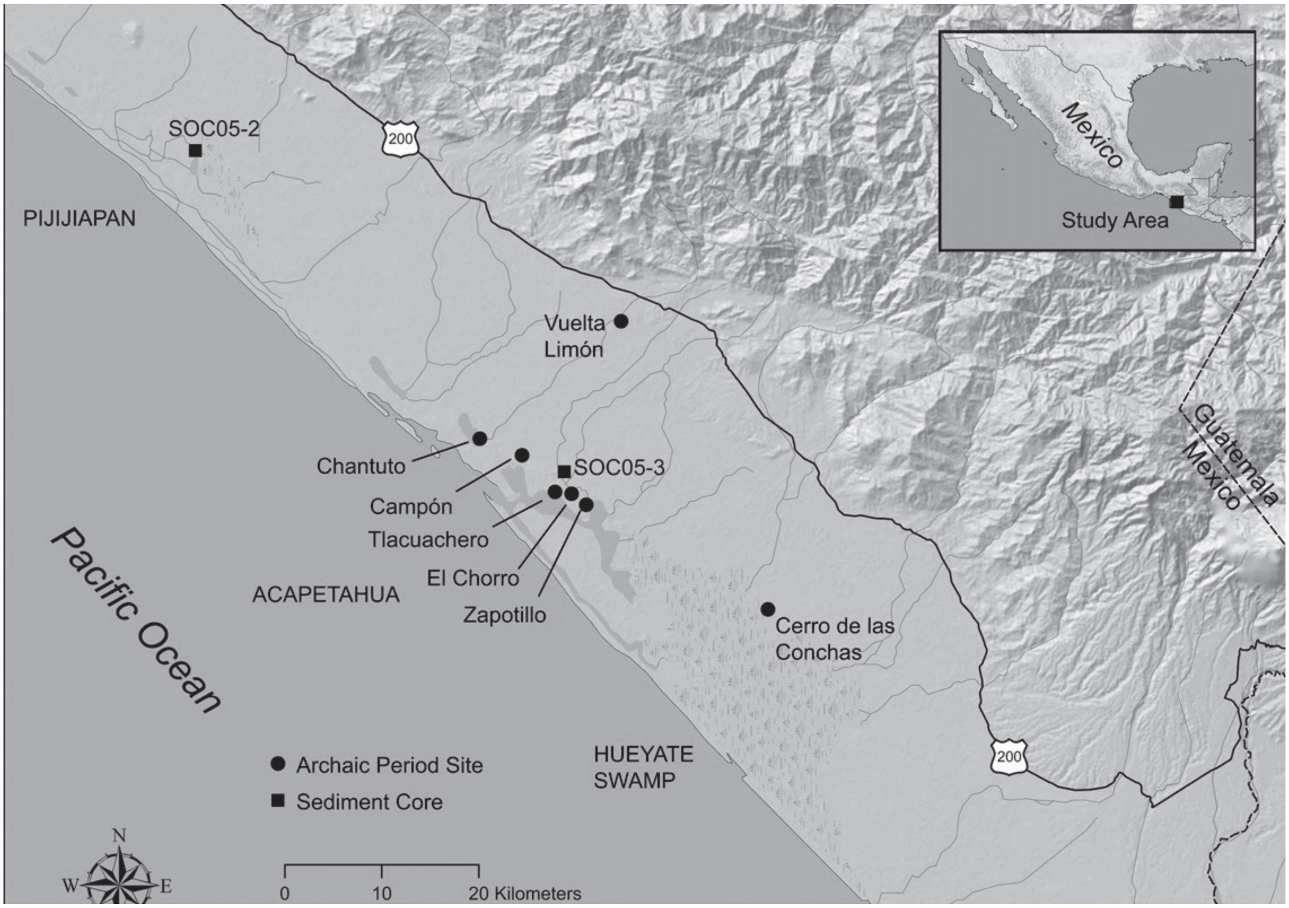


Figure 7.1. The location of Tlacuachero and other Archaic period sites mentioned in the text along with the location of two sediment cores (from Kennett et al. 2010:Figure 1).

Jones and Voorhies (2004) also examined the phytolith record from CAP-78, a Middle Formative period site located only 1 km from Vuelta Limón (Figure 7.1) and exposed in a riverbank. This site has relatively little time depth, yet the trends observed mirror those found at other sites. In the strata contemporaneous with the occupation of the site, there is a high level of disturbance indicators including grass and Cyperaceae types. After its abandonment, disturbance-indicating taxa are replaced by forest indicators such as Chrysobalanaceae, Marantaceae, and *Bactris* sp. phytoliths.

Kennett et al. (2010) also examined phytoliths from two cores from coastal Chiapas at several locations that are not near archaeological sites (Figure 7.1). The first of the two cores examined, SOC05-2, was taken approximately 50 km northwest of Tlacuachero. This core sheds light on the phytolith record from approximately 6600 to 200 cal B.P. The other core, SOC05-3, was taken less than 3 km from Tlacuachero along the inner edge of the Acapetahua Estuary. The core contains sediments dating from 4700 to 2300 cal B.P. Although the taxa identified in these cores are not directly comparable to Jones and Voorhies's (2004) investigations, due to a lack of universally used phytolith-categorization schemes and nomenclature, they provide additional phytolith evidence for the region. Overall, SOC05-2 is dominated by grass phytoliths. Bamboos such as *Chusquea* are well represented at the base of the core. At 6500 cal B.P., bamboos are replaced by disturbance-indicating weedy grasses and *Heliconia* sp. phytoliths. In addition to these disturbance-indicating taxa, evidence for maize is present at 6500 cal B.P. in the form of cob and leaf phytoliths. SOC05-3 complements SOC05-2, although its phytolith record is uneven due to shifting depositional circumstances. Similar to SOC05-2, it records abundant grasses throughout the record.

Kennett et al. (2010) also identified phytoliths diagnostic of maize in the SOC05-3 core at 4100 cal B.P.

Spatial Analyses of Microbotanical Remains

The concept of spatially analyzing microbotanical remains has existed for some time now (Scott 1979). Linda Scott (1979) completed an analysis for the Dolores Archaeological Project (a large mitigation program in southwestern Colorado) that consisted of an examination of the distribution of pollen grains across a series of prehistoric sites. She compared the abundances of different pollen-producing taxa from samples collected from a combination of floor surfaces and features throughout the sites. Variations in the prevalence of different pollen types were noted on an intersite and intrasite level. Scott's (1979) analysis led to a number of conclusions regarding plant storage and preparation areas based on variability in the presence of pollen types representing economic taxa such as *Zea*. Although raw count numbers are not available, it appears taxa were distributed quite unevenly and provided an avenue for interpretive explanation. Scott (1979) was able to interpretively detect a number of plant-use signatures, such as likely maize-storage areas, based on pollen evidence and circumstantial knowledge about the study area.

Despite the fact that an intrasite spatial analysis of pollen was conducted by Scott (1979), such a detailed study has not been attempted using phytolith evidence. In theory, phytoliths should provide a more interpretable signal of local plant use, since their deposition is more spatially limited than that of pollen. Many of the most prolifically produced types of pollen have been selected through evolutionary processes to be buoyant and mobile, so that they may disperse and travel great distances to pollinate distant plants (Rousseau et al. 2006). In contrast, phytoliths are internalized botanical structures composed of heavy silicates and are released into the environment when a plant decomposes or is burned (Pearsall 1982). Thus phytoliths will not typically be distributed over long distances, except when they are transported by animals or carried downstream in waterways.

Summary

The Chiapas region of Mexico has been a focus of interest for Mesoamerican archaeologists for some time now. Although a great deal is known about later periods in the area, with their monumental architecture and larger city-states, the Archaic period, with its ephemeral sites often obscured by high sedimentation rates, is less well understood. Thus researchers examining the Archaic period necessarily focus on visible shellmounds such as Tlacuachero. The Tlacauchero site, because it was occupied during the transition to agriculture, provides an excellent opportunity to examine this period in the region. At this particular site, this transitional point is uniquely marked with the formation of several floors, although regional data show that agriculture was in vogue elsewhere by this time. Previous spatial investigations of ancient plant use have focused on the analysis of pollen. Due to oxidation-related preservation issues at Tlacuachero, any related paleovegetational investigations are limited to phytoliths. Phytoliths do not disperse widely, so they should provide the ability to examine distributional patterns of localized plant use. It is hoped that the phytolith record at the site will help provide data on the use of native and domesticated flora during the transition to agriculture in the region.

Methods

The phytolith analysis involved four key stages: the field collection of samples; quantification and processing of the samples; identification and calculation of relative frequencies of different phytolith types; and the analysis and interpretation of the count data using computer-generated contour maps. I was unable to visit the site in person, so the analyses presented in this chapter are based on the analysis of a number of samples sent by Barbara Voorhies to John G. Jones and me at Washington State University. I personally completed all steps of the phytolith analysis after the samples were collected.

Field Sample Collection and Quantification

Archaeologists collected samples of sediment from floors 1 and 2 in a gridded pattern of 1-m increments, in addition to nonrandom samples associated with cultural features (Chapter 4; Voorhies 2009). These samples were taken from just below the surface of the floors in an attempt to reduce the potential for contamination from overlying sediments. Approximately 5 g of the fine-fraction of each sample were allocated for the phytolith analysis.

Sample Selection

In total I chose 42 samples from the Tlacuachero floors for the phytolith analysis. The focus of this analysis, Floor 1, was represented by 38 samples. These samples were chosen randomly from the total available samples, although toward the end of the selection process, I chose some samples selectively to ensure that all areas were represented in the analysis. In addition to the overall gridded samples, I selected a small number of samples from the set of samples associated with cultural features. The preliminary assessment of Floor 2 includes four samples chosen in a similar fashion.

Sample Processing

Sample processing, following procedures utilized by Jones (2012), included a series of steps undertaken to remove undesired and irrelevant components of the sediment. These unwanted components include carbonates, materials larger than 150 microns, humates, organic materials, and irrelevant silicate materials such as clays, silts, and sands (Piperno 1988). First, to remove the carbonates, the samples were immersed and disaggregated in 10 percent hydrochloric acid. This relatively weak acid allowed for the dissolution and removal of carbonates without harm to the phytolith assemblage. Next the samples were screened through 150-mu mesh to remove all particles beyond the upper range of diagnostically useful phytoliths. Next the samples were rinsed in 5 percent potassium hydroxide (KOH) for approximately 30 seconds. This step facilitated the removal of alkaline-soluble humates with successive rinses of distilled water. Following the KOH wash, the samples were placed in Shultz's solution (Jones 2012), a mix of nitric acid and potassium chlorate, and were heated in a water bath. This step acted to dissolve all unwanted organic materials that would obscure phytoliths during counting.

After the undesired components were removed, the remaining samples were fractionated into 3- to 25-mu and 25- to 150-mu fractions and were separated from heavier silicates, including all clays, silts, and sands. To fractionate the samples, each sample was added to a 300-ml beaker of water, which was agitated and allowed to settle for two minutes and 20 seconds. This provided time for all the material under 25 mu to settle to the bottom. The water containing still-suspended material was poured off to create the fine (less than 25-mu) fraction of the sample. The material that settled on the bottom was collected to create the coarse (greater than 25-mu) fraction. Because different phytolith types occur in different size ranges, fractionation of the samples facilitated analysis by reducing the overall number of types counted at a given time. After this step, a heavy density separation was performed. Samples were added to a sodium polytungstate solution with a specific gravity of 2.350. The samples were then centrifuged for six minutes to allow sufficient time for the lighter phytolith component to rise to the surface while the heavier components sank to the bottom. At this point, a small amount of distilled water was gently added to the surface of the heavy-density solution to facilitate collection of the phytoliths for sample preparation. The remaining sodium polytungstate was saved for later reclamation.

After the samples underwent fractionation and heavy density separation, they were stored in 1-dram vials for curation and sample preparation. Slides were created by placing a small amount of the sample suspended in ethyl alcohol (ETOH) onto a cover slip; the ETOH was allowed to evaporate, leaving dry phytoliths adhering to the slides. Slides were made permanent with melt-mount (Stromburg et al. 2007) added to the inverted cover slips. The remaining phytolith samples in ETOH were stored in the 1-dram vials for curation.

Sample Counting

After the samples were mounted on slides, a minimum of 300 individual phytoliths were identified from each slide fraction. These identifications were made using a Nikon stereomicroscope with 400x to 1000x magnification. Each type was identified based on published keys and reference materials (Piperno 1988). After the first 300 phytoliths encountered on each slide were recorded, the remainder of each slide was scanned for poorly represented or interpretively important phytolith types, such as maize or squash. It was hoped that by counting the first 300 phytoliths encountered, we would obtain a representative sample that would shed light on the remaining unobserved data set. To reduce introduced biases, effort was given to ensure that all phytoliths were counted, regardless of their identifiability.

Computer-Generated Mapping

Once the phytolith percentages were recorded, these data were entered into a computer program, Golden Software's Surfer, to create distributional maps. This program was chosen for its familiarity with and ease in combining location data with intensity values. The data were gridded using a number of interpolating methods; the most productive of these used kriging with a linear variogram. Kriging estimators are commonly used algorithms for gridding data and a form of linear regression to interpolate data points (Goovaertz 1997:126). The gridded data were then used to create distributional maps that show relative frequency data for each type across the site.

Results

The following discussion focuses on issues of preservation of phytoliths at Tlacuachero, the limitations posed by phytolith analysis for interpreting the past presence of plants, and the spatial distribution of selected phytoliths on Floor 1 and Floor 2.

Phytolith Preservation

The high oxidation-reduction potential at Tlacuachero has prevented the preservation of pollen. However, phytolith preservation at the site appears to be excellent. This is likely due to phytoliths' robust silica-rich composition. Numerous phytoliths were observed in each sample. Other silica-based remains such as diatoms were preserved in the samples, although they were not quantified or analyzed. Although many phytoliths were observed, the absolute concentrations of phytoliths per unit of sediment are unknown. No known exotic biosilicate tracers that would allow this determination to be made, as is common in pollen investigations, are available, although some phytolith analysts have reported success in calculating phytolith concentrations by adding exotic *Lycopodium* spores (Lunning et al. 2008).

Phytoliths and Their Limitations

Phytolith analysis, a relatively young method of inquiry, has been shown to be a valuable tool for investigating paleoecological conditions (Piperno 1988). Despite its utility, phytoliths are not without their own limitations. Phytoliths are diagnostic of varying levels of taxonomic classification. Phytoliths from some plants, such as *Zea mays*, have been found to be diagnostic to the species level (Piperno et al. 2009). In contrast, other phytolith types, such as the *Sabal*-type, are known to be diagnostic only to the family or genus level. In addition, not all plants produce phytoliths. Phytolith analyses can thus be blind to shifts in the presence of certain plants that do not produce phytoliths, such as red mangrove. These shifts would be detectable only indirectly through the interpretation of proxies, such as relative levels of disturbance-indicating taxa to forest taxa. Phytolith analyses are also complicated by a lack of universally used type categories. For example, Jones and Voorhies (2004:320) call one phytolith type Chrysobalanaceae type, whereas Kennett et al. (2010:3408) appear to refer to the same type as arboreal spheres. As in the example presented, some analysts prefer to reference certain phytolith types by their morphological characteristics, whereas other analysts prefer to assign a taxonomic name. Following Jones and Voorhies (2004), phytolith types are identified in this chapter to the most specific taxonomic level possible.

Floor 1 Results

Six different phytolith types were identified during the analysis (Table 7.1). These include phytoliths from the Chrysobalanaceae family, *Sabal*-type palms, the Poaceae family (grasses), the Marantaceae family, *Heliconia* sp., and unknown types. Although the area contains many other important species, such as mangroves, not all plants produce diagnostic phytoliths, so they cannot be accounted for in this study.

Phytoliths from Chrysobalanaceae, sometimes referred to as the coco plum family, were particularly common in the Tlacuachero samples. This family includes *Chrysobalanus*, *Couepia polyandra*, *Hirtella americana*, and a number of other trees that are relatively common in the area and are expected to be well represented in the phytolith assemblages. These have also been found to be very common in other phytolith investigations in the area (Jones and Voorhies 2004; Kennett et al. 2010; Voorhies et al. 2002). Chrysobalanaceae phytoliths are the dominant type throughout the samples analyzed. On average, this group represents 70.6 percent of each sample, with a standard deviation of 8.6 percent. Despite its position as the best-represented phytolith type in the assemblage, the coefficient of

Table 7.1. Raw Counts of Identified Phytoliths from Floor 1.

FS #	Poaceae 1	Poaceae 2	Poaceae 3	Chrysobalanaceae	Marantacae	*Sabal* type	*Heliconia* sp.	Bulliform	Unknown (t)	Unknown (ss)	Other
290	3	2	0	183	4	98	1	0	0	9	0
292	2	0	0	157	1	133	0	0	0	7	0
294	2	1	0	207	0	89	0	0	0	1	0
296	2	2	0	242	7	34	0	0	3	10	0
471	0	0	0	245	4	27	1	1	4	18	0
473	1	0	0	218	26	45	0	0	3	7	0
474	0	0	0	229	1	50	0	1	2	17	0
475	1	1	1	188	12	89	0	1	3	4	0
480	0	0	2	221	7	59	0	0	1	10	0
485	2	1	0	251	1	28	0	0	5	12	0
88-309	0	1	0	252	5	29	0	0	0	13	0
A-02	0	1	0	240	7	44	0	0	1	7	0
A-04	1	3	1	224	10	49	0	0	3	9	0
A-06	1	2	0	244	5	33	0	0	2	13	0
A-09	3	3	0	248	5	29	0	0	0	12	0
B-04	3	7	0	233	4	40	0	0	0	13	0
B-08	0	0	0	229	1	50	0	1	2	17	0
C-10	1	0	1	180	1	113	0	0	0	4	0
C-07	2	0	1	178	3	105	0	1	0	10	0
D-02	2	3	0	202	0	83	0	0	0	10	0
D-05	5	2	0	192	2	94	1	0	0	4	0
D-09	1	1	0	253	0	42	0	0	0	3	0
E-04	8	19	0	190	0	81	0	0	0	2	0
E-06	0	0	0	168	2	114	0	0	0	16	0
F-06	0	0	0	192	2	82	1	0	0	23	0
G-01	0	0	0	192	1	96	0	0	0	11	0
G-03	3	1	0	152	1	123	0	0	0	20	0
G-07	3	3	0	214	2	65	3	0	1	9	0
G-09	3	0	0	172	0	113	1	0	5	6	0
H-00	0	0	0	169	2	125	0	0	2	2	0
H-04	2	2	0	177	0	104	0	0	2	13	0
H-06	2	0	0	178	3	107	0	0	0	10	0
H-08	5	5	0	184	2	91	0	0	1	9	3
J-06	5	18	2	214	1	55	0	0	0	5	0
J-08	8	4	0	207	0	73	3	0	1	4	0
K-07	0	0	0	228	1	63	0	0	1	7	0
L-05	2	1	0	177	0	111	0	0	0	9	0

variation value is very low, at 0.12, suggesting that the distribution of Chrysobalanaceae is quite even across the site.

Another significant phytolith type observed represents palms consistent with the genus *Sabal*. This genus includes *S. mexicana*, *S. mauriiformis*, and others. As with the Chrysobalanaceae family, *Sabal*-type palms are very common today on and near the site, produce large quantities of diagnostic phytoliths, and should be well represented at the site. *Sabal*-type palm phytoliths were common, constituting on average 22.8 percent of the samples. *Sabal*-type palm phytoliths are more variably distributed than those of the Chrysobalanaceae, as indicated by their higher coefficient of variation of .41.

The *Sabal* sp. contour map for Floor 1 provided very interesting results. As shown in Figure 7.2, the highest relative presence of *Sabal*-type palm phytoliths is in the center of the excavated area. This pattern is very strong and is driven by seven different sampling locations. Interestingly, this pattern appears to follow a series of postholes that encircle the central finger holes. Overall, this distribution is approximately 4 m wide and 6 m long in a roughly north-to-south orientation. The average intensity of *Sabal* sp. phytoliths at these points is 34.8 percent, compared to an average frequency of 20.6 percent in the remaining samples. Outside of this large centrally located zone of high density, additional high-frequency occurrences can be seen on the contour map scattered throughout the site. Despite intensity values approaching that of the centrally located pattern, none of these *Sabal*-type palm hot spots is confirmed by high values at two or more adjacent (less than 2 m) sampling locations. Thus these depositional hot spots can be considered spatially restricted, especially when compared to the 24 m² pattern discussed above.

Diagnostic phytoliths characteristic of grasses, members of the Poaceae family, were rare at Tlacuachero. Grass types represent 1.6 percent of each sample on average, with a coefficient of variation of 1.41. When compared to the *Sabal*-type palm and Chrysobalanaceae phytoliths, grass phytoliths are much rarer, but they are more variable in their relative representation among the analyzed samples.

The individual grass types were combined for the purposes of constructing a visually intuitive contour map (Figure 7.3) for Floor 1 at Tlacuachero. This pooling of data is due to the overall paucity of grass phytoliths, but it is also due to the grasses occupying the same interpretive niche. The grass types encountered may be considered essentially equal with respect to their interpretability and so will thus be considered together to aid in interpretation. As seen in Figure 7.3, the highest concentration of grasses is spatially restricted and is circumscribed by the central feature of finger-molded holes. In all, five sampling locations drive this high-grass pattern, and the mean percentage of grass phytoliths at these locations is 6.2 percent versus 0.9 percent for samples outside of this pattern. Beyond the extent of this high-concentration pattern, additional points of interest can be seen. However, these hot spots are each driven by a single sample and are not confirmed by the adjacent (less than 2 m) samples.

Phytoliths from Marantaceae, commonly referred to as the sweet prayer plant family, are also poorly represented in the Tlacuachero samples. Members of the Marantaceae family include *Calathea* sp., *Maranta arundinacea* (arrowroot), *Stromanthes*, and others. Overall, the Marantaceae phytolith types are less well represented than the Chrysobalanaceae, *Sabal*-type, and Poaceae phytoliths, with an average occurrence of 1.2 percent and a standard deviation of 1.7 percent. The coefficient of variation of 1.35 indicates that its presence fluctuates more in relation to its mean value among the different sampling locations than either the Chrysobalanaceae or *Sabal*-type phytoliths.

A contour map was generated for the distribution of Marantaceae phytoliths (Figure 7.4). When compared to the *Sabal*-type palm and grass contour maps, the contour map for Marantaceae phytoliths is less well defined. Although there is higher relative variability overall in the distribution of Marantaceae phytoliths, the points of highest concentration do not occur in adjacent samples, as was found in the first two groups. Instead, the highest points of relative concentration are spread throughout the site, with the highest concentration (8.6 percent) located in the northwestern area of the excavation. This contrasts to the nearest sampling location, 2 m south, containing a total Marantaceae phytolith representation of 0.7 percent. Beyond this high-concentration location are three additional locations identified in the southeastern portion of Floor 1 with relatively higher occurrences of Marantaceae phytoliths and one location in the southwestern portion.

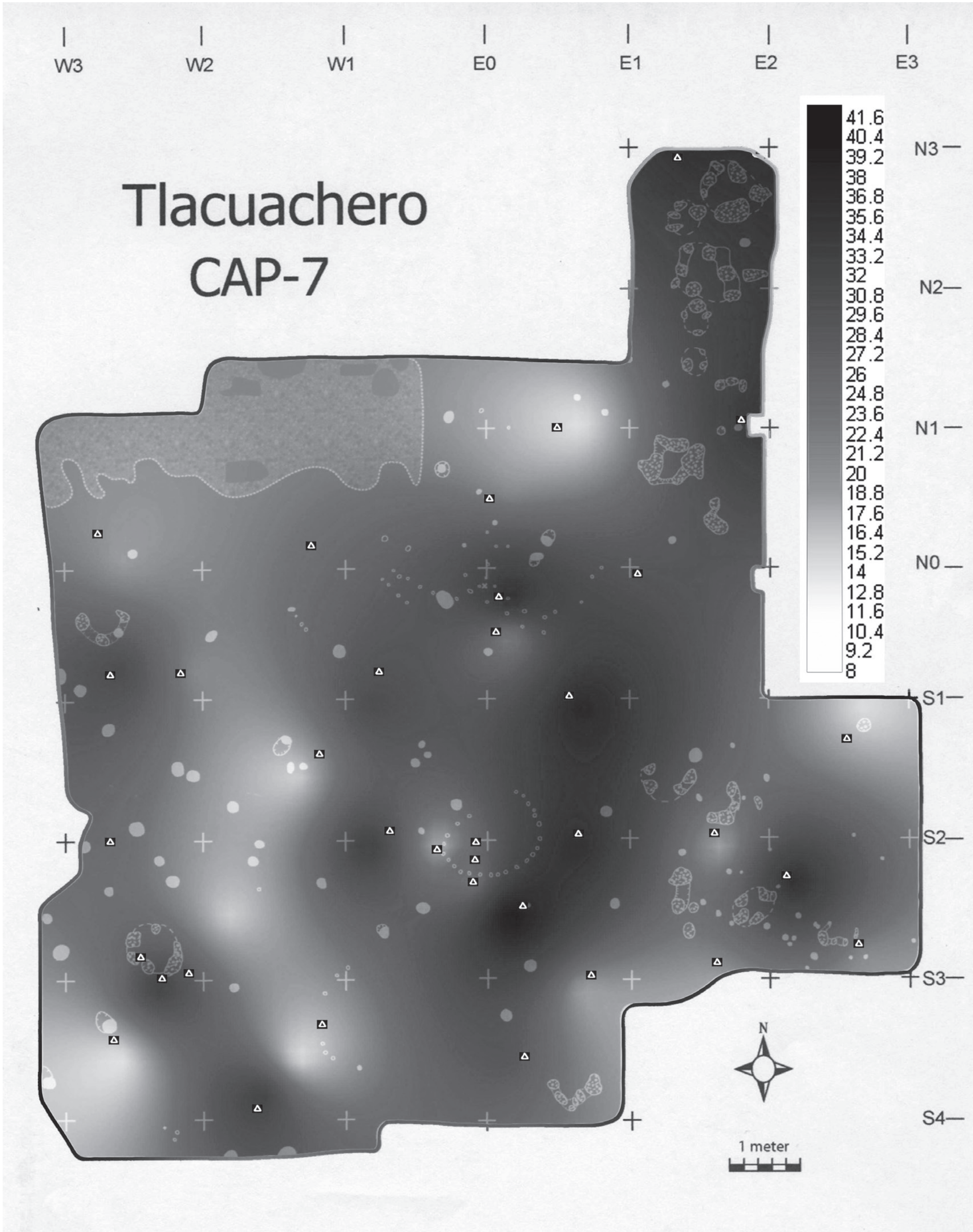


Figure 7.2. Map of the distribution (%) of Sabal-type phytoliths across Floor 1 at Tlacuachero (illustration by Doug H. Drake).

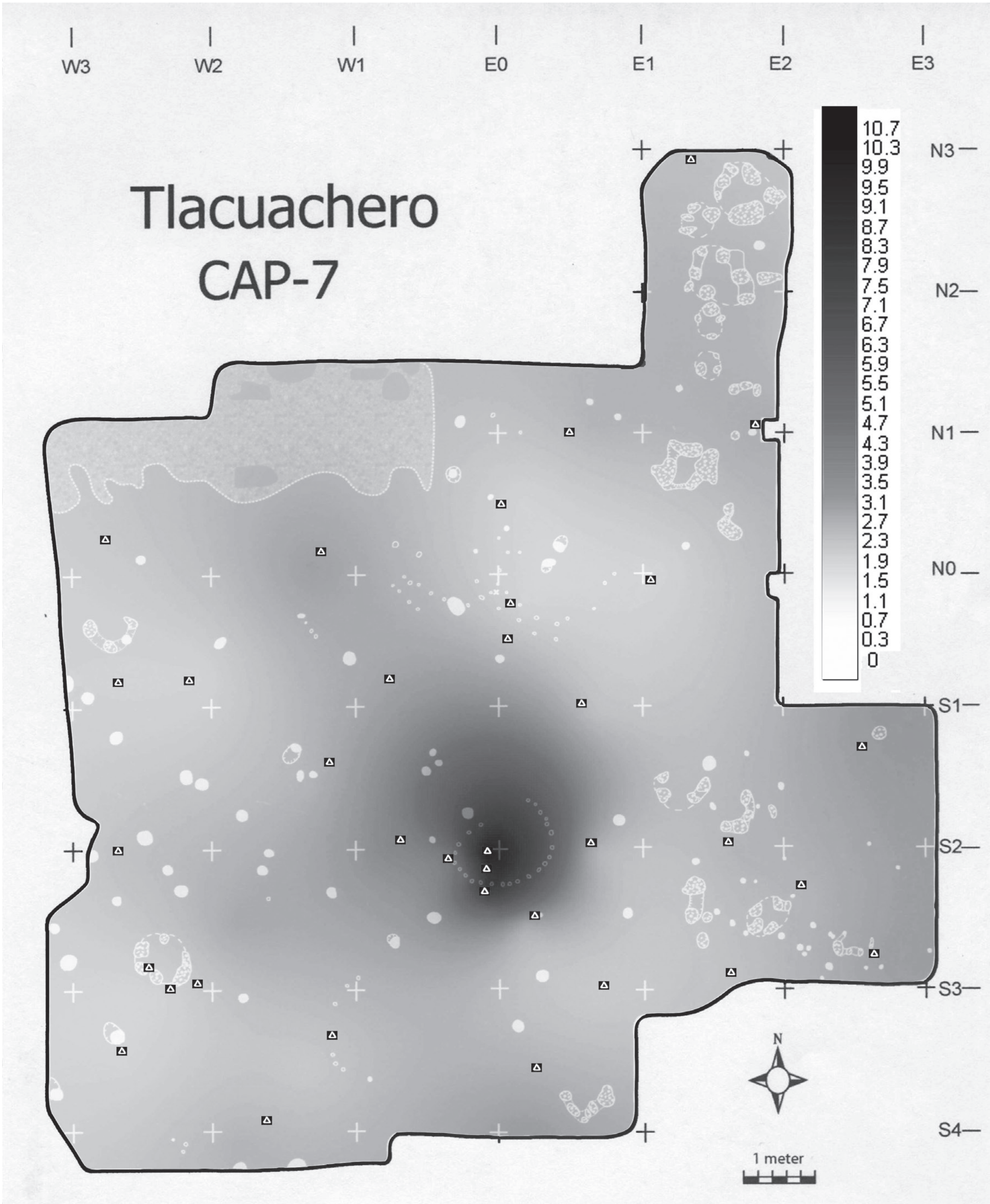


Figure 7.3. Map of the distribution (%) of grass phytoliths across Floor 1 at Tlacuachero (illustration by Doug H. Drake).

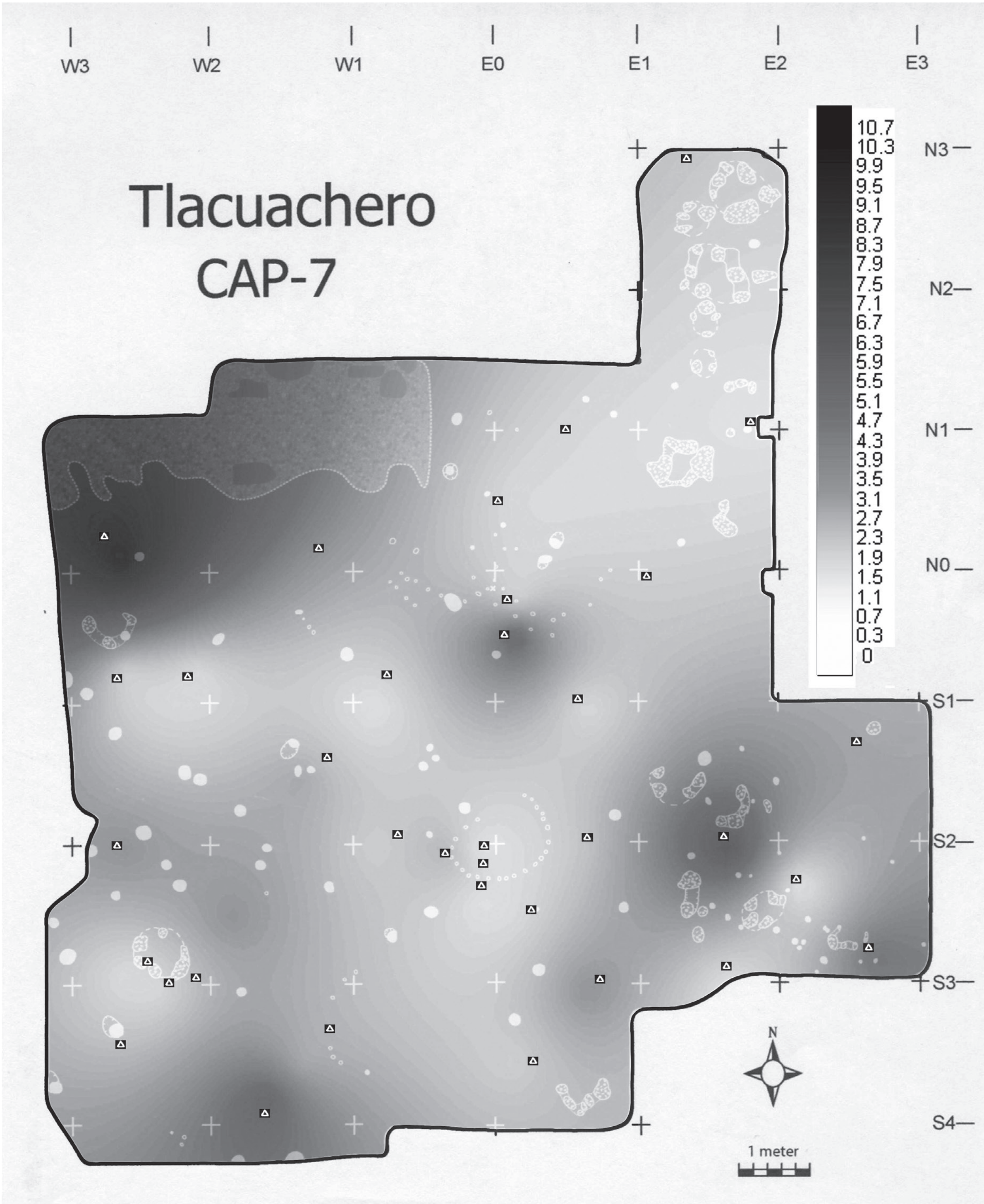


Figure 7.4. Map of the distribution (%) of Marantaceae phytoliths across Floor 1 at Tlacuachero (illustration by Doug H. Drake).

Phytoliths representing *Heliconia* sp., whose members are sometimes referred to commonly as wild plantains or false bird-of-paradise, represented on average only 0.1 percent of the phytoliths encountered. A coefficient of variation was calculated at 2.3 for *Heliconia* sp. phytoliths, which indicates that the relative amount of variation in *Heliconia* sp. phytoliths is high compared to the other phytolith types identified. This increase in variability, however, is largely due to the overall scarcity of *Heliconia* sp. phytoliths.

A distributional contour map was generated for *Heliconia* sp. phytoliths (Figure 7.5) across Floor 1 at Tlacuachero. The highest concentrations of *Heliconia* sp. occur near and immediately south of the central finger-molded holes. This pattern is primarily driven by two samples, which average approximately 1 percent *Helconia* sp. phytolith representation. Although this is a very low overall representation, it contrasts with the average of 0.1 percent representation throughout samples that are not part of the pattern. This pattern is also confirmed, beyond the two sampling locations, by one more sample adjacent (less than 2 m) to the northern end of the pattern, although it contains only 0.3 percent *Heliconia* sp. phytoliths. Beyond this point of highest relative concentration, isolated *Heliconia* sp. phytoliths were found spread throughout the site in the northwestern and eastern portions of Floor 1.

Three unknown phytolith types were identified in the phytolith assemblage from Floor 1 at Tlacuachero. These types include "spherical irregular," "unknown type t," and "other unknown." Spherical irregular and unknown type t are morphologically consistent throughout the assemblage. However, they could not be identified with the use of published keys or reference collections. Spherical irregular is a spined spherical-type phytolith with a large hemispherical concavity. Unknown type t is a small semicircular phytolith with a shape reminiscent of a slice of watermelon. The other unknown group is made up of a small number of other observed biosilicates that fall within the size range of phytoliths and that could not be alternatively identified as diatoms or sponge spicules. These unknown types constitute an average of 3.5 percent of each sample, and the total standard deviation for this group is 1.8 percent. These values result in a coefficient of variation of 0.5, which shows that the group has a size-adjusted amount of variability comparable to that of the *Sabal*-type palm phytoliths. Due to their lack of interpretive utility, distributional maps were not generated for the unknown phytolith types.

Floor 2 Results

The phytolith assemblage identified from Floor 2, a floor found immediately below Floor 1, is shown in Table 7.2 and is similar to the assemblage seen from Floor 1. The taxa identified from the phytolith assemblages of Floor 2 are the same as those found on Floor 1. However, a difference in the overall representation of each phytolith type may signal a change in vegetation represented at the site (Table 7.3).

As seen in Table 7.3, the phytolith record from Floor 2 contrasts with the record from Floor 1 in a few ways. Phytoliths representing the grasses and the Marantaceae family are less well represented in Floor 2 compared with Floor 1. In contrast, *Heliconia* sp. and *Sabal*-type palm phytoliths are slightly better represented. Despite

Table 7.2. Raw Counts of Identified Phytoliths from Floor 2.

FS #	Poaceae 1	Poaceae 2	Poaceae 3	Chysobalanaceae	Marantaceae	*Sabal* type	Heliconia sp.	Bulliform	Unkown (t)	Unkown (ss)	Other
I-1	0	0	0	193	1	101	0	0	1	4	0
I-8	5	2	1	213	0	70	2	0	0	7	0
I-9	1	0	0	210	0	83	0	0	0	6	0
III-3	0	0	0	179	1	107	0	0	1	12	0

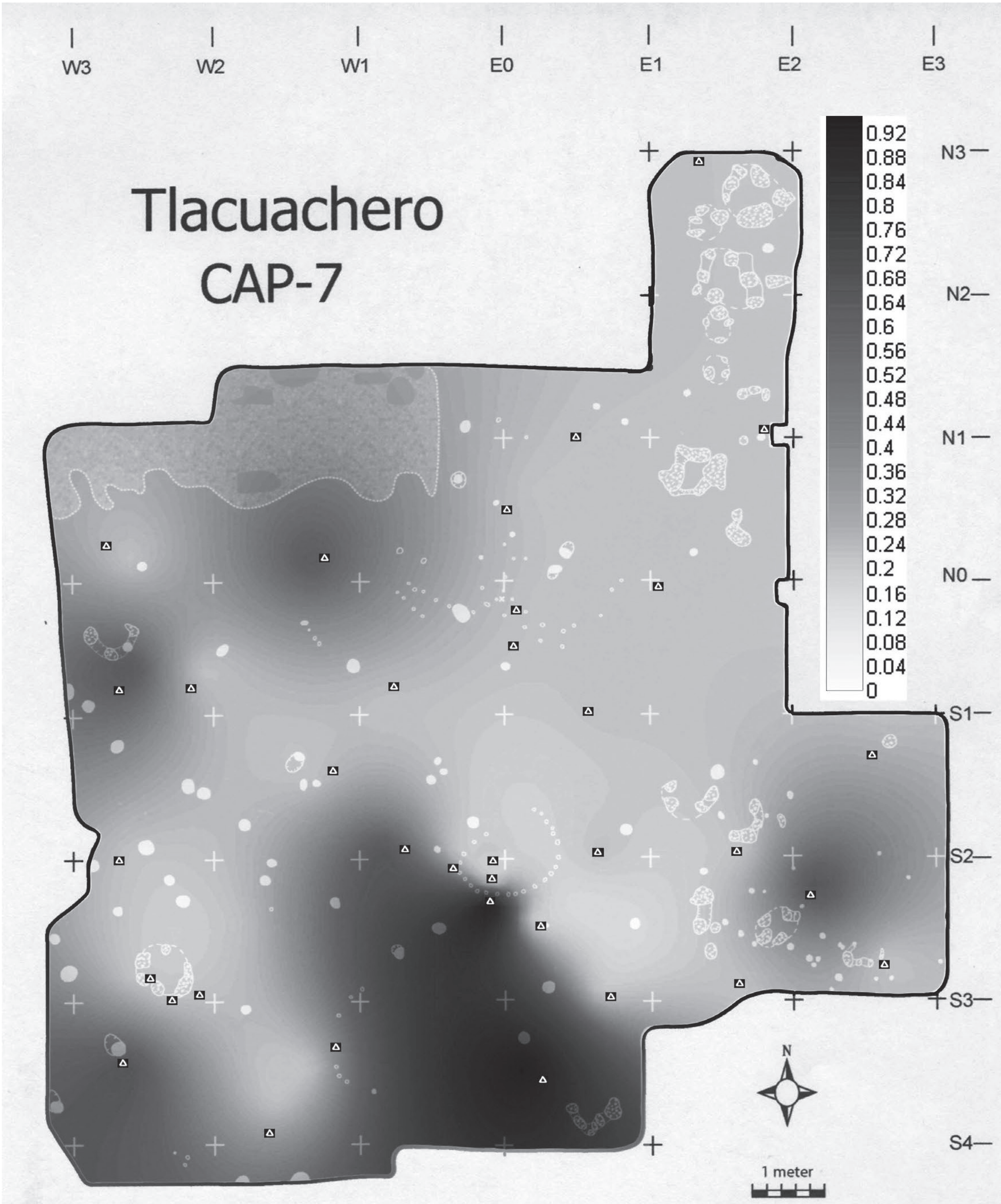


Figure 7.5. A map of the distribution (%) of Heliconia sp. phytoliths across Floor 1 at Tlacuachero (illustration by Doug H. Drake).

Table 7.3. Average Percentages of Phytolith Taxa from Floor 1 and Floor 2.

	Chrysobalanaceae	*Sabal* sp.	Grasses	Marantaceae	*Heliconia* sp.	Other
Floor 1	68.6%	25.5%	1.4%	1.0%	0.0%	3.5%
Floor 2	66.3%	30.0%	0.7%	0.2%	0.2%	2.6%

these differences in the mean representation of different types, each difference is relatively minor and no taxa frequency value from Floor 2 exceeds the total range of variation previously found in Floor 1.

Phytolith data from Floor 2 allow for a limited examination of the distribution of phytoliths. It should be noted, however, that only four samples from Floor 2 at Tlacuachero were analyzed for their phytolith content, so the resolution of the spatial distribution is very low. In addition, the small sample size prevents the ability to compare a given result to that of adjacent samples, making it difficult to assess the overall area encompassed in each detected hot spot. Thus it is likely that the distributions observed may appear substantially different with the inclusion of additional analyzed samples.

Sabal-type palm phytoliths are found to represent from 25 to 35 percent, with the areas of higher relative abundance located toward the northern end of the exposed portion of Floor 2. Grass-type phytoliths make up zero to 2.6 percent of each sample and appear to be most prevalent in the central portion of the exposed floor. Marantaceae-type and *Heliconia* sp. phytoliths are rare on Floor 2 and make up from zero to 0.3 percent of each sample. Marantaceae-type phytoliths appear to be more common toward the northern end of the excavation, while phytoliths representing *Heliconia* sp. are more common toward the southern portion of the sampled area. Taking into consideration the extreme localization and variability in the representation of *Heliconia* sp. and Marantaceae phytoliths on Floor 1, the distribution of these types is probably most susceptible to major differences with the addition of additional sampling locations.

Discussion

It is now time to consider the potential sources of the distributional patterns of the phytoliths and some possible interpretations of the patterns on Floor 1 and Floor 2. I also discuss the implications of this study for our understanding of plant use during the Archaic period and offer some recommendations for future studies.

Potential Sources of Phytolith Distributional Patterns

As shown in figures 7.2 to 7.5, patterning in the distribution of selected phytoliths has been found on Floor 1 at the Tlacuachero site. The depositional patterns encountered at Tlacuachero could be caused by a number of factors, including site creation processes, post-floor-use phytolith migration, and on-site plant use contemporaneous with use of the floor. Each of these possibilities is discussed and their overall effect on the ultimate phytolith distributions is assessed.

The first potential source of the phytolith patterns seen at the site relates to phytoliths possibly incorporated into the floor material at the time of floor formation. Several possibilities deserve consideration. Neff et al. (Chapter 5) think that the fine sediment of the floors originated as wood ash, comminuted shell, or a combination of these two substances. It is conceivable that ash might contain phytoliths, and also that phytoliths might slip through the filtering system of clams, thus allowing them to be transported inside the shells of fresh clams to the location to the site. Moreover, water used to moisten the floor starting material when it was laid out most likely came from the estuary. The large numbers of aquatic diatoms and sponge spicules that I encountered in the floor samples during the phytolith analysis prove that estuarine water was arriving at the site. Since phytoliths are known to be transported and deposited by water (Piperno 2003), this is another possible mechanism for introducing phytoliths into the material of the floors.

An important question to ask at this point is what pattern should be expected from phytoliths present in the sediment as a result of such nonanthropogenic processes? It may be expected that, assuming that phytolith-bearing estuarine water was being introduced to the site, the phytolith profile should be roughly consistent across the floor. The distributional patterns (figures

7.2–7.5) demonstrate that the distribution of each phytolith type is independent across the site. This suggests that the distribution patterns were not a function of the formation of the floor itself.

The second potential driver of phytolith variation at the site is the degree to which phytoliths can migrate through sediment, something that is not well understood (Fishkis et al. 2009, 2010). If downward phytolith migration is present at the site, we should expect an inflation of smaller types across the site (Fishkis et al. 2010). This factor, however, is hopefully avoided in this analysis because interpretations focus on intrasite differences among individual phytolith types.

The third potential source of the variation in phytolith patterns observed on Floor 1 at Tlacuachero is from plants being taken to the site and used during the time the floor was in use. This source of patterning is the most interpretively useful and the focus of this analysis. Luckily, the phytolith distribution of a given plant is usually highly localized when compared to other microbotanical remains, which makes phytoliths useful for this type of analysis (Sullivan and Kealhofer 2004). As previously seen (figures 7.2–7.5) and as mentioned above, it appears that each phytolith type is distributed independently of the distribution of other phytolith types. This suggests that most of the distributions were primarily driven by anthropogenic activities at the site, allowing for interpretation. Regardless, there is still a degree of uncertainty inherent in making any interpretation of prehistoric plant use, as many plants have multiple uses.

Interpretations: Floor 1

The first distribution requiring explanation is that of the Chrysobalanaceae family phytoliths. These phytoliths, the most common type, are found very uniformly across the site. The coefficient of variation value for this type, 0.12, is so low that it may be rightly considered background noise resulting from phytoliths already present in material prior to its use in floors, nearby forests present during floor use, or post–floor use phytolith migration. Thus no interpretation of its distribution is required or put forth beyond the fact that Chrysobalanaceae trees were likely common in the area around the site before, during, and after the use of Floor 1.

The distribution of *Sabal*-type palm phytoliths has higher variability than that of the Chrysobalanaceae phytoliths. Thus there is potential for the *Sabal*-type palm phytoliths to shed light on where and how these plants were being used at the site. Ethnographically, *Sabal* sp. palms have been used for a variety of tasks, including thatching and weaving (Joyal 1996). When thatching, many layers of leaves are overlain on a substructure to provide a roof. In the study area today, *Sabal* sp. palm leaves are also sometimes used to weave mats on which small fish and shrimp are dried (Voorhies, personal communication 2009), and the fresh leaves are often used for seating purposes or to serve food.

Taking into consideration the location and distribution of the *Sabal*-type phytoliths (Figure 7.2), it appears that two interpretations are consistent with the data. First, it is possible that a thatched structure was once present above the floor. This is consistent with the large (24 m^2) circular pattern high in *Sabal*-type palm phytoliths possibly being demarcated by postholes at the center of the Floor 1 exposure. The alternative potential explanation is that the *Sabal*-type palms were being used as matting to dry shrimp and small fish or to provide seating areas or serve food. This second scenario is discussed further by Voorhies (Chapter 10). Perhaps differentiation between these two possible interpretations may be enabled with the addition of geochemical and other analyses. Regardless, it can be said that palms producing *Sabal*-type phytoliths were present at the site during its use, and they appear to have been used most intensively near the center of the excavated portion of Floor 1. This *Sabal*-type palm use area also appears to be flanked by postholes; however, it is not clear what relationship exists between the postholes and the use area. In addition, a number of the *Sabal*-type palm phytoliths were darkened, likely due to burning. Although they were not quantified, a portion of the *Sabal*-type palms present at the site may have been used as fuel. Or, if they were part of a structure, it may have been razed by burning. Exposing phytoliths to fire does not destroy them; the extreme heat of a fire will simply darken their appearance (Piperno 2006:15).

The next phytolith distributional pattern observed is that of the Poaceae family (grasses) (Figure 7.3). As previously mentioned, the highest concentration of grass phytoliths maps onto the central finger-molded holes feature and is within the pattern high in *Sabal* sp. phytoliths. For such a strong and narrowly distributed pattern to arise, it appears that grasses must have been present—and allowed to decompose—in the area of the central finger-molded holes. This could have been because people at the site intentionally placed grass over the

central finger-molded hole feature. This type of pattern could also arise as a result of grass growing where people do not walk. If there were some barrier (sticks placed in the holes) preventing access to the area, grasses might be expected to proliferate. As with the *Sabal*-type palm phytoliths, the relationship between the finger-molded holes and grass phytolith distribution is not immediately obvious without additional data. I hope that the presence of grasses at this location will be explained in the future when the purpose of the finger-molded holes is better understood (see Chapter 10).

A patterned distribution of Marantaceae family phytoliths was also observed on Floor 1 (Figure 7.4). This phytolith type, although rarer here than phytoliths of Chrysobalanaceae or *Sabal* sp. palms, is economically important. The Marantaceae family includes members such as arrowroot (*Maranta arundinacea)* that produce starchy tubers high in calories (Piperno and Pearsall 1998:213). As seen in Figure 7.4, Marantaceae phytoliths are found spread throughout Floor 1. In contrast to the previous types, none of the hot spots pinpointed could be confirmed by adjacent (less than 2 m) sampling locations. The case may be that plants in the Marantaceae family were not limited to use in certain locations within the site or that the presence of Marantaceae phytoliths is simply the result of background forest.

Lastly, the distribution of *Heliconia* sp. phytoliths was examined (Figure 7.5). *Heliconia* sp. plants have edible flowers and leaves that can be used to wrap and cook foods, as well as to thatch buildings (Kubitzky 1998:229; Piperno 1991:176). As seen in Figure 7.5, these phytoliths were found to be most abundant immediately south of the central finger-molded hole feature. This implies that the greatest amount of *Heliconia* sp. use was in this location. It is difficult, however, to determine if the majority of use was in this location or if the majority of deposition simply occurred there. Ultimately, in a case similar to that of the Marantaceae phytoliths, the *Heliconia* sp. phytoliths are found spread throughout the site. This implies that the use of *Heliconia* sp. plants was not restricted to a single location or that they intruded into the site only through natural processes.

Interpretations: Floor 2

As I previously mentioned, the phytolith data gained from Floor 2 is similar to that from Floor 1. This suggests that the vegetation present at the site during the formation and use of Floor 2 was similar to that present during the formation and use of Floor 1. One notable similarity is that the grass phytolith types appear to be generally higher in prevalence toward the center of the excavated area, as was seen in Floor 1. A notable difference from Floor 1 is that the *Sabal*-type palm phytoliths were most common toward the northern extent of the excavated area. *Heliconia* sp. and Marantaceae phytoliths appear to be distributed throughout, as was seen in Floor 1. Although it may be tempting to interpret the slight differences between the phytoliths from Floor 1 and Floor 2, it may be most sensible to suggest that the two floors were formed and used in a similar way. In addition, the minor differences found between the two floors may be a function of the small sample size from Floor 2.

Implications for the Archaic Period in Chiapas

The phytolith data from the floors at Tlacuachero allow for new insights into the Archaic period in Chiapas. Importantly, the phytolith data provide new information regarding previous suggestions by Kennett and Voorhies (1996) that the Chantuto people were in the midst of a reorientation of their subsistence strategies toward the inclusion of more domesticated food sources. Previous phytolith investigations by Jones and Voorhies (2004) at Tlacuachero identified a single phytolith diagnostic of *Zea mays* from Floor 1. Although *Zea mays* is known to be have been present at the site during the time Floor 1 was in use, this study has not identified any additional phytoliths from maize or other domesticates at the site during this time. Considering the rarity of phytolith evidence for domesticates from Tlacuachero, it appears unlikely that maize or other domesticates were a major element of the diet at the Tlacuachero site during the use of Floor 1. However, the lack of phytolith evidence for the extensive use of domesticates at Tlacuachero during this time period does not preclude the possibility that the people using Floor 1 were experimenting with domesticates at sites farther inland, such as Vuelta Limón. If recent suggestions that the Chantuto people were experimenting with maize agriculture farther inland are correct, then they did not feel the need to bring large quantities of their domesticated foods to Tlacuachero. Considering Tlacuachero's location within an estuarine system, it may be that there was enough locally available aquatic food and too many transportation hazards to justify the risk of spoiling their hard-earned maize.

Recommendations for Future Research

A number of recommendations can be made for future phytolith analyses of the kind performed at Tlacuachero. Although they were not quantified, a number of phytoliths observed at the site were discolored, likely as a result of burning. If these phytoliths had been quantified, they could have provided additional information about how the plants they represent were being used or discarded at the site. Diatoms present in the sediments also were not quantified or analyzed, although they could be useful in understanding the conditions and circumstances of the sediment prior to its use as a floor.

It would also be beneficial for future studies to add an exotic tracer element during the sample preparation process, allowing for quantification of the estimated phytolith concentration per volume of sediment. A volumetric estimate of absolute phytolith concentrations could provide the analyst with the ability to better understand the circumstances surrounding phytolith deposition under various contexts. The addition of an exotic tracer would be especially useful if the tracer were composed of silica, so that it could be added prior to processing to also act as a control against processing errors.

Additionally, it may be beneficial to perform experimental sampling of phytoliths under modern huts thatched with *Sabal*-type palms. This type of experimental sampling would provide more insight into what phytolith signatures could be expected from this type of structure and would allow a greater ability to discern the presence of such structures in archaeological deposits. In a similar vein of possible future research, it would be very useful to examine the phytoliths present in modern encampments of hunting and gathering peoples. It is likely that investigations of this type would provide a greater understanding of the way phytoliths are deposited under different situations of plant use.

Conclusions

The spatial analysis of phytoliths at Tlacuachero has provided new information regarding plant use at the site. The creation of distributional plots that appear to document anthropocentrically driven patterns allows for new insights into the way plants were used at the site. Plant taxa demonstrated to be present include Chrysobalanaceae, *Sabal* sp. palms, grasses, Marantaceae, and *Heliconia* sp. Ultimately, Chrysobalanaceae phytoliths appear to be present as a result of nearby forests and probably represent background noise because of this taxon's relatively uniform phytolith distribution across the site, potentially even having been incorporated as part of the sediment used to form the floor. *Sabal*-type palm and grass plants appear to have been used most intensively in the center of the excavated portion of Floor 1. *Sabal*-type palms may have been used as roof thatch, fish-drying mats, or serving "platters," whereas grasses were most likely used as matting of some type or protected covers, or they were intruded as a function of the space being undisturbed by walking. Although Marantaceae and *Heliconia* sp. plants were present, the location of their use appears to be spatially restricted, suggesting their use was connected to a more mobile activity. Previous investigations at Tlacuachero by Jones and Voorhies (2004) identified the presence of a *Zea mays* phytolith on Floor 1. However, I found no phytoliths diagnostic for maize in the present study. As a result, it seems likely that maize was exceedingly rare at Tlacuachero during the period when Floor 1 was in use.

Although phytoliths are at present typically analyzed in vertical columns, phytolith analyses may provide additional insights when samples are collected horizontally across living surfaces. These horizontally oriented phytolith examinations trade the ability to document long-term vegetative trends for the ability to document previously invisible plant use areas. This research has highlighted the potential utility of these types of investigations, particularly for understanding plant use during such early time periods.

Acknowledgments. This study was conducted as partial fulfillment of requirements at Washington State University–Pullman for the master's degree in anthropology. Many thanks go to all current and past committee members for their patience and their help in completing this project. In particular, I would like to thank Dr. John G. Jones for providing the phytolith analytical techniques, equipment, training, and overall support for the project. Although Dr. Jones was the committee chair and primary adviser to the project, external circumstances prevented him from participating in this project at the time of its completion. A special thanks also goes to Dr. Andrew Duff for his help and encouragement in crossing the proverbial finish line. Thanks must go to Dr. Barbara Voorhies of UCSB for providing the opportunity to work on this project, as well as for background information, samples, maps,

financial support, and much more. Thanks also go to Dr. Hector Neff of California State University–Long Beach for providing computerized mapping tools and the requisite training needed to create the distributional maps. Additional thanks go to everyone who has contributed to the research at Tlacuachero and also to the National Geographic Society and UC Mexus for funding research at the site, and to the Mexican National Institute for Anthropology and History for issuing the research permit. Lastly, this project would not have been possible without the unending patience, care, and support of my wife, Melissa Drake.

Notes

1 The samples taken in a vertical column and analyzed for phytoliths (Jones and Voorhies 2004) came from a location at Tlacuachero where Floor 1 was not underlain by additional floors.

References Cited

Clark, John E.

1994 The Development of Early Formative Rank Societies in the Soconusco, Chiapas, Mexico. Unpublished Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.

Cowgill, George L.

1996 Population, Human Nature, Knowing Actors, and Explaining the Onset of Complexity. In *Debating Complexity: Proceedings of the 26th Annual Chacmool Conference*, edited by Daniel A. Meyer, Peter C. Dawson, and Donald T. Hanna, pp.16–22. Archaeological Association of the University of Calgary, Calgary.

Drucker, Philip

1948 Preliminary Notes on an Archaeological Survey of the Chiapas Coast. *Middle American Research Records* 1:151–169.

Feinman, Gary M.

1995 The Emergence of Inequality: A Focus on Strategies and Processes. In *Foundations of Social Inequality*, edited by T. Douglas Price and Gary M. Feinman, pp. 255–279. Plenum Press, New York.

Fishkis, Olga, Joachim Ingwersen, and Thilo Streck

2009 Phytolith Transport in Sandy Sediment: Experiments and Modeling. *Geoderma* 151:168–178.

2010 Phytolith Transport in Soil: A Field Study Using Fluorescent Labeling. *Geoderma* 157:27–36.

Goovaertz, Pierre

1997 *Geostatistics for Natural Resources Evaluation*. Oxford University Press, New York.

Jones, John G.

2012 Analysis of Pollen from Excavations at Montpelier, Virginia. Department of Archaeology, Montpelier Station, Virginia.

Jones, John G., and Barbara Voorhies

2004 Human and Plant Interactions. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 300–343. University Press of Florida, Gainesville.

Joyal, Elaine

1996 The Use of *Sabal Uresana* (Arecaceae) and Other Palms in Sonora, Mexico. *Economic Botany* 50:429–445.

Kennett, Douglas J., Dolores R. Piperno, John G. Jones, Hector Neff, Barbara Voorhies, Megan K. Walsh, and Brenden J. Culleton

2010 Pre-Pottery Farmers on the Pacific Coast of Southern Mexico. *Journal of Archaeological Science* 37:3401–3411.

Kennett, Douglas J., and Barbara Voorhies

1996 Oxygen Isotopic Analysis of Archaeological Shells to Detect Seasonal Use of Wetlands on the Southern Pacific Coast of Mexico. *Journal of Archaeological Research* 23:689–704.

Kubitzky, Klaus

1998 *The Families and Genera of Flowering Plants: 4. Monocotyledons Alismatanae and Commelinanae (except Gramineae)*. Springer-Verlag, Berlin.

Lorenzo, José Luis

1955 Los concheros de la costa de Chiapas. *Anales del Instituto Nacional de Antropologia e Historia* 7:41–50. Mexico City.

Lunning, N. G., K. L. Verosub, and M. J. Singer

2008 Can Phytolith Concentrations Indicate That Wind Erodes Drained Peatlands? American Geophysical Union Fall Meeting 2008, Abstract B13B-0449. Electronic document, http://adsabs.harvard.edu//abs/2008AGUFM.B13B0449L, accessed November 20, 2014.

Matsuoka, Yoshihiro, Yves Vigouroux, Major M. Goodman, G. Jesus Sánchez, Edward Buckler, and John Doebley

2002 A Single Domestication for Maize Shown by Multilocus Microsatellite Genotyping. *Proceedings of the National Academy of Sciences* 99:6080–6084.

Michaels, George H., and Barbara Voorhies
1995 Late Archaic Period Coastal Collectors in Southern Mesoamerica: The Chantuto People Revisited. In *Pacific Latin America in Prehistory: The Evolution of Archaic and Formative Cultures*, edited by Michael Blake, pp.39–54. Washington State University Press, Pullman.

Neff, Hector, Deborah M. Pearsall, John G. Jones, Bárbara Arroyo, Shawn K. Collins, and Dorothy E. Freidel
2006 Early Maya Adaptive Patterns: Mid-Late Holocene Paleoenvironmental Evidence from Pacific Guatemala. *Latin American Antiquity* 17:287–315.

Pearsall, Deborah M.
1982 Phytolith Analysis: Applications of a New Paleoethnobotanical Technique in Archaeology. *American Anthropologist* 84:862–871.

Piperno, Dolores R.
1988 *Phytolith Analysis: An Archaeological and Geological Perspective*. Academic Press, San Diego.
1991 The Status of Phytolith Analysis in the American Tropics. *Journal of World Prehistory* 5:155–191.
2003 Tracking Environmental Change Using Lake Sediments: Phytoliths. *Developments in Paleoenvironmental Research* 3:235–251.
2006 *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*. AltaMira Press, Lanham, Maryland.

Piperno, Dolores R., and Deborah M. Pearsall
1998 *The Origins of Agriculture in the Lowland Neotropics*. Academic Press, San Diego.

Piperno, Dolores R., Anthony J. Ranere, Irene Holst, José Iriarte, Ruth Dickau, and Jerry A. Sabloff
2009 Starch Grain and Phytolith Evidence for Early Ninth Millennium B. P. Maize from the Central Balsas River Valley, Mexico. *Proceedings of the National Academy of Sciences* 106:5019–5024.

Pope, Kevin O., Mary E. D. Pohl, John G. Jones, David L. Lentz, Christopher von Nagy, Francisco J. Vega, and Irvy R. Quitmyer
2001 Origin and Environmental Setting of Ancient Agriculture in the Lowlands of Mesoamerica. *Science* 292 (5520):1370–1373.

Price, T. Douglas, and James A. Brown
1985 Aspects of Hunter-Gatherer Complexity. In *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*, edited by T. Douglas Price and James A. Brown, pp. 3–19. Academic Press, New York.

Rousseau, D. D., P. Schevin, D. Duzer, G. Cambon, J. Ferrier, D. Jolly, and U. Poulsen
2006 New Evidence of Long Distance Pollen Transport to Southern Greenland in Late Spring. *Review of Paleobotany and Palynology* 141:277–286.

Scott, Linda J.
1979 *Dolores Archaeological Program Technical Reports: Pollen Analysis. Report No. DAP-049.* Cultural Resources Mitigation Program, Dolores Project, Bureau of Reclamation, Upper Colorado Region, Salt Lake City.

Stromburg, Caroline A. E., Lars Werdelin, Else Marie Friis, and Gerçek Saraç
2007 The Spread of Grass-Dominated Habitats in Turkey and Surrounding Areas During the Cenozoic: Phytolith Evidence. *Palaeogeography, Palaeoclimatology, Palaeoecology* 250:18–49.

Sullivan, K. A., and L. Kealhofer
2004 Identifying Activity Areas in Archaeological Soils from a Colonial Virginia House Lot Using Phytolith Analysis and Soil Chemistry. *Journal of Archaeological Science* 31:1659–1673.

Voorhies, Barbara
1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico*. Papers of the New World Archaeological Foundation, No. 41. Brigham Young University, Provo, Utah.
2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.
2009 Archaeological Evidence of a Possible Hunter-Gatherer Ceremonial Site in Chiapas, Mexico. Final Narrative Report Submitted to UC Mexus in Partial Fulfillment for Conditions of a 2008 UC Mexus Grant. UC Mexus, University of California, Riverside.

Voorhies, Barbara, Douglas Kennett, John G. Jones, and Thomas A. Wake
2002 A Middle Archaic Archaeological Site on the West Coast of Mexico. *Latin American Antiquity* 13:179–200.

Chapter 8

Early Use of Chipped Stone at Tlacuachero

Elizabeth H. Paris

Recent excavations at the Tlacuachero shellmound have recovered ignimbrite, obsidian, and quartz chipped stone artifacts dating to the Late Archaic Chantuto B phase (3000–1800 BCE; Blake et al. 1995), which augment the sample of the earliest chipped stone tools documented on the Soconusco coast of Chiapas, Mexico. This analysis supports previous studies of the chipped stone technology of the shellmound users during this period that have emphasized the predominance of bipolar percussion technology and the use of relatively local chipped stone sources.

Previous investigations of chipped stone from this and other Archaic period shellmounds on the Chiapas coast suggest that lithic material for chipped stone tools was a scarce resource for the Archaic period Chantuto people or, alternatively, was not much in demand at the shellmounds. Chipped stone artifacts are found in low densities at several Late Archaic period coastal shellmounds: Tlacuachero, Zapotillo, Campón, and El Chorro (Clark 1989; Kennett et al. 2007; Nelson and Voorhies 1980; Voorhies 1976, 2004). They are also found at the contemporaneous inland site, Vuelta Limón (Voorhies 2004; Voorhies and Kennett 1995). Chipped stone artifacts recovered at these sites predominantly consist of utilized and nonutilized debitage from bipolar percussion reduction, including some flakes that were used as informal scraping tools (Voorhies 1976). In contrast, chipped stone was not recovered from the nearby Middle Archaic shellmound Cerro de las Conchas, suggesting that the people who formed the site may have relied on other types of cutting materials, such as the modified ark shells *Anadara grandis* (Voorhies et al. 2002:187). These ark shells, which have their umbos removed, manifest edge damage on the distal edge consistent with use as scraping and cutting tools. Damage to the dorsal ribs suggests less frequent use as anvils for cutting and pounding activities (Voorhies 2004; Voorhies et al. 2002).

As discussed in chapters 1 and 4, the 2009 excavations at Tlacuachero exposed portions of three or more superimposed floors within the bedded shell deposits in a restricted area under the site summit. Such floors have not been found elsewhere at Tlacuachero or at the other investigated shellmounds (Voorhies 1976, 2004). The floors are designated Floor 1, Floor 2, and Floor 3, from higher to lower. These floors exhibit numerous cultural features such as rock emplacements, postholes, and finger-molded holes (Chapter 4, this volume) and occasional clusters of faunal remains. Artifacts are extremely scarce on the floor surfaces, with the exception of the small 2 x 2 m area exposed in Floor 3 described in Chapter 4. Chipped stone artifacts recovered during the 2009 excavations at Tlacuachero from

Late Archaic period contexts were found on the floor surfaces, within the floor matrices, and in the bedded shell deposits both above and below the floors.

The 2009 Tlacuachero Chipped Stone Assemblage

The total chipped stone assemblage from the 2009 excavations at Tlacuachero consists of 54 artifacts. Of these, 41 items are from Late Archaic period contexts, including 25 from the floors (Table 8.1; Figure 8.1). Sixteen additional pieces are from the bedded shell deposits (Stratum C). For analytical purposes, I separate Stratum C deposits into upper levels from above the floors (n = 5) and lower levels from below the floors (n = 11). The remaining 13 chipped stone artifacts were recovered from strata A and B (hereafter jointly referred to as Stratum A/B), both located in the upper mantle of dark soil that postdates the Archaic period. These upper deposits were highly bioturbated and contained mixed and abundant ceramics dating predominately to the Middle Formative, Late Formative, and Early Classic periods (see Chapter 3, this volume). For this reason, the chipped stone from the upper soil mantle cannot be reliably attributed to any particular time period. Two percussion flakes were also recovered from "slump" deposits from Stratum A (FS 09-209; FS 09-213) and therefore lack specific provenience. As a result, in the following discussion I do not consider these undated objects from Stratum A/B.

Bipolar percussion flakes and bipolar percussion flake fragments constitute 36.6 percent (n = 15) of artifacts in the Late Archaic Tlacuachero assemblage (Table 8.1; figures 8.1a, 8.1e, 8.1f, 8.1g, 8.1h). Other chipped stone artifacts include fragments, chunks, or corner flakes from bipolar cores at 12.2 percent (n = 5; figures 8.1b, 8.1i, 8.1n), prismatic blade fragments at 4.9 percent (n = 2; figure 8.1l, 8.1m), direct percussion flakes and flake fragments at 17.1 percent (n = 7; figures 8.1j, 8.1k), and percussion flakes and flake fragments at 29.3 percent (n = 12; figures 8.1c, 8.1d). I made the initial technological classifications drawing on established regional typologies (Clark 1981, 1988; Clark and Bryant 1997; Wilcoxon in Voorhies 1976), which subsequently were modified in consultation with John E. Clark.

Many of the Late Archaic period flakes and chunks were produced using bipolar percussion, in which cobbles or nodules are placed on a hard flat surface such as a stone anvil and split using hard hammer percussion (Clark 1989:218–219). These flakes often have thick, cortical, unprepared platforms and irregular,

Table 8.1. Late Archaic Period Chipped Stone Objects from the 2009 Tlacuachero Excavations Listed by Archaeological Context.

Flake Type	Stratum C (Upper)	Floor 1	Floor 3	Stratum C (Lower)	Total #	Total %
Bipolar core fragment				2	2	4.9%
Bipolar percussion flake	1	1	8	3	13	31.7%
Bipolar percussion flake fragment		1	1		2	4.9%
Chunk from bipolar core			1		1	2.4%
Corner flake from bipolar core		1		1	2	4.9%
Direct percussion flake			2	1	3	7.3%
Direct percussion flake fragment			3	1	4	9.8%
Flake fragment		1	3		4	9.8%
Percussion flake	1		1	1	3	7.3%
Percussion flake fragment	2	2		1	5	12.2%
Prismatic blade fragment	1			1	2	4.9%
Total	5	6	19	11	41	100%

Note: Analyzed by Elizabeth Paris and John E. Clark

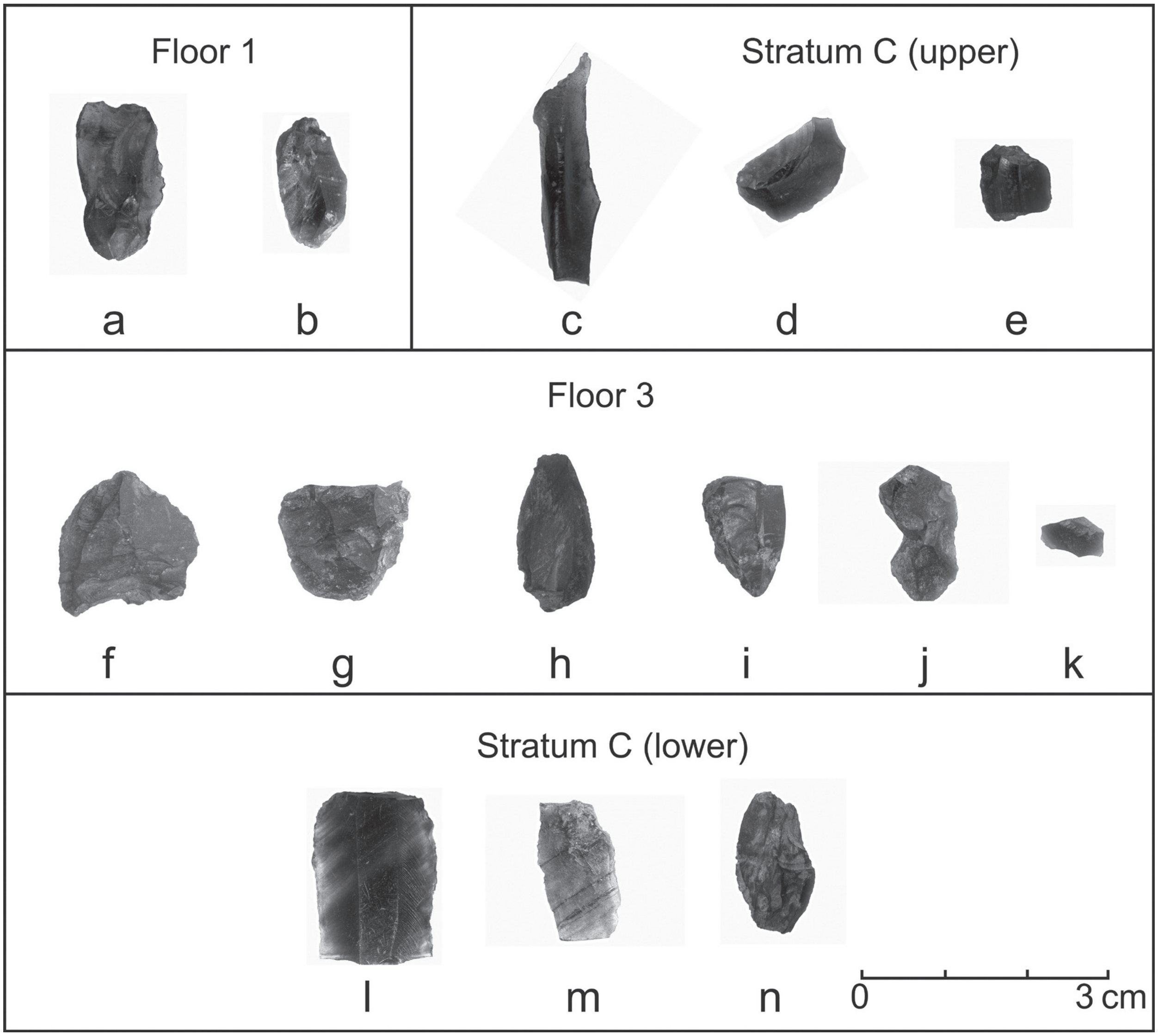


Figure 8.1. Thirteen selected ignimbrite and obsidian chipped stone artifacts from various Late Archaic period contexts: (a, e, f, g, h) bipolar percussion flakes; (b, n) corner flakes from a bipolar core; (i) chunk of a bipolar core; (j) direct percussion flake; (d) percussion flake; (c) percussion flake fragment; (l, m) prismatic blade fragments; (k) flake fragment (photographs and illustration by Elizabeth H. Paris).

microfractured dorsal and ventral surfaces with diffuse bulbs of percussion, or occasionally two bulbs of percussion, one at either end of the detached flake (Voorhies 2004:371). The assemblage also includes corner flakes, chunks, and fragments of bipolar cores. Other flakes and flake fragments were created through direct or indirect percussion, although no polyhedral flake cores or core fragments were present. Bipolar reduction assemblages also often contain a relatively large amount of shatter and blocky fragments, as does the Tlacuachero assemblage.

Two prismatic blade fragments were found in Late Archaic period Stratum C, one above and one below the floors (Table 8.1). Both represent third-series blades (Clark and Bryant 1997); FS 09-511 is a medial section with two well-defined parallel ridges on the dorsal side (Figure 8.1l) while FS 09-95 is a thin, narrow, hinged proximal section with no sharply defined dorsal ridges (Figure 8.1m). Prismatic blade technology has not been previously recovered in Late Archaic period deposits at Soconusco sites but is commonly associated with

other cultural developments during the subsequent Formative period. However, due to the small sample size, it remains a possibility that the prismatic blades postdate the Late Archaic deposits and are intrusive into these strata due to contamination such as rodent or tree root activity.

The high proportion of bipolar percussion debris in the Tlacuachero assemblage is consistent with the findings of other studies of Late Archaic period chipped stone artifacts at Tlacuachero and its neighbors (Voorhies 1976) and the inland coeval site of Vuelta Limón (Voorhies 2004; Voorhies and Kennett 1995). Artifacts at these sites created through bipolar percussion include notched flake tools (modified by retouch), utilized flakes and flake fragments, nonutilized flakes and flake fragments, and shatter (Voorhies 1976:85–93), as well as bipolar core fragments (Voorhies 2004). The majority of the flakes in these studies reflect bipolar percussion techniques (Voorhies 1976, 2004).

Scholarly opinions differ regarding the significance of bipolar percussion techniques relative to other types of lithic production techniques, such as direct percussion or pressure blade production. Several authors (Goodyear 1993; Shott 1989) have argued that the bipolar technique is evidence of economic use of rare or dwindling resources. Jeske (1992) suggests that bipolar reduction is common when high-quality raw materials are rare or absent and when the difficulties encountered in the use of bipolar products are outweighed by costs of obtaining higher-quality material. For example, at ninth- and thirteenth-century sites in the Bahamas, bipolar reduction of chert and limestone was employed to make microliths where raw materials were also highly scarce (Berman et al. 1999). Other researchers have argued that bipolar reduction techniques represent a lack of producer skill (Boksenbaum 1980). For example, ethnographic evidence on informal tool production from New Guinea suggests that bipolar technologies tend to be favored by less experienced knappers, while those with more advanced knapping skills tend to avoid using this technique, saying it causes the nodule to fracture uncontrollably (Sillitoe and Hardy 2003). However, De León (2008:453) argues that archaeological evidence from San Lorenzo suggests that bipolar reduction strategies were used by highly skilled knappers at that site, who used bipolar techniques to produce standardized wedge tools. Finally, bipolar techniques may be used when raw materials are in the form of small nodules that cannot be flaked by freehand techniques; bipolar techniques provide added support for the core through the use of an anvil, allowing the knapper to bring down the hammer with greater force than if the core were held freehand (De León 2008; Geier 1990; Hayden 1980; Honea 1965; Jeske 1992; Jeske and Lurie 1993). No standardized tools have been found at Tlacuachero beyond prismatic blade fragments, such as the wedges found at San Lorenzo (De León 2008). However, the use of bipolar techniques at Tlacuachero may represent efforts to maximize the utility of rare and small lithic raw materials and may have allowed for usable flakes to be produced from small cores and nodules.

More than half of the chipped stone artifacts in the 2009 Late Archaic Tlacuachero assemblage are whole (Table 8.1), whereas the remainder consist of flake and core fragments, many of which were likely created through trauma, trampling, or postdepositional factors. Most of the partially complete artifact fragments exhibit midsection snap breaks, with infrequent occurrences of longitudinal breaks from the proximal end to the distal end. Floor 3 had the highest proportions of complete artifacts at 57.8 percent, followed by Stratum C (lower) at 54.6 percent, Stratum C (upper) at 40.0 percent, and Floor 1 at 33.3 percent.

The lack of cortex on all the flakes recovered from Late Archaic period Tlacuachero contexts suggests that early-stage reduction activities were not performed at the site itself. However, numerous bipolar core fragments and corner flakes were recovered at the site. This suggests that early-stage reduction activities might have been conducted elsewhere, whereas production stages represented at the contexts in this sample represent only late-stage reduction. The presence of bipolar core fragments also suggests that at least some late-stage production activities were likely performed on-site rather than being performed at inland residential sites.

In terms of size and mass, clear differences are present between chipped stone artifacts associated with different contexts (Table 8.2; Figure 8.2). Artifacts from Floor 1 are longer, wider, thicker, and heavier than other Late Archaic period artifacts from both above- and below-floor deposits in Stratum C and Floor 3, with one exception: artifacts from Stratum C (upper) have a mean length equal to the mean length of artifacts from Floor 1. Thus artifacts did not increase in size over time in a linear fashion.

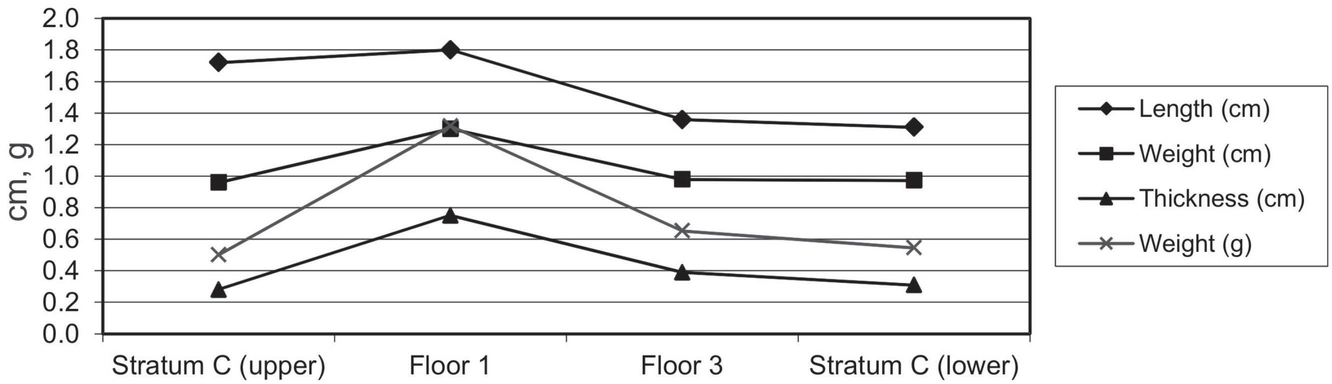


Figure 8.2. Mean values for chipped stone artifacts from the Tlacuachero 2009 sample (illustration by Elizabeth H. Paris).

Density of Chipped Stone

Density data from the 2009 excavations at Tlacuachero suggest previously undetected diachronic changes in chipped stone over time. The level of the floors marks a tipping point in the frequency of chipped stone at the site: below the level of the floors there are 1.8 pieces of chipped stone per cubic meter, whereas above the floors the frequency drops to 0.17 pieces per cubic meter. This new finding parallels previously observed diachronic changes in the phytolith, oxygen isotope, and zooarchaeological records at the Tlacuachero site (Voorhies 2004 and this volume).

The highest horizontal concentration of chipped stone artifacts, 4.75 pieces per square meter, was found on the surface of Floor 3 (n = 19; Table 8.3), which was exposed only in a 2 x 2 m area (Unit N1W1). The surface of Floor 3 in this unit likely represents an activity area. In addition to the high density of chipped stone, there was a higher density than usual of animal bone, including two worked bone fragments, as well as fire features (such as charcoal stains and burned shell gravel with charcoal and ash). In contrast, the area of Floor 1 that was newly exposed in 2009 had only 0.21 pieces of chipped stone per square meter. This difference is striking because only a very small area of Floor 3 has been exposed; 4 m^2 of Floor 3 compared to 34 m^2 of Floor 1 were newly exposed in the 2009 excavations. No chipped stone artifacts were found in association with Floor 2.

Use-Wear Identifications

Thirty-seven percent of the chipped stone artifacts from the 2009 excavations at Tlacuachero have patterned edge wear, suggesting that these artifacts were utilized as informal cutting tools. To investigate use-wear patterns, I examined all chipped stone items, both macroscopically with a 10x hand lens and microscopically with a Leica binocular microscope. Independent macroscopic inspections by John E. Clark were used to refine these analyses. The two analyses were in agreement in 49 of 54 cases (90.7 percent). Based on a reexamination of the photomicrographs of the remaining five cases, I concluded that the edge damage is likely the result of postdepositional factors. Patterns of damage were characterized by the hardness of the materials the chipped stone tools were used on, as experimental

Table 8.2. Mean Values for Tlacuachero Chipped Stone Objects Listed by Archaeological Context.

Mean	Stratum C (Upper)	Floor 1	Floor 3	Stratum C (Lower)
Length (cm)	1.7	1.8	1.4	1.3
Weight (cm)	1.0	1.3	1.0	1.0
Thickness (cm)	0.3	0.8	0.4	0.3
Weight (g)	0.5	1.3	0.7	0.5

Table 8.3. Artifacts by Unit and Context from the 2009 Tlacuachero Chipped Stone Sample.

Unit	Stratum C (Upper)	Floor 1	Floor 3	Stratum C (Lower)	Total #	Total %
N1E1					0	0.0%
N1W1			19	7	26	63.4%
N1W2	4	2			6	14.6%
N1W2/N1W1		1			1	2.4%
N2E1, Unit 2					0	0.0%
S2W1	1	3			4	9.8%
S3E0				4	4	9.8%
Total	5	6	19	11	41	100%

studies were not possible at the time of writing. In some cases, edge modification resulted from midsection breaks and longitudinal breaks, snap and hinge fractures along tool edges where the lack of associated microwear suggests that these breaks most likely resulted from trampling, or other factors not related to prehistoric use. These types of edge damage were not considered in this study.

Of the 41 chipped stone artifacts recovered from Late Archaic period contexts in the 2009 field season at Tlacuachero, 16 artifacts (39 percent) have some form of microscopic edge damage suggesting use-wear (Table 8.4). Comparisons to Clark's (1988) experimental study suggest patterns consistent with cutting hard materials (n = 4), cutting medium materials (n = 2), cutting soft materials (n = 9), and cutting soft materials and drilling (n = 1; see Table 8.4). This suggests that the majority of these artifacts were used to cut soft materials, possibly as part of animal processing, while the other artifacts could have been used in activities such as woodworking or bone modification. These results expand previous use-wear studies from Tlacuachero by Wilcoxon (in Voorhies 1976), which identified wear on Tlacuachero tools suggesting use as unidirectional or bidirectional scrapers. Notably, Wilcoxon found edge damage suggesting use-wear on only 5 out of 57 (8.8 percent) Late Archaic period chipped stone artifacts, which included flakes and flake fragments (in Voorhies 1976:tables 20–23). This is significantly lower than the incidence of use-wear in the present study.

Table 8.4. Use-Wear on Chipped Stone Objects from the 2009 Tlacuachero Excavations Listed by Archaeological Context.

	Context					
Use-Wear	Stratum C (Upper)	Floor 1	Floor 3	Stratum C (Lower)	Total #	Total %
No use-wear	2	2	12	9	25	61.0
Cutting soft materials	1	3	5		9	22.0
Cutting soft materials/drilling				1	1	2.4
Cutting medium materials		1	1		2	4.9
Cutting hard materials	2		1	1	4	9.8
Total	5	6	19	11	41	100
% total with use wear	60.0	66.7	36.8	18.2	39.0	

Note: Analyzed by Elizabeth Paris and John E. Clark.

Source Identifications

The findings of this study are consistent with those of previous investigations at other Archaic period Soconusco sites that suggest that coastal residents relied predominantly on ignimbrite from the Tajumulco source (Clark 1989; Nelson and Voorhies 1980; Voorhies 1976, 2004). Source identifications made by John E. Clark in 2011 (tables 8.5 and 8.6) using the visual sourcing technique suggest that 85 percent of Late Archaic period chipped stone items excavated at Tlacuachero in 2009 were created from Tajumulco ignimbrite. The Tajumulco source is the closest source of raw material for chipped stone production to the site and is located along the Pacific coast to the southeast of Tlacuachero, just east of the Mexico–Guatemala border (Figure 8.3). Tajumulco ignimbrite is compacted molten volcanic

Figure 8.3. Map with raw material source locations and proportion of chipped stone in the Late Archaic period assemblage from Tlacuachero (illustration by Elizabeth H. Paris).

ash that has the physical characteristics of low-quality obsidian; it has a granular structure due to the inclusion of separate particles and other fine debris (Clark 1989:273). It was likely imported to Tlacuachero in the form of small water-worn pebbles and nodules gathered from streambeds radiating from the Tajumulco volcano (Voorhies 2004:370, 380). Bipolar percussion would have been a technique suitable for reducing these small nodules and cobbles, which are otherwise very difficult to reduce (Whittaker 1994:113), although direct percussion reduction strategies were used as well (Table 8.5).

The Late Archaic people using the site also obtained small amounts of high-quality obsidian from San Martín Jilotepeque in highland Guatemala, a source that continued to be exploited in southeast Mesoamerica to the Spanish contact period (Braswell 2003; Clark 1989; Clark and Lee 1984). Small amounts of obsidian from San Martín Jilotepeque were associated with Stratum C deposits both above (n = 3) and below (n = 2) the floors, and from Floor 1 (n = 1). Obsidian from the El Chayal source was associated only with the mixed deposits of Stratum A/B (n = 1) and not with Late Archaic period deposits. Additionally, a single small chunk of quartz from an unknown source was associated with the below-floor deposits in Stratum C.

In addition to prismatic blades, San Martín Jilotepeque obsidian artifacts included a direct percussion flake, two bipolar percussion flakes, and a percussion flake fragment (Table 8.5). Notably, the assemblage does not include artifacts suggesting on-site production of obsidian, such as prismatic core fragments, bipolar core fragments, corner flakes, and platform removal flakes. Thus obsidian flake artifacts could potentially have been brought to the site in finished form, as opposed to being produced at the Tlacuachero site.

The Late Archaic period source acquisition patterns observed in the 2009 sample indicate a heavy reliance on Tajumulco ignimbrite, with low frequencies of San Martín Jilotepeque, and are broadly similar to patterns observed in prior studies of obsidian from Late Archaic Soconusco sites (Table 8.6). For example, Nelson and Voorhies (1980) report the results of elemental analyses

Table 8.5. Source Identifications for Late Archaic Period Chipped Stone from the 2009 Tlacuachero Excavations by Context, Including Ignimbrite from Tajumulco (TAJ) and Obsidian from San Martín Jilotepeque (SMJ).

	Stratum C (Upper)		Floor 1		Floor 3	Stratum C (Lower)				Total
Flake Type	TAJ	SMJ	TAJ	SMJ	TAJ	TAJ	SMJ	Quartz	Unknown	
Bipolar core fragment						2				2
Bipolar percussion flake		1		1	8	2			1	13
Bipolar percussion flake fragment			1		1					2
Chunk from bipolar core					1					1
Corner flake from bipolar core			1			1				2
Direct percussion flake					2		1			3
Direct percussion flake fragment					3			1		4
Flake fragment			1		3					4
Percussion flake	1				1	1				3
Percussion flake fragment	1	1	2			1				5
Prismatic blade fragment		1					1			2
Total	2	3	5	1	19	7	2	1	1	41

Note: Identifications made visually by John E. Clark.

Table 8.6. Source Acquisition Patterns in Late Archaic Period Contexts at Soconusco Sites.

Raw Material Source	Tlacuachero (2009)	Campón, Tlacuachero, Zapotillo	Vuelta Limón
Tajumulco	85.0%	72.20%	92.90%
El Chayal		27.80%	
San Martín Jilotepeque	15.0%		7.10%
Total	100%	100%	100%

Note: Samples are from the 2009 Tlacuachero excavations, the 1973 excavations of three shellmounds (Nelson and Voorhies 1980), and the 1994 excavations at the open-air site of Vuelta Limón (Voorhies 2004).

(using in some cases neutron activation analysis [NAA] and in others both NAA and x-ray fluorescence [XRF]) of 18 chipped stone items dating to the Late Archaic period from Tlacuachero (CAP-7), Campón (CAP-6), and Zapotillo (CAP-8). These three sites, excavated by Voorhies in 1973, are located 2–3 km apart within the same wetlands (Voorhies 1976). Trace element analysis of obsidian artifacts from these three shellmounds suggests that during the Late Archaic period, local residents predominantly exploited the Tajumulco source while also utilizing more distant sources from highland Guatemala (Nelson and Voorhies 1980). Of the 18 Late Archaic period specimens analyzed, 72 percent of the raw material originated at Tajumulco, whereas 28 percent was from El Chayal. Similarly, Tajumulco ignimbrite constituted 93 percent of Late Archaic period chipped stone assemblages from the nearby inland site of Vuelta Limón, whereas 7 percent of the assemblage was from San Martín Jilotepeque (Table 8.6; Voorhies 2004:372–374). These results are based upon a combination of visual inspection and geochemical analysis of 14 specimens.

The prevalence of Tajumulco ignimbrite in the Late Archaic assemblage testifies to the adequacy of the material for local needs. Tajumulco yields poor-quality raw material for chipped stone because of inclusions within the glass matrix that cause large flakes to chip and break irregularly, thus preventing the manufacture of blades (Nelson and Voorhies 1980). However, as the Tajumulco source is the closest known source of suitable stone to the Chantuto zone (Nelson and Voorhies 1980), the transportation costs would have been less for Tajumulco ignimbrite than for any other obsidian potentially available to local consumers (Nelson and Voorhies 1980). In addition, the small sharp flakes and chunks that seem to have been the major tool types in the Chantuto zone do not require high-quality obsidian and can be easily manufactured from the Tajumulco material (Nelson and Voorhies 1980).

The people at Tlacuachero may have procured Tajumulco ignimbrite themselves, on foot or by taking a canoe along the coast and then walking inland, a round-trip journey that could have taken a week or two. Coastal residents could also have organized provisioning expeditions to highland Guatemala obsidian sources, San Martín Jilotepeque and El Chayal, which are both farther from the Chantuto zone than the Tajumulco source. The transportation costs for obtaining obsidian from either source would have been significantly greater than the cost of obtaining Tajumulco ignimbrite (Nelson and Voorhies 1980). Alternatively, Tlacuachero groups could have relied on exchange networks to acquire Tajumulco ignimbrite and/or more distant resources such as higher-quality obsidian from San Martín Jilotepeque and El Chayal. Possible mechanisms for the long-distance exchange of obsidian or ignimbrite include down-the-line barter with neighboring groups or trade with passing travelers. The presence of highland Guatemala obsidian at the Late Archaic period Tlacuachero site documents the antiquity of the exploitation of these sources and suggests long-distance exchange networks between the highlands and the Pacific coastal plain (Nelson and Voorhies 1980). Given the small volume of lithic raw material found at Tlacuachero, an exchange scenario seems likely and also suggests that such exchanges were small scale and infrequent. Although obsidian from both El Chayal and San Martín Jilotepeque is considered to be of better quality than Tajumulco ignimbrite, the Late Archaic period Chantuto people indiscriminately made the same kinds of tools from both sources (Nelson and Voorhies 1980). As Nelson and Voorhies (1980) have documented, the proportion of highland Guatemala obsidian at Tlacuachero

amplified during Formative- and Early Classic period occupations (Table 8.6). As I discuss below, this pattern is observed at numerous other Formative period sites, both on the Soconusco coast and more broadly throughout Mesoamerica.

Temporal and Spatial Comparisons

The 2009 assemblage from Tlacuachero presents several notable differences compared to the chipped stone technology of its contemporaries in other areas of Mesoamerica, as well as compared to changes in production techniques and raw materials acquisition patterns during the Formative period. While bipolar percussion, hard-hammer percussion, and the exploitation of local raw materials continued in Early Formative period assemblages in the Soconusco, prismatic blades were increasingly incorporated into tool assemblages over time. The residents of these Formative period sites were also able to greatly increase their access to imported obsidian from highland Guatemalan sources such as San Martín Jilotepeque, El Chayal, and Ixtepeque, as well as Basin of Mexico sources such as Otumba and Sierra de las Navajas.

The heavy reliance on direct and bipolar percussion flaking techniques at the Early Formative period site of Paso de la Amada is similar to the Late Archaic period Tlacuachero assemblage. Paso de la Amada was a large village in the Mazatán region, approximately 20 km southeast of Tlacuachero, which contains numerous earthen mounds, a chiefly residence, and a ballcourt dating to 1400 BCE (Clark 1994). Deposits at the site span the Barra phase (1900–1700 BCE), Locona phase (1700–1500 BCE), Ocos phase (1500–1400 BCE), and Cherla phase (1400–1300 BCE; Bryant et al. 2005:Figure 1.3; cf. Clark 1994:Figure 57). Clark (1981) initially conducted an individual flake analysis of a sample of 2,074 chipped stone artifacts out of a total collection of 16,627 pieces; further analyses are included in his later publications (Clark 1994; Clark and Lee 1984). As at Tlacuachero, both direct percussion technologies and bipolar percussion technologies were strongly represented in the sample. Artifacts related to bipolar percussion techniques included bipolar flakes (17.8 percent), bipolar corner flakes (7.9 percent), bipolar cores (1.9 percent), scalar cores (exhausted bipolar cores; 6.1 percent), and *pièce esquillées* (battered pieces; 2.4 percent). By comparison, 31.7 percent of the pieces were percussion flakes. The remaining artifacts included casual cores (0.3 percent), chunks (7.1 percent), flake shatter (23.3 percent), and unidentified pieces (1.4 percent). Like the site-users of Tlacuachero, Locona phase residents of Paso de la Amada obtained most of their chipped stone raw materials from Tajumulco (86.23 percent), as well as small amounts of material from San Martín Jilotepeque (9.83 percent) and El Chayal (3.93 percent; calculated from Clark 1994:Appendix 1). However, smaller Locona phase sites near Paso de la Amada have high proportions of El Chayal obsidian, such as Aquiles Serdan (47.55 percent), El Horizonte (28.5 percent), and El Vivero I (35.14 percent; from Clark 1994:Appendix A), suggesting that Guatemalan obsidian was increasingly available to local residents during this period. Clark (1981:280) notes the widespread distribution of production debris at nearly all domestic units at the site and suggests that lithic tool production was a nonspecialized domestic industry performed by nearly all households.

Similarly, the Early Formative period sites of Los Cerritos and El Grillo provide evidence for changing raw material networks during the Early Formative period, while the morphological characteristics of chipped stone artifacts suggest a high degree of continuity in reduction techniques between Late Archaic and Early Formative periods. Los Cerritos is an earthen mound site just southeast of Tlacuachero, within the Acapetahua Estuary coastal wetlands (Kennett and Voorhies 2002; Kennett et al. 2002). The site has been interpreted as a small, sedentary fishing-farming community, occupied from 1475 to 1275 BCE, with predominantly Cherla phase (1400–1300 BCE) ceramics. One hundred and seventy-two obsidian fragments were recovered during the excavation of Los Cerritos, representing a simple flake industry consisting of large bipolar flakes (4.65 percent), bipolar flakes (26.74 percent), bipolar corner flakes (16.86 percent), and scalar cores (12.79 percent). Percussion flakes (20.93 percent), chunks (4.65 percent), and shatter (12.79 percent) are also present in the deposit (Kennett and Voorhies 2002). All 172 pieces were examined visually in consultation with John Clark to attribute the sources of raw material; an additional 39 pieces were analyzed using XRF. In contrast to sites in the Mazatán area such as Paso de la Amada, visual sourcing suggests that the greatest proportion of chipped stone at Los Cerritos was obtained from the El Chayal source (95.32 percent), followed by

Tajumulco (3.51 percent) and San Martín Jilotepeque (1.17 percent); these results were confirmed by the XRF analysis (Kennett and Voorhies 2002). As at other Early Formative period sites, chipped stone debitage at Los Cerritos was found associated with residential contexts in both areas of the site, suggesting that it was a domestic and nonspecialized industry.

Like Los Cerritos, El Grillo is an Early Formative period earthen mound site in the littoral zone of the Acapetahua Estuary zone (Kennett et al. 2007). The site's occupation spans the Locona–Ocos (1400–1100 BCE), Cherla (1100–1000 BCE), and Cuadros (1000–900 BCE) ceramic phases. One hundred and two chipped stone pieces were recovered, with artifacts related to bipolar percussion strongly represented in the assemblage. Bipolar flakes (50.98 percent), bipolar cores (10.78 percent), *pièce esquillées* (7.84 percent), bipolar corner flakes (3.92 percent), and scalar cores (3.92 percent) were concentrated in the deepest deposits from occupations dating to the Locona–Ocos and Cherla phases; as at Los Cerritos, the majority of pieces were from the El Chayal source (Kennett et al. 2007:cuadros 6 and 7). As at other Early Formative period sites, prismatic blades were rare; the three prismatic blades found at El Grillo were from deposits most likely associated with the Cuadros phase.

The origin, development, and spread of prismatic blade technology have been the subject of scholarly investigation and debate. Several scholars have proposed that blades began to circulate widely across Mesoamerica around 1000 BCE (Boksenbaum 1978; Clark 1989:222; De León 2008:179), transforming lithic industries based on direct percussion and bipolar percussion techniques. As the data from Tlacuachero (in the present study) and El Grillo (Kennett et al. 2007) suggest, very small quantities of prismatic blades were produced in the Late Archaic and Early Formative periods, although direct percussion and bipolar percussion techniques were far more commonly used. Changes in production technology and the expansion of interregional obsidian exchange networks have been observed in Middle Formative period components at several sites on the Soconusco coast, including La Blanca (Jackson and Love 1991; Nance and Kirk 1991) and Cuauhtémoc (Rosenswig 2010). Clark (1987:260) argues that the spread of blade technology was neither uniform nor rapid and suggests that it followed the emergence of complex chiefdoms in any given region, and thus was a result of competitive elite behavior. However, De León (2008) has recently argued against elite control over prismatic blade production and consumption, suggesting a gradual shift that took place at the household level (see discussion below).

The prevalence of prismatic blade technology and high-quality obsidian use increased during the following Middle Formative period. By the Conchas phase (900–600 BCE) at La Blanca, on the Pacific coast of Guatemala, prismatic blades formed 92.3 percent of the assemblage, whereas 5.3 percent of the artifacts were associated with bipolar flaking or blades modified through bipolar flaking. The remaining 2.4 percent were classified as flakes, blade or flake fragments, or spalls (Nance and Kirk 1991:375). Furthermore, the bipolar artifacts no longer resembled the small flakes from Archaic period deposits but were mostly modified blades, including blades resharpened by removing a burin-like spall from a break platform, burins, a bipolarly worked end tool, and a blade seemingly worked bipolarly for the production of microblades—that is, a blade bipolar core (Nance and Kirk 1991:375). Other nonblade tools include two bipolarly produced flakes or blades, a bipolar splinter, and a bipolar core (Nance and Kirk 1991:375). Nance and Kirk propose that bipolar techniques were used as a solution to the increasing scarcity of obsidian at La Blanca over the course of the Conchas phase, due to a growing population, diminishing supply, or more intensive utilization of obsidian (Nance and Kirk 1991:375). Virtually all obsidian at La Blanca was imported from the Guatemalan highlands, from El Chayal, San Martín Jilotepeque, and Ixtepeque, with no significant difference in obsidian sources used between elite and nonelite households (Jackson and Love 1991). Similarly, Rosenswig (2010:237) notes that at the Soconusco site of Cuauhtémoc, the proportion of nonlocal El Chayal obsidian increased relative to local Tajumulco ignimbrite during the Middle Formative period.

Soconusco chipped stone technological traditions bear many similarities to those observed in the Basin of Mexico (Boksenbaum et al. 1987) and at San Lorenzo (Cobean et al. 1971). In the Basin of Mexico, the use of prismatic blade techniques and nonlocal obsidian may have first occurred during the Archaic period (Niederberger 1976, 1979, 1987). As at Tlacuachero, Zohapilco prismatic blade samples originally dated to the Archaic period are very small (Niederberger 1976)

and could therefore be intrusive into earlier deposits; alternatively, they may date to a later period than previously hypothesized. The lithics attributed to the Playa 1 subphase (approximately 6000 to 4500 BCE, based on Niederberger's calibrated radiocarbon dates of material from stratigraphic boundaries) include predominantly retouched hard-hammer percussion flakes, while obsidian artifacts imported from Otumba sources formed a small part of lithic assemblages relative to local materials (Niederberger 1979:135). Niederberger has also identified fragments of possible prismatic blades in Playa 2 subphase (4500–3000 BCE) and Zohapilco phase (3000–2200 BCE) deposits, although these occur in very low quantities, particularly in proportion to artifacts associated with microlithic flake technology (Niederberger 1979:138). She also notes an increase in the proportion of imported obsidian during the Zohapilco phase, both from the Otumba source and the Pachuca source. Similarly, Boksenbaum et al. (1987) report that prismatic blades increased in frequency at Basin of Mexico sites throughout the Formative period (1300–750 BCE) and that the number of obsidian sources utilized continued to increase during this period.

A similar trajectory in chipped stone tool development is observed at the well-known Olmec center of San Lorenzo Tenochtitlán. Cobean et al. (1971) argue that prismatic blade technology emerged coincident with the site's political ascendance; however, De León's (2008:33) more recent work suggests that this increased use of prismatic blades was not due to their control by San Lorenzo elites but due to production and consumption choices made in domestic contexts. During the first occupation of San Lorenzo, in the Ojochi phase (circa 1500–1350 BCE), chipped stone artifacts occur as small percussion flakes and bipolar production debris in low densities (Cobean et al. 1971; De León 2008:177), although a single Ojochi phase percussion blade fragment was recovered by Coe and Diehl (1980:247). The earliest pressure blades at San Lorenzo appear during the Chicharras phase (1250–1150 BCE), although they are rare (n = 4; De León 2008:161). Pressure blades began to occur in significant amounts in San Lorenzo A subphase deposits (1150–1000 BCE; 4 percent of De León's total phase sample), become common in San Lorenzo B subphase deposits (1000–850 BCE; 28 percent of De León total phase sample), and remain present in the Nacaste phase (850–700 BCE; 7 percent of De León's total phase sample) during the final Olmec occupation of the site (De León 2008:193). However, direct and bipolar percussion remained the dominant tool technologies even after blades became common, suggesting that at San Lorenzo, blades were an addition to flake tools rather than a substitute (De León 2008:204).

For most of San Lorenzo's occupation, blades were brought into the site as finished tools, while percussion flakes and wedges were produced at the site itself (De León 2008:197). As early as the Ojochi phase (1500–1350 BCE), obsidian was imported from the El Chayal source and was also imported from central Mexican sources by the following Chicharras phase (Cobean et al. 1971; De León 2008). There is evidence of blade production at the site itself during the San Lorenzo B and Nacaste phases, although such activities were conducted at a small scale (De León 2008:161). However, even during the San Lorenzo B phase, where the sample size is large, only 5 percent of all artifacts had any cortical surface, suggesting that the raw materials brought to the site were either river cobbles (with no cortex) or preshaped blocks of obsidian (De León 2008:202). The lack of cortical flakes is similar to the Tlacuachero assemblage. Notably, pressure blades are nearly absent from the Group D elite zone, strongly arguing against elite control of blade trade or blade production (De León 2008:417), in contrast to arguments that the spread of core-blade technology throughout Middle Formative Mesoamerica was the result of competitive elite behavior (Clark 1987).

Soconusco lithic tool assemblages from Late Archaic period contexts bear little resemblance to those from contemporary sites in northern and central Belize; however, by the Middle Formative period, obsidian prismatic blades appear in assemblages, despite the prevalence of high-quality chert and chalcedony raw material in this region. Knappers at Archaic period Belizean sites created radically different chipped tool assemblages than those used by contemporary Soconusco peoples and used different technologies. Late Preceramic period deposits (3500–1500 BCE) include a number of bifacial hafted points (Clark and Cheetham 2002:304; Kelly 1993:224; Lohse 2007; Lohse et al. 2006), macroblades up to 25 cm long, large macroblade cores, pointed blades, small flake-blades (Iceland 1997:29; Wilson et al. 1998), "snowshoe-shaped" constricted unifaces (Lohse et al. 2006), and retouched flakes (Iceland 1997).

Obsidian has not been reported from Late Preceramic contexts, suggesting that producers relied on widely available cherts and chalcedonies to make these implements. However, by the Middle Formative period, obsidian was incorporated into northern Belize assemblages despite the abundance of high-quality chert. For example, Middle Formative residents of Colha (Brown et al. 2004) obtained prismatic blades predominantly from San Martín Jilotepeque (64 percent), with smaller quantities from El Chayal (32 percent) and Ixtepeque (4 percent).

As at sites in the Soconusco, the Basin of Mexico, and the Gulf Coast, major changes in lithic technology occurred in northern and central Belize in the Formative period. In the Belize Valley, the preceramic Early Formative (1100–900 BCE) chert assemblages shift to emphasize implements such as scrapers, drills, and burins. Obsidian was imported to sites in the Belize Valley in small quantities during the Middle Formative period (Garber et al. 2004:32). At Cahal Pech, most Middle Formative obsidian artifacts consist of flakes and blades (Healy et al. 2004:114), with prismatic blades largely replacing flakes by the outset of the late Middle Formative period at Cahal Pech and other lowland Maya sites (Awe and Healy 1994:197–198). Cahal Pech residents obtained obsidian only from the El Chayal source during the Early Formative period (Cunil phase), but by the Middle Formative period the San Martín Jilotepeque source was dominant (72 percent), with smaller amounts from El Chayal (24 percent) and Ixtepeque (Awe and Healy 1994:197–198). At Cahal Pech, these shifts in chipped stone tool assemblages occurred during a time of population increase, heightened construction activity, and increased social inequality.

Conclusions

Chipped stone tool technologies at Tlacuachero reflect emergent provisioning strategies and exchange networks among increasingly sedentary populations. At Soconusco shellmounds such as Tlacuachero, chipped stone artifacts were extraordinarily scarce. These artifacts are mostly bipolar percussion flakes produced from small ignimbrite nodules from the nearby Tajumulco source and are particularly associated with one of several floors stratified within bedded shell deposits (Voorhies 2011). These chipped stone tools and debitage reflect informal technologies that could potentially have been practiced by nonspecialists. Bipolar percussion reduction techniques would likely have maximized the utility of scarce raw materials. To obtain these materials, coastal producers may have engaged in long-distance resource acquisition strategies or participated in emergent, low-volume exchange networks to obtain volcanic resources from highland Guatemala. These artifacts may have included the occasional prismatic blade, although it remains possible that these artifacts may be the result of bioturbation or rodent activity from Formative or Classic period strata.

The Late Archaic period chipped stone lithic assemblages from Tlacuachero take on greater significance in light of recent paleoecological findings (Kennett et al. 2010) that suggest that the people who formed Tlacuachero, among other sites, were invested in plant cultivation and were perhaps more sedentary than was formerly thought. Previous data suggested that Archaic period shellmounds in the Acapetahua Estuary zone were formed by semimobile collectors, who created the mounds by periodically visiting coastal lagoons and processing large quantities of marsh clams, fish, and other aquatic resources (Voorhies 1976, 2004; Voorhies et al. 2002). However, Kennett et al. (2010) suggest that people living along this stretch of Pacific coast may have been slash-and-burn farmers, living in proximity to this perennially inundated estuarine zone and periodically visiting it to harvest and process marsh clams and other resources. Pollen, phytolith, and charcoal records indicate forest disturbance and maize phytoliths by 4100 cal B.P. Maize phytoliths are associated with the upper Late Archaic floor (Floor 1) at Tlacuachero (Jones and Voorhies 2004), and high ^{13}C values in human bone samples from one burial in association with that floor also support the idea of extensive maize cultivation and consumption at the site (Blake et al. 1992). Similarly, starch grains recovered from lithic tools at Late Archaic period sites in northeastern Belize, including "snowshoe-shaped" constricted unifaces and small bifacial tools, document the cultivation of maize, squash, beans, manioc, and chili peppers in this region (Rosenswig et al. 2014). These data support paleoecological studies from elsewhere in Mesoamerica that suggest that the cultivation of maize, squash, manioc, and other domesticates in slash-and-burn farming systems was in place well before 3,800 years ago in some parts of lowland tropical Mesoamerica, southern Central America, and

South America (Neff et al. 2006; Pearsall et al. 2004; Piperno and Pearsall 1998; Piperno et al. 2000; Piperno et al. 2007; Piperno et al. 2009; Pohl et al. 1996; Pope et al. 2001; Ranere et al. 2009).

Late Archaic period lithic reduction strategies at Tlacuachero and elsewhere in the Soconusco reflect the preferential exploitation of relatively proximate materials over more distant ones and the use of simple reduction techniques such as bipolar percussion that could be practiced by nonspecialists to create informal tools over specialized techniques and complex formal tools that required high levels of skill. The absence of cortex on these artifacts suggests segmented production stages at multiple loci, in which debitage from early reduction stages was deposited elsewhere and only the products of late-stage production were deposited at Tlacuachero. However, the presence of some Tajumulco ignimbrite bipolar core fragments and corner flakes from bipolar cores suggests that some flake tools made from this material could have been manufactured on-site from prepared bipolar flake cores. In contrast, obsidian cores and core fragments were not represented in the assemblage; evidence for on-site production of obsidian flakes and/or blades is currently lacking.

The relative scarcity of obsidian and ignimbrite raw materials likely contributed to the predominance of informal tools in the Tlacuachero assemblage as well as similar Late Archaic and Early Formative period assemblages in the Basin of Mexico and the Gulf Coast. In contrast, abundant fine-grained chert raw materials and high levels of producer skill likely contributed to the chert formal tools produced at Archaic period sites in northern and central Belize. By the Middle Formative period, lithic assemblages in northern and central Belize had also shifted to emphasize prismatic blade technology and imported obsidian from highland Guatemala, despite the abundance of local fine-grained lithic raw materials and a distinct tradition of lithic production. The changes in many lithic assemblages from the Late Archaic to Middle Formative period in many different areas of Mesoamerica suggest dramatic shifts in lithic technology, as the residents of emerging chiefdoms increasingly gained access to high-quality obsidian and specialist-produced prismatic blades.

Acknowledgments. Many thanks to Barbara Voorhies for her invitation to examine this collection and for her collaboration, guidance, and support since then. I am also grateful to John E. Clark for his insights and expert advice on chipped stone technology and to Artemio Villatoro for his consultations on raw materials. This analysis was made by possible by the members of the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, who granted the excavation permit. I am indebted to the New World Archaeological Foundation for the use of its laboratory space for the initial analysis and to the New York State Museum in Albany, particularly Marian Lupulescu, for allowing me to use the microscopic equipment. I would also like to thank PEO International and the Dumbarton Oaks Research Library and Collection for their support while I wrote this article.

References Cited

Awe, Jaime J., and Paul F. Healy
1994 Flakes to Blades? Middle Formative Development of Obsidian Artifacts in the Upper Belize River Valley. *Latin American Antiquity* 5:193–205.

Berman, Mary J., April K. Sievert, and Thomas R. Whyte
1999 Form and Function of Bipolar Lithic Artifacts from the Three Dog Site, San Salvador, Bahamas. *Latin American Antiquity* 10:415–432.

Blake, Michael, Brian S. Chisholm, John E. Clark, Barbara Voorhies, and Michael W. Love
1992 Prehistoric Subsistence in the Soconusco Region. *Current Anthropology* 33:83–94.

Blake, Michael, John E. Clark, Barbara Voorhies, George Michaels, Michael W. Love, Mary E. Pye, Arthur A. Demarest, and Bárbara Arroyo
1995 Radiocarbon Chronology for the Late Archaic and Formative Periods on the Pacific Coast of Southeastern Mesoamerica. *Ancient Mesoamerica* 6:161–183.

Boksenbaum, Martin W.
1978 Lithic Technology in the Basin of Mexico During the Early and Middle Preclassic. Unpublished Ph.D. dissertation, Department of Anthropology, City University of New York.
1980 Basic Mesoamerican Stone-Working: Nodule Smashing? *Lithic Technology* 9:12–25.

Boksenbaum, Martin William, Paul Tolstoy, Garman Harbottle, Jerome Kimberlin, and Mary Neivens
1987 Obsidian Industries and Cultural Evolution in the Basin of Mexico before 500 BCE. *Journal of Field Archaeology* 14:65–75.

Braswell, Geoffrey E.
2003 Obsidian Exchange Spheres. In *The Postclassic Mesoamerican World*, edited by Michael E. Smith and Frances F. Berdan, pp. 131–158. University of Utah Press, Salt Lake City.

Brown, David O., Meredith L. Dreiss, and Richard E. Hughes
2004 Preclassic Obsidian Procurement and Utilization at the Maya Site of Colha, Belize. *Latin American Antiquity* 15:222–240.

Bryant, Douglas Donne, John Clark, and David Cheetham
2005 *Ceramic Sequence of the Upper Grijalva Region, Chiapas, Mexico.* Papers of the New World Archaeological Foundation, No. 67, Vol. 1. Brigham Young University, Provo, Utah.

Clark, John E.
1981 The Early Preclassic Obsidian Industry at Paso de la Amada, Chiapas, México. *Estudios de Cultura Maya* 13:265–283.
1987 Politics, Prismatic Blades, and Mesoamerican Civilization. In *The Organization of Core Technology*, edited by Jay K. Johnson and Carol A. Morrow, pp. 259–284. Westview Special Studies in Archaeological Research. Westview Press, Boulder, Colorado.
1988 *The Lithic Artifacts of La Libertad, Chiapas, Mexico: An Economic Perspective*. Papers of the New World Archaeological Foundation, No. 52, Brigham Young University, Provo, Utah.
1989 Obsidian Tool Production. In *Ancient Trade and Tribute: Economies of the Soconusco Region of Mesoamerica*, edited by Barbara Voorhies, pp. 215–228. University of Utah Press, Salt Lake City.
1994 The Development of Early Formative Rank Societies in the Soconusco, Chiapas, Mexico. Unpublished Ph. D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.

Clark, John E., and Douglas Donne Bryant
1997 A Technical Typology of Prismatic Blades and Debitage from Ojo de Agua, Chiapas, Mexico. *Ancient Mesoamerica* 8:111–136.

Clark, John E., and David Cheetham
2002 Mesoamerica's Tribal Foundations. In *The Archaeology of Tribal Societies*, edited by William A. Parkinson, pp. 278–339. International Monographs in Prehistory, Ann Arbor, Michigan.

Clark, John E., and Thomas A. Lee Jr.
1984 Formative Obsidian Exchange and the Emergence of Public Economies in Chiapas, Mexico. In *Trade and Exchange in Early Mesoamerica*, edited by Kenneth G. Hirth, pp. 235–274. University of New Mexico Press, Albuquerque.

Cobean, Robert H., Michael D. Coe, Edward A. Perry Jr., Karl K. Turekian, and Dinkar P. Kharkar
1971 Obsidian Trade at San Lorenzo Tenochtitlan, Mexico. *Science* 174(4010):666–671.

Coe, Michael D., and Richard Diehl
1980 *In the Land of the Olmec.* University of Texas Press, Austin.

De León, Jason P.
2008 *The Lithic Industries of San Lorenzo-Tenochtitlán: An Economic and Technological Study of Olmec Obsidian.* Unpublished Ph. D. dissertation, Department of Anthropology, Pennsylvania State University, State College.

Garber, James, M. Kathryn Brown, Jaime J. Awe, and Christopher J. Hartman
2004 Middle Formative Prehistory of the Central Belize Valley: An Examination of Architecture, Material Culture, and Sociopolitical Change at Blackman Eddy. In *The Ancient Maya of the Belize Valley: Half a Century of Archaeological Research*, edited by James F. Garber, pp. 25–47. University Press of Florida, Gainesville.

Geier, Clarence R.
1990 A Middle Woodland Bipolar Pebble Technology in the Lower Chesapeake Area of Tidewater, Virginia. *Journal of Middle Atlantic Archaeology* 6:55–74.

Goodyear, Albert C.
1993 Tool Kit Entropy and Bipolar Reduction: A Study of Interassemblage Lithic Variability Among Paleo-Indian Sites in the Northeastern United States. *North American Archaeologist* 14:1–23.

Hayden, Brian
1980 Confusion in the Bipolar World: Bashed Pebbles and Splintered Pieces. *Lithic Technology* 9:2–7.

Healy, Paul F., David Cheetham, Terry G. Powis, and Jaime J. Awe
2004 Cahal Pech: The Middle Formative Period. In *The Ancient Maya of the Belize Valley: Half a Century of Archaeological Research*, edited by James F. Garber, pp. 103–124. University Press of Florida, Gainesville.

Honea, Kenneth H.
1965 The Bipolar Flaking Technique in Texas and New Mexico. *Texas Archeological Society Bulletin* 36:259–267.

Iceland, Harry B.
1997 *The Preceramic Origins of the Maya: The Results of the Colha Preceramic Project in Northern Belize*. Unpublished Ph. D. dissertation, Department of Anthropology, University of Texas, Austin.

Jackson, Thomas L., and Michael W. Love
1991 Blade Running: Middle Preclassic Obsidian Exchange and the Introduction of Prismatic Blades at La Blanca, Guatemala. *Ancient Mesoamerica* 2:47–59.

Jeske, Robert J.
1992 Energetic Efficiency and Lithic Technology: An Upper Mississippian Example. *American Antiquity* 57:467–481.

Jeske, Robert J., and Rochelle Lurie
1993 The Archaeological Visibility of Bipolar Technology: An Example from the Koster Site. *Midcontinental Journal of Archaeology* 18:131–160.

Jones, John G., and Barbara Voorhies
2004 Human and Plant Interactions. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 300–345. University Press of Florida, Gainesville.

Kelly, Thomas C.
1993 Preceramic Projectile-Point Typology in Belize. *Ancient Mesoamerica* 4:205–227.

Kennett, Douglas J., Dolores R. Piperno, John G. Jones, Hector Neff, Barbara Voorhies, Megan K. Walsh, and Brendan J. Culleton
2010 Pre-Pottery Farmers on the Pacific Coast of Southern Mexico. *Journal of Archaeological Science* 37:3401–3411.

Kennett, Douglas J., and Barbara Voorhies
2002 Informe final de "Temporada del Campo: Proyecto Costero Arcaico-Formativo, Chiapas, 2000-2001." Report submitted to the Consejo de Arqueología, Instituto Nacional de Antropología e Historia, Manuscript on file, Archivo Técnico del Consejo de Arqueología, Mexico City.

Kennett, Douglas J., Barbara Voorhies, John G. Jones, Hector Neff, Dolores R. Piperno, Thomas A. Wake, Megan K. Walsh, Karry L. Blake, Brendan J. Culleton, Josué Augusto Gómez Garcia, and Natalia Martínez Taqueña
2007 *Informe Técnico final del Proyecto Arcaico-Formativo: Costa de Chiapas*. Report submitted to the Instituto Nacional de Antropología e Historia. Manuscript on file, Archivo Técnico del Consejo de Arqueología, Mexico City.

Kennett, Douglas J., Barbara Voorhies, and Sarah B. McClure
2002 Los Cerritos: An Early Fishing-Farming Community on the Pacific Coast of Mexico. *Antiquity* 76:631–632.

Lohse, Jon C.
2007 In Search of the Preceramic: 2006 Season Investigations at Actun Halal, Belize. Report submitted to the Foundation for the Advancement of Mesoamerican Studies, Inc. Grant no. 06019. Texas State University, San Marcos.

Lohse, Jon C., Jaime J. Awe, Cameron Griffith, Robert M. Rosenswig, and Fred Valdez Jr.
2006 Preceramic Occupations in Belize: Updating the Paleoindian and Archaic Record. *Latin American Antiquity* 17:209–226.

Nance, C. Roger, and Katharine A. Kirk
1991 Obsidian Blades from La Blanca, a Changing Lithic Industry on the South Coast of Guatemala. *Latin American Antiquity* 2:371–383.

Neff, Hector, Deborah M. Pearsall, John G. Jones, Bárbara Arroyo, Shawn K. Collins, and Dorothy E. Freidel
2006 Early Maya Adaptive Patterns: Mid-late Holocene Paleoenvironmental Evidence from Pacific Guatemala. *Latin American Antiquity* 17:287–315.

Nelson, Fred W., and Barbara Voorhies
1980 Trace Element Analysis of Obsidian Artifacts from Three Shell Midden Sites in the Littoral Zone, Chiapas, Mexico. *American Antiquity* 45:540–550.

Niederberger, Christine
1976 *Zohapilco: cinco milenios de ocupación humana en un sitio lacustre de la Cuenca de México*. Instituto Nacional de Antropología e Historia, SEP, Departamento de Prehistoria, Mexico City.
1979 Early Sedentary Economy in the Basin of Mexico. *Science* 203(4376):131–142.
1987 *Paléopaysages et archéologie pré-urbaine du bassin de México (Mexique)*. Centre d'études mexicaines et centraméricaines, Mexico City.

Pearsall, Deborah M., Karol Chandler-Ezell, and James A. Zeidler
2004 Maize in Ancient Ecuador: Results of Residue Analysis of Stone Tools from the Real Alto Site. *Journal of Archaeological Science* 31:423–442.

Piperno, Dolores R., and Deborah M. Pearsall
1998 *The Origins of Agriculture in the Lowland Neotropics*. Academic Press, San Diego.

Piperno, Dolores R., J. Enrique Moreno, José Iriarte, Irene Holst, Matthew Lachniet, John G. Jones, Anthony J. Ranere, and Ronald Castanzo
2007 Late Pleistocene and Holocene Environmental History of the Iguala Valley, Central Balsas Watershed of Mexico. *Proceedings of the National Academy of Sciences* 104(29):11874.

Piperno, Dolores R., Anthony J. Ranere, Irene Holst, and Patricia Hansell
2000 Starch Grains Reveal Early Root Crop Horticulture in the Panamanian Tropical Forest. *Nature* 407(6806):894–897.

Piperno, Dolores R., Anthony J. Ranere, Irene Holst, José Iriarte, and Ruth Dickau
2009 Starch Grain and Phytolith Evidence for Early Ninth Millennium BP Maize from the Central Balsas River Valley, Mexico. *Proceedings of the National Academy of Sciences* 106(13):5019.

Pohl, Mary D., Kevin O. Pope, John G. Jones, John S. Jacob, Dolores R. Piperno, Susan D. deFrance, David L. Lentz, John A. Gifford, Marie E. Danforth, and J. Kathryn Josserand
1996 Early Agriculture in the Maya Lowlands. *Latin American Antiquity* 7:355–372.

Pope, Kevin O., Mary D. Pohl, John G. Jones, David L. Lentz, Christopher von Nagy, Francisco J. Vega, and Irvy R. Quitmyer
2001 Origin and Environmental Setting of Ancient Agriculture in the Lowlands of Mesoamerica. *Science* 292(5520):1370.

Ranere, Anthony J., Dolores R. Piperno, Irene Holst, Ruth Dickau, and José Iriarte
2009 The Cultural and Chronological Context of Early Holocene Maize and Squash Domestication in the Central Balsas River Valley, Mexico. *Proceedings of the National Academy of Sciences* 106(13):5014.

Rosenswig, Robert M.
2010 *The Beginnings of Mesoamerican Civilization: Inter-Regional Interaction and the Olmec*. Cambridge University Press, Cambridge.

Rosenswig, Robert M., Deborah M. Pearsall, Marilyn A. Masson, Brendan J. Culleton, and Douglas J. Kennett
2014 Archaic Period Settlement and Subsistence in the Maya Lowlands: New Starch Grain and Lithic Data from Freshwater Creek, Belize. *Journal of Archaeological Science* 41:308–321.

Shott, Michael J.
1989 Bipolar Industries: Ethnographic Evidence and Archaeological Implications. *North American Archaeologist* 10:1–24.

Sillitoe, Paul, and Karen Hardy
2003 Living Lithics: Ethnoarchaeology in Highland Papua New Guinea. *Antiquity* 77:555–566.

Voorhies, Barbara
1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico*. Papers of the New World Archaeological Foundation, No. 41, Brigham Young University, Provo, Utah.
2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.
2011 Informe de Proyecto "Los Origines de Arquitectura Pública en la Costa Sur de México." Report submitted to the Instituto Nacional de Antropología e Historia, Archivo del Consejo de Arqueología,. Manuscript on file, Archivo Técnico del Consejo de Arqueología, Mexico City.

Voorhies, Barbara, and Douglas Kennett
1995 Buried Sites on the Soconusco Coastal Plain, Chiapas, Mexico. *Journal of Field Archaeology* 22:65–79.

Voorhies, Barbara, Douglas J. Kennett, John G. Jones, and Thomas A. Wake
2002 A Middle Archaic Archaeological Site on the West Coast of Mexico. *Latin American Antiquity* 13:179–200.

Whittaker, John C.
1994 *Flintknapping: Making and Understanding Stone Tools*. University of Texas Press, Austin.

Wilson, Samuel M., Harry B. Iceland, and Thomas R. Hester
1998 Preceramic Connections Between Yucatan and the Caribbean. *Latin American Antiquity* 9: 342–352.

Chapter 9

The Tlacuachero Vertebrate Fauna

Thomas A. Wake and Barbara Voorhies

In this article we examine vertebrate fauna whose remains were left behind in the archaeological deposits at Tlacuachero. The analysis is based upon faunal remains recovered at this site during the 2009 field season. Particular attention is paid to investigating evidence of diachronic changes represented in these surviving remains.

Prior Analyses of Comparable Faunal Remains

Previously, several studies have been conducted on vertebrate faunal remains from Tlacuachero and other comparable shellmound sites on the outer coast of Chiapas, Mexico. Since our principal interest in this paper is on faunal remains from the Archaic period, we begin by discussing prior studies conducted on faunal remains dating to both the Late and Middle Archaic periods at these sites.

Late Archaic Period

Elizabeth Wing and Kathie Johnson identified vertebrate remains from Tlacuachero and Campón, both Late Archaic period shellmounds in the Acapetahua Estuary that Voorhies excavated in 1973. All excavated material had been screened through 5-mm mesh (Voorhies 1976:34). The faunal analysts recorded minimal number of individuals (MNI) and weights. These data were interpreted using archaeological components as the basic analytical units (Voorhies 1976). Thus fauna from the Late Archaic period from each of the two sites were compared with fauna from post-Archaic deposits, which at the time were thought to date principally to the Early Classic period. Subsequently, Hudson et al. (1989) converted the combined bone weights from the Archaic period deposits at these two sites to estimated meat weights to provide a better measure of dietary importance of different faunal classes. The results were then compared with findings for other sites on the Chiapas coast.

Natalie Anikouchine analyzed the faunal remains from a third Late Archaic shellmound, Zapotillo, which Voorhies also had excavated in 1973 but which had never been studied. All the excavated material from Zapotillo had been screened through 5-mm mesh. Anikouchine reported number of individual specimens (NISP), MNIs, and weights in an unpublished master's thesis (1990). She also calculated estimated biomass for identified taxa in the faunal assemblages in each of the three shellmounds (Tlacuachero, Campón, and Zapotillo) excavated in 1973. These data, subsequently published by Wake et al. (2004), provide comparisons

of different faunal classes among the three shellmounds and between the Archaic and post-Archaic components at the three sites.

Subsequently, Cooke et al. (2004), specialists in archaeoithyofauna, further analyzed the fish bones from Tlacuachero and Zapotillo. The analysts were interested particularly in reconstructing fishing practices of the people who formed the shellmounds. The two sets of samples from Tlacuachero analyzed by Cooke et al. (2004) were obtained by Voorhies in the 1988 field season and had not been studied previously. One of these sets of samples derived from a vertical column taken from an excavation sidewall from the ground surface to Floor 1, about 4.6 m below the surface. The second set consisted of two samples from a series of samples taken horizontally in a relatively wide swath only a few centimeters above Floor 1. We often refer to this set of samples as skim samples, since each sample was only a few centimeters thick. In both sets of samples, the sediments were dry sieved in the laboratory through a graduated set of geologic sieves, of which the smallest mesh size was approximately 2 mm. The Zapotillo fish bone samples, in contrast, were from the excavation unit whose faunal remains had been excavated in 1973 and studied previously by Anikouchine (1990). Cooke and colleagues (2004) recorded NISP, MNI, and weight, although the weights were not reported in the published article. However, these weights were used to estimate edible biomass, which was included in the publication.

Wake also analyzed vertebrate faunal remains from the Late Archaic period shellmound El Chorro, which Voorhies excavated in 2005. All excavated material had been passed through 5-mm mesh. Wake reported NISP and MNI in this analysis (Kennett et al. 2007). In addition, Voorhies and Kennett (2011) measured the diameters of fish bones from this excavation, which were consistently small and overwhelmingly from the Pacific fat sleeper (*Dormitator latifrons*). This finding awakened our awareness that there were significant differences among the shellmounds in the size and type of fish that were being procured by the Chantuto people.

Middle Archaic Period

The vertebrate remains from the sole investigated Middle Archaic period shellmound, Cerro de las Conchas, are documented and discussed by Voorhies et al. (2002). The assemblage that was analyzed by Wake came from two contiguous pits, Pit 2 and Pit 4, located on the northwestern flank of the mound. John Clark (Pit 2) and Richard Lesure (Pit 4) had earlier excavated these units (Clark 1994). Both investigators screened all material through 5-mm mesh. Voorhies et al. (2002) reported both NISP and MNI for the specimens they identified. Weights were not recorded, and estimated edible biomass was not calculated.

Principal Prior Findings

Prior work on various archaeofaunal assemblages from shellmounds in the Acapetahua Estuary has revealed distinct patterns that shed light on how the ancient Chantuto people and their successors interacted with animals in their environment.

First, the data suggest strongly that the catchment area for the Chantuto people and their successors, while they sojourned on the shellmounds, was restricted to the lagoon–estuary system, plus the surrounding marsh and mangrove forest. That is, the catchment area included only the various biomes of the coastal wetlands; there are no remains of wild animals exotic to the immediate environment of the shellmounds. Most significantly, our data show clearly that the people responsible for forming the shellmounds, both during the Archaic period and subsequently, never exploited the open oceanic environment. Cooke and coauthors (2004:291) observe that the assemblage of archaeoithyofauna from Tlacuachero has a different taxonomic composition from what would be expected if the Chantuto people had fished the nearshore marine environment.

Second, while clams undisputedly contributed the bulk of meat represented by the remains in the Archaic deposits at the shellmounds,[1] among the vertebrates, fish was the most important dietary contributor. For example, Wake et al. (2004:189) show that during the Archaic period, fish constituted 73 percent of estimated meat from vertebrates at three Late Archaic period shellmounds. However, the role of fish drops precipitously to only 21 percent in ceramic times at these same three sites. Notably, the contribution of mammal is the reverse, with only 17 percent of the estimated meat biomass in the Archaic period but 64 percent for later ceramic users at these sites. In comparison, the contribution of reptiles (turtles and iguanas) over time does not change dramatically. Reptiles contribute 10 percent in Archaic times and 14 percent in later times. Birds

and amphibians constitute negligible amounts of meat for both time periods.

Third, during the Archaic period, the Chantuto people may have targeted a relatively small number of potentially available species of fish. Cooke et al. (2004:Table 5.6) reconstruct potential fish fauna in the present-day Acapetahua Estuary using published data from biological surveys of Mexican lagoons. What is apparent from this exercise is high species richness; the authors propose that about 200 species may have been available in the paleolagoons fished by the Chantuto people. In stark contrast, the archaeological samples are dominated by only a few taxa; only 30 positively or tentatively identified species were found in the shellmounds. Of these, only one can be considered a regular food. The Pacific fat sleeper (*Dormitator latifrons*) represents 92 percent of NISP averaged for the two fine-screened sample sets from Tlacuachero. However, when biomass is estimated, the Pacific fat sleeper contributes only 47 percent of total biomass in the Tlacuachero column sample and 36 percent of the Tlacuachero skim sample (Cooke et al. 2004:Table 5.7c). Despite the dramatic difference between NISP and estimated biomass values, these data demonstrate that the Pacific fat sleeper was a very important focal resource for the Chantuto people during the Late Archaic. Even today, this species is among the most significant in terms of catch volume in the Tres Palos Lagoon, coastal Guerrero (Violante-González et al. 2008:1419, citing Pilo-Guzmán 2003).

A fourth important aspect of prior studies concerns inferences about fishing practices. Cooke et al. (2004) used their knowledge of modern artisanal fishing to draw inferences about possible fishing practices in the prehistoric past. Turtle shell fishhooks had been found at the Middle Archaic period site of Cerro de las Conchas at the time of Cooke et al.'s 2004 publication, but not in any of the Late Archaic period shellmounds. This situation has now changed: in 2009 we found two fragments of turtle shell fishhooks at Tlacuachero in the bedded shell deposits below the level of the floors (Figure 9.1). Thus we now have conclusive evidence that angling was one fishing technique practiced by the Chantuto people during both Middle and early Late Archaic times. This technique would have been appropriate to procure the high-trophic-level fish, such as snook, corvina, and snapper, whose bones are present in the archaeofauna in significant numbers, representing important dietary components. Cooke and colleagues note also that very small fish were important to the diet of the Chantuto people. The average size of the Pacific fat sleeper from fine-screened deposits at Tlacuachero was estimated to be only 60 g (Cooke et al. 2004:280). These very small detritivores cannot be caught with hook and line. They must have been procured using some kind of net or trap.

A final interesting observation by Cooke and colleagues is that when Zapotillo data for number of bones from the top predators (snook, snapper, and corvina) are plotted by excavation level to number of bones from

Figure 9.1. Two turtle shell fishhooks from the lower bedded shell deposits at Tlacuachero (photograph by Barbara Voorhies).

the Pacific fat sleeper (Cooke et al. 2004:Figure 5.7), the two curves are out of phase. That is, in excavation levels where the number of bones from top predators is high, the number of sleeper bones is low, and vice versa. This suggests to the authors that different fishing practices were being used, which also is apparent from the different ecological niches of these fishes, as we just mentioned. Several possible interpretations might explain this observation, such as differences in seasonality, topography, fishing methods, or sexual division of labor (Cooke et al. 2004:298). Voorhies and Kennett (2011) have pursued further this last possibility and found that it has the merit of explaining several different lines of diachronic changes in the archaeological records of these shellmounds.

Methods

The faunal assemblage reported here consists of 13,070 identified skeletal elements recovered during the 2009 excavations. In this section we briefly discuss methods of data collection and data analysis.

Excavation Methods

Since the principal research objective in 2009 was to unearth a larger area of the deeply buried floors than had been previously exposed, the excavators had to remove huge amounts of archaeological overburden as quickly as possible. Because of this, it was sometimes necessary to forego screening of the matrix being removed, since the process of screening greatly slows down excavation progress. Such decisions have enormous implications for faunal analyses, of course (Gobalet 2005; Vale and Gargett 2002; Wake 2004; Zohar and Belmaker 2005).

In certain situations, principal investigator Voorhies decided not to screen excavated material, either because she knew that the deposits could not be dated accurately or because a screened sample had already been collected. For example, in 2009 Voorhies decided not to screen any of the excavated material from the upper, dark-soil stratum, since prior work had shown that the deposits had little archaeological value: the unbedded stratum contains artifacts from several different post-Archaic time periods, but they are mixed and not in correct stratigraphic position. Because of this, Voorhies knew that faunal remains from the upper stratum could not be attributed to specific occupation periods. Moreover, in previous work at the site, archaeologists had screened the excavated dark soil, and faunal remains recovered therein had been identified and reported (Voorhies 1976). Therefore, the hand-collected faunal remains from the upper stratum are not reported in this study.

In contrast, the excavation methods that we adopted for the bedded shell deposits are appropriate for making inferences about the vertebrate animals procured by the Chantuto people at Tlacuachero. The following discussion describes the excavation methods at the site so that the reader can evaluate the implications for faunal analysis. It is important to note that somewhat different methods were used at different locations.

The two principal excavation blocks that extend vertically from ground level to the level of the second floor (Unit S2W1 and Unit N1W2) provide the most carefully collected faunal remains for the bedded shell deposits *overlying* the floors. These units are not the same size, so for some purposes their contents should not be compared directly without making volumetric corrections. The horizontal dimensions of Unit S2W1 are 4 x 4 m, whereas those of N1W2 are 2 x 6 m. In both units the excavators used 20 cm excavation levels within natural strata. Contact between the bedded shell deposits and the overlying dark soil is irregular, which means that during the excavation process, shell deposits first appear as discrete patches on the floor of an excavation unit. These patches of shell increase in size with depth. As soon as one of these areas of shell was at least 1 x 1 m within an excavation unit, a sample of the shell matrix was collected (0.2 m^2) and screened through 5-mm (0.25-inch) mesh. The faunal remains caught by the screen were bagged separately from faunal remains hand collected from the rest of the same arbitrary level. This meant that for levels that consisted mainly of bedded shell deposits, we regularly had one bag of faunal remains that had been hand collected from the excavation (that is, unscreened) and one bag of faunal remains from the 1 x 1 m screened material. When we removed Floor 1 from these two excavation units, we screened all the material.

In addition, a column sample of bedded shell deposits was taken from the west wall of S2W1 to permit a detailed analysis of site contents. This series of samples was removed in a continuous vertical strip, with each sample 20 cm in depth, approximately 10 cm wide, and 10 cm deep. The samples were bagged at the site

and moved to laboratory facilities of the New World Archaeological Foundation, where they were screened through a set of Wentworth geologic sieves with the following mesh sizes: 12.5 mm (0.5 inch), 4 mm (0.157 inch), 2 mm (0.0787 inch), and 1 mm (0.0394 inch). This subsample of fine-screened material allows us to recover bones from very small animals, in this case almost exclusively small fish.

The faunal sample from the bedded shell deposits *below* the floors, as well as samples from floors 2 and 3, was collected from Unit N1W1, a 2 x 2 m unit that penetrated deposits from the elevation of Floor 1 to 6.8 m below the ground surface at the unit datum. In this unit we screened all excavated material through 5-mm (0.25-inch) mesh. In addition, a set of column samples was taken from the east wall of the unit. These column samples were similar to those from the S2W1 column, except that each sample was only 10 cm in its vertical dimension. This means that each 20-cm excavation level of the unit is matched by two corresponding column samples.[2]

A few additional samples from bedded shells located below the floors came from Unit S2E1. This unit had been started in 1988, when excavators removed Floor 1 and a small amount of bedded shells underlying the floor. In 2009 we excavated deeper into the sub–Floor 1 deposits. Floors 2 and 3 were not present in this unit, which shows that these two floors did not extend this far south. We did not screen any material removed in the block labeled Unit N2E1. Therefore, the faunal remains that we recovered from it are not reported here.

Laboratory Methods

Thomas Wake, José Benito Guzmán, and the staff of the Zooarchaeology Laboratory sorted the Tlacuachero faunal material by vertebrate class upon its arrival in the Cotsen Institute of Archaeology (CIOA) at UCLA. Each class was then identified individually to limit potential confusion. For each identified specimen, the analysts recorded skeletal element, side, and portion. Taphonomic characteristics such as fragmentation, gnawing (carnivore and rodent), burning, cut marks, or other obvious modifications were recorded. Identifications were confirmed using comparative vertebrate osteological collections housed in the CIOA Zooarchaeology Laboratory, the UCLA Department of Biology, and the Los Angeles County Museum of Natural History. Identifications were aided and habitat information was garnered from a series of field guides, identification manuals, and FishBase.org (e.g., Alvarez del Toro 1977, 1983; Amezcua-Linares 1996; Bussing 1998; Campbell and Vannini 1989; Emmons 1990; Fischer et al. 1995a, 1995b; Howell and Webb 1995; Iverson 1992; Jantzen 1983; Miller et al. 2005; Page et al. 2013; Reid 1997; Rojo 1991).

The Tlacuachero vertebrate archaeofaunas are measured using NISP and MNI counts per analytical unit. The NISP measure is a straight count of all the identified bone specimens representing a given taxonomic category. The MNI is a derived determination of the minimum number of individual animals represented in the sample at hand. MNI determinations here are based on counts of the greatest number of paired elements from either side (left or right) of a given taxon or the number of unique skeletal elements represented (vertebra no. 1, for example), whichever is greater. We also used size of individual skeletal elements in the determination of MNI. For example, when two specimens representing one side of a specific paired skeletal element of a given taxon might suggest the presence of a minimum of two individuals, a much larger or smaller specimen representing the opposite side would indicate the presence of another individual animal.

Of course, both NISP and MNI measures have well-known potential biases. NISP is subject to fragmentation effects, among others, and MNI measures are subject to aggregation effects (Grayson 1984; Lyman 1994a, 1994b, 2008). While each of these counts (NISP and MNI) has its inherent problems, viewed together they provide a fairly accurate representation of the relative abundance of the different identified animals present in the overall assemblage.

To address the question of fish size, we measured the diameter of fish vertebrae as a proxy for overall fish size (Reitz et al. 1987; Voorhies 2004). The tedious job of measuring the vertebrae fell to two individuals, whose contributions are hereby gratefully acknowledged. Fernando Girón Campero measured the bones from both sets of column samples (from Unit S2W1 and Unit N1W1), whereas Tyler Turran measured the bones from both corresponding excavations. Wake measured both greatest length and greatest width of the *Cynoscion albus* otoliths. All measurements were taken with digital calipers.

Results

The identified 2009 Tlacuachero vertebrate archaeofauna consists of 13,070 bone specimens identified to at least the class level (Table 1). Fifty-one genera and 33 species representing 39 families of vertebrates are identified. Fish, both cartilaginous (Elasmobranchiomorphii—three genera, one species, three families) and bony (Actinopterygii—23 genera, 22 species, 21 families), are the most common and diverse group, with 26 genera and 23 species representing 24 families. Reptiles (10 genera and species representing seven families) and mammals (eight genera and seven species representing eight families) are both fairly well represented. Birds (four genera and three species representing three families) and amphibians are the least common vertebrate classes, with the only marine toad (*Bufo marinus*) representing amphibians. This general pattern of taxonomic diversity holds for all three stratigraphic groupings discussed here—above the floors (1.6 m–4.2 m below datum), the series of floors of fine sediment (approximately 4.2–4.6 m below datum), and below the floors (4.6–6.8 m below datum).

Fish

Cartilaginous fish (Elasmobranchiomorphii: sharks and rays) are present in relatively low numbers in the Tlacuachero vertebrate archaeofauna (Table 1). Three families of cartilaginous fish are represented: the Carcharhinidae, including the bull shark (*Carcharhinus leucas*), represent large, predatory sharks; the Dasyatidae represent stingrays (*Dasyatis* sp.); and the Rajidae represent rays (*Raja* sp.). All the sharks and rays identified in the assemblage reported here prefer saltwater and are commonly found in lower estuaries (Amezcua-Linares 1996; Fischer et al. 1995a, 1995b).

Bony fish (Actinopterygii) dominate the Tlacuachero vertebrate archaeofauna in terms of raw numbers (11,683) and diversity (23 genera, 22 species, 21 families). The most common bony fish in this collection is the Pacific fat sleeper (PFS, *Dormitator latifrons*, n = 3,353: Eleotridae). The tropical gar (TG, *Atractosteus tropicus:* Lepisosteidae) is represented by 3,846 identified specimens, of which 3,338 are the ubiquitous, durable, enamel-coated, bony dermal ganoid scales, also known as scutes. Based on skeletal elements other than scutes, as with all the other identified fish, tropical gar provide 508 identified specimens, making this species the second-most-common vertebrate in this assemblage. Both the PFS and TG can tolerate relatively high salinities but prefer lower-salinity upper estuary and freshwater habitats (Amezcua-Linares 1996; Fischer et al 1995a; Violante-Gonzalez et al. 2008).

The next most common fish family reported here are the sea catfish (Ariidae, n = 309). The identified sea catfish include three genera and three species (*Ariopsis guatemalensis*, n = 14; *Cathorops fuerthii*, n = 4; and *Occidentarius platypogon*, n = 1; Table 1) of estuarine inhabitants that prefer higher salinities than either TG or PFS but can be found in relatively fresh water. The fourth most common fish family at Tlacuachero is the Cichlidae (n = 248). Two genera and two species of cichlids are identified here (*Amphilophus macracanthus*, n = 38 and *Amphilophus trimaculatum*, n = 6; Table 1). Both prefer freshwater and do not tolerate well any amount of salinity (Bussing 1998; Miller et al. 2005).

Snook (*robalo*, genus *Centropomus*, n = 211: Centropomidae) follow the cichlids in relative abundance. Four species of snook are identified, all from tooth-bearing and complex cranial bones: *C. unionensis* (n = 11), *C. nigrescens* (n = 5), *C. medius* (n = 4), and *C. viridis* (n = 1, Table 1). All the snook species can tolerate relatively high salinities and are commonly found in upper and lower estuaries but rarely in the open ocean (Bussing 1998; Fischer et al. 1995a; Miller et al. 2005).

Corvina (genus *Cynoscion*, n = 147: Sciaenidae) and snapper (*huachinango*, genus *Lutjanus*, n = 118: Lutjanidae) are the next most common identified fish genera at Tlacuachero. Three species of the genus *Cynoscion* are identified: *C. albus* (n = 30), *C. reticulatus* (n = 1), and *C. stoltzmani* (n = 1), all from otoliths (saggitae). Two species *of Lutjanus*, *L. jordani* (n = 2) and *L. colorado* (n = 1), are identified, both from tooth-bearing bones.

Mullets of the genus *Mugil* are well represented by 76 specimens. Mullets are low-trophic-level filter feeders but can get quite large. One species of mullet, the white mullet (*M. curema*), is identified. Sixty-four specimens represent another group of low-trophic-level filter feeders, the Clupeiformes (anchovies and sardines). Two first vertebrae represent the single identified clupeiform species, the Pacific anchovy (*Cetengraulis mystecetus*). The remaining 62 specimens are identified to either the Clupeidae, the Engraulidae, or their order.

Two other fish groups—the Gerreidae (mojarras) and the Haemulidae (grunts)— are relatively common and perhaps even underrepresented considering their

modern occurrence in local habitats (Amezcua-Linares 1996). Fewer than 20 specimens each represented both families. Two genera of grunts are identified: *Microlepidotus* (n = 2) and *Pomadasys* (n = 16). Both genera are common in coastal lagoons, estuaries, and mangroves. Likewise, two genera and one species of mojarra are identified: *Eucinostomus* sp. (n = 3) and *Gerres cinereus* (n = 10), with six specimens identified to the family level. Members of the Gerreidae are common in estuaries, coastal lagoons, and mangroves.

The remaining identified fish taxa are all represented by approximately 10 specimens each and include members of the Elasmobranchiomorphii: *Carcharhinus leucas* (bull shark, n = 5), *Carcharhinus* spp. (sharks, n = 5), a stingray (*Dasyatis* sp., n = 1), and a ray (*Raja* sp., n = 1). One milkfish (*Chanos chanos*) vertebra is identified. Silversides, (Atherinopsididae, n = 13), mollies (Poeceliidae, n = 2), and needlefish (Belonidae, n = 1) are present. Four specimens represent the swamp eel (*Synbranchus marmoratus*).

Other relatively uncommon fish include members of the Carangidae: *Caranx* sp., a jack, represented by four specimens, and *Oligoplites* sp., a leatherjack, represented by a single specimen. Single specimens represent both bobos (*Polydactylus* sp.) and puffer fish (*Sphoeroides* sp.). Five specimens represent gobies (cf. *Awaous* sp.). Some 3,192 fragments are identifiable only as bony fish (Actinopterygii).

Common Fish Natural Histories

Below we provide brief natural histories and descriptions of the more common or noteworthy species in the Tlacuachero vertebrate archaeofauna. More detailed information on these and other taxa present in the assemblage but not discussed below can be obtained from the following resources (Bussing 1998; Fischer et al. 1995a, 1995b; Froese and Pauly 2012; Miller et al. 2005).

Sea Catfish (*Ariidae*). Sea catfish are relatively common in tropical and subtropical waters. Five genera and several species are found in southwestern Mexican waters. All ariid catfish have two strong, sharp, barbed, pectoral spines and one similar dorsal spine that can inflict painful wounds and are poisonous in some species. Ariid catfish tend to be omnivorous, with larger individuals consuming larger prey items such as crabs, fish, and other vertebrates (Kailola and Bussing 1995). The most common ariid fish in the Tlacuachero assemblage, the widehead sea catfish (*Ariopsis guatemalensis*), is described as abundant in marine and brackish waters and often found in freshwater. The blue sea catfish is omnivorous, apparently quite vulnerable to overfishing, and has a trophic level (tl) value of 3.6 (Cheung et al. 2005).

Tropical Gar (*Atractosteus tropicus*). Tropical gar are essentially living fossils, relatively unchanged since the Upper Cretaceous. These gar are usually found in slow-moving or stagnant freshwaters such as swamps and sometimes in slow-moving rivers. They are highly carnivorous, consuming primarily fish as well as copeopods and insects (tl 4.2). Gar have a vascularized swim bladder that allows them to breathe air. It is noteworthy that their eggs are poisonous and cannot be eaten (Robins et al. 1991). These fish are still consumed today, often sold in markets roasted on a stick. One peels off the layer of skin holding the scorched, bony, enamel-covered scales, much akin to a banana peel, and eats the meat. Tropical gar are highly vulnerable to overfishing (Cheung et al. 2005).

Mojarras (*Cichlidae*). The two genera of cichlids identified in the Tlacuachero fish assemblage (*Amphilophus macracanthus* and *Cichlasoma trimaculatum*) are sympatric and have similar habitat requirements. They inhabit slow-moving waters of swamps and lower river valleys and prefer soft bottoms, where they live among roots and weeds. Both genera are omnivorous, feeding on small fishes, macroinvertebrates, and aquatic and terrestrial insects. These cichlids are commonly consumed throughout their range and are moderately vulnerable to overfishing (Cheung et al. 2005).

Mullets (*Mugil* sp.). Mullet are cosmopolitan, large (up to 1 m and 5 or more kg), low-trophic-level (tl 2.0) filter feeders that are common in coastal estuaries and nearshore environments. Mullet are members of the family Mugilidae. They penetrate freshwater and are currently cultivated in freshwater and brackish ponds. Several species of Mugilid fish are found in southwest Mexican waters. Mullet are relatively vulnerable to overfishing (Cheung et al. 2005).

Pacific Fat Sleeper (*Dormitator latifrons*). The Pacific fat sleeper is a member of the family Eleotridae, which lives in Pacific Mexican coastal waters. It is found along the Pacific littoral from Long Beach, California, through the Gulf of California, and all the way to northern Peru, often in lower-salinity brackish, turbid waters associated with mangroves. It prefers freshwater

swamps in the upstream portions of mangrove-dominated estuarine systems. A notable characteristic of the species is its ability to live in water deficient in oxygen and with wide variations in temperature and salinity (Castro Rivera et al. 2005:46). It has an important ecological role in that it can convert energy from detritus into a form that is usable for organisms in higher trophic levels. It also filters plankton (Bussing 1998; Miller et al. 2005). Its common name in some parts of Mexico is *popoyote* or *dormilón*, but in our field area it is known as *sambuco*. This fish species reaches a maximum length of 41 cm.

Although this fish has little commercial value, it is consumed frequently in coastal communities in Guerrero and Oaxaca. The fish has white flesh and is high in proteins (Castro Rivera et al. 2005:46). It is important to note that PFS has been linked to gnathostomiasis, a parasitic infection by an annoying nematode (Díaz-Camacho et al. 2008; Rojas-Molina 1999). This fish is also commonly placed in aboveground water storage tanks, known locally as *pilas*, with the express purpose of consuming mosquito larvae. This fish is easily caught with a seine or a dip net and does not seem vulnerable to overfishing (Cheung et al. 2005).

Queen Corvina (*Cynoscion albus*). The queen corvina is a member of the Sciaenidae that lives in Pacific Mexican littoral waters and ranges from Sonora, Mexico, to Colombia. This species prefers saltwater, with juveniles entering estuaries, mangrove systems, shallow bays, and river mouths.

This fish has a relatively high local commercial value and is consumed frequently in coastal communities throughout its range. It is valued for its fine white flesh and delicate flavor. This species is a voracious carnivore, consuming shrimp and other smaller fishes. As such, it is classified as a high-trophic-level (4.19) species, with low resilience to population pressure and vulnerable to overfishing (Cheung et al. 2005). *Cynoscion albus* reaches a maximum length of 130 cm. These fish will bite on hooks and can be captured with seines, gill nets or static weirs (e.g., Cooke and Tapia 1994a, 1994b).

Snook (genus *Centropomus*). Snook (*robalo*) are members of the family Centropomidae and range from northern Mexico to Peru. Some species prefer saltwater, with juveniles entering estuaries, mangrove systems, shallow bays, and river mouths. Others are predominantly brackish to freshwater species. Snook are valued for their fine white flesh and delicate flavor. They have a relatively high local commercial value and are consumed frequently in coastal communities throughout their range. Snook tend to be voracious carnivores, consuming shrimp and other smaller fishes. Some *robalo* reach sizes of 140 cm, with most species ranging from 35 to 75 cm. Snook species are all relatively high-trophic-level carnivores with considerable vulnerability to overfishing (Cheung et al. 2005).

Snappers (genus *Lutjanus*). Snappers (*pargo*, *huachinango*) are members of the family Lutjanidae and range worldwide in tropical waters. In the Americas they can be found from northern Mexico to Peru. All species prefer saltwater, with juveniles entering estuaries, mangrove systems, shallow bays, and river mouths. *Pargo* are valued for their white flesh and delicate flavor. They have a high local and international commercial value and are consumed frequently in coastal communities throughout their range. Snapper tend to be voracious carnivores, consuming shrimp and other smaller fishes. Some snapper reach sizes of 140 cm, with most species ranging from 35 to 75 cm. Adult snappers are all relatively high-trophic-level carnivores and vulnerable to overfishing (Cheung et al. 2005).

Amphibians

A single amphibian species is identified, the marine toad (*Bufo marinus*, n = 8). These toads can get fairly large, and while they exude toxic skin secretions, they can be eaten if skinned and cooked. These same toads also appear in regional iconography (statuary) several thousand years later at Izapa and Takalik Abaj (Kennedy 1982).

Reptiles

After fish, reptiles are the next most common vertebrates in this Tlacuachero assemblage (n = 1,160), represented by 10 genera and species. The most common reptiles are turtles, especially the red-cheeked mud turtle (*Kinosternon scorpioides*, n = 792). The next most common turtle is the pond slider (*Trachemys scripta*, n = 68). The Central American wood turtle (*Rhinoclemmys pulcherrima*, n = 12) and Pacific coast giant musk turtle (*Staurotypus salvinii*, n = 6) follow in abundance. Two sea turtle (Cheloniidae) carapace fragments are identified, as are 18 specimens identifiable only as turtle (Testudinata).

Lizards follow turtles in terms of abundance at Tlacuachero. The terrestrial black iguana (*Ctenosaura*

similis, n = 49) is a bit more common than the arboreal green iguana (*Iguana iguana*, n = 35). Specimens identifiable as simply "Iguana" (n = 78) outnumber both and could represent either genus.

Crocodilians are somewhat less common than lizards at Tlacuachero, represented by two genera and species: the American crocodile (*Crocodylus acutus*, n = 21) and the spectacled caiman (*Caiman crocodilus*, n = 9). Twelve specimens are identified simply as "Crocodilia." Both caimans and crocodiles can provide a considerable amount of meat, with caimans reaching up to 2 m in length and larger crocodiles sometimes up to 5 m.

Snakes are the least common reptiles in the Tlacuachero assemblage, represented by two genera and species, the red-tailed boa (*Boa constrictor*, n = 17) and the indigo snake (*Drymarchon corais*, n = 1). Both of these snake species are large, with adult indigo snakes commonly eating other serpents. The heavy-bodied boa could provide more meat than any other snake of the same length. Two specimens are identified as Colubridae, or nonvenomous snakes.

Birds

Aside from the amphibians, birds are the least common taxonomic order represented at Tlacuachero (n = 59), with five genera and three species identified, representing three families. All the identified birds represent some sort of waterfowl, primarily marine. The most common bird is the cormorant (*Phalacrocorax* sp., n = 18), followed by the pelican (*Pelecanus occidentalis*, n = 2). The remaining identified taxa are all represented by single specimens and include a duck (Anatidae), the green heron (*Butorides virescens*), the least bittern (*Ixobrychus exilis*), and the tiger heron (*Tigrisoma* sp.). The remaining 35 specimens are identified as representing various size classes of birds (Table 9.1).

Mammals

Mammals are represented by 186 specimens, of which 111 are fragments identifiable only to a relative size class (Table 1). Eight genera and seven species of mammals are identified, representing eight families. Artiodactyls are the most common mammalian order (n = 33), including white-tailed deer (*Odocoileus virginianus*, n = 22) and collared peccary (*Pecari tajacu*, n = 11). Raccoon (*Procyon lotor*, n = 11) and dog (*Canis familiaris*, n = 1) represent the carnivores. Two rodent genera are identified: rice rat (*Oryzomys* sp., n = 4) and cotton rat (*Sigmodon hispidus*, n = 5). Six armadillo (*Dasypus novemcinctus*) specimens are present as well. Fifteen human bone fragments and teeth are identified but were not analyzed in detail.

Human Effects on the Archaic Period Tlacuachero Fishery

Carnivorous fish tend to be preferred by humans for a variety of reasons, including a perceived higher quality of meat, large size, and relative ease of capture (Cooke 1992). Several species of high-trophic-level carnivorous fish species are present in the Tlacuachero vertebrate archaeofauna discussed here, including snook, weakfish, snapper, gar, and catfish. These highly ranked carnivorous fish are much more common in the stratigraphically older layers of the site, particularly those beneath the floors.

The highest-ranked fish species at Tlacuachero, in terms of trophic level values, are most abundant in the lowest excavated levels of the site. They then decline in relative abundance, with decreasing depth in the bedded shell layers beneath the floors. These same species then greatly diminish in the excavated levels just above the floors, and they virtually disappear in the uppermost, bedded shell strata (Figure 9.2). These data illustrate a shift to the dominance of the Pacific fat sleeper, a low-trophic-level Eleotrid fish, in numerical terms in the more recent deposits above the floor levels.

Trophic Levels Through Time

Another way to measure the focus of a fishery is to determine the mean trophic level of the representative fish bone assemblage, as described in the above "Methods" section. In Figure 9.3 we present the results of a stratigraphic approach to mean trophic level analysis of the Tlacuachero fish bone assemblage. Wake first divided the raw bone count data into 1-m depth segments, with each segment representing a stratigraphically deeper and older portion of the overall archaeological deposit. To determine the mean trophic level of each stratigraphic segment at Tlacuachero, we referred to FishBase (Froese and Pauly 2012) for trophic level values of each identified taxon, multiplied this value by the MNI per taxon, added up all trophic level (MNI)

Table 9.1. Identified Vertebrate Remains from the 2009 Tlacuachero Excavations.

Common Name	Scientific Name	Above Floors	Floors	Below Floors	Total
Bull shark	*Carcharhinus leucas*		1	5	6
Shark	*Carcharhinus* sp.		3	2	5
Stingray	*Dasyatis* sp.		1		1
Ray	*Raja* sp.		1		1
Tropical gar	*Atractosteus tropicus*	163	1,086	2,597	3,846
Anchoveta	*Cetengraulis mysticetus*	2			2
Sardines	Clupeidae	4			4
Anchovies	Eugraulidae	13			13
Anchovies and sardines	Clupeiformes	45			45
Milkfish	*Chanos chanos*	1			1
Congo sea catfish	*Cathorops fuerthi*		1	3	4
Sea catfish	*Cathorops* sp.	2	3	18	23
Widehead sea catfish	*Ariopsis guatemalensis*	5	4	5	14
Cominate sea catfish	*Occidentarius platypogon*	1			1
Sea catfish	Ariidae	45	45	177	267
White mullet	*Mugil curema*	3		4	7
Mullet	*Mugil* sp.	14	6	49	69
Silversides	Atherinopsidae	12		1	13
Mollies	Poeciliidae	1		1	2
Needlefish	Belonidae	1			1
Mottled swamp eel	*Synbranchus marmoratus*	1	3		4
Blackfin snook	*Centropomus medius*			4	4
Black snook	*Centropomus nigrescens*	1	2	2	5
Humpback snook	*Centropomus unionensis*		2	9	11
White snook	*Centropomus viridis*			1	1
Snook	*Centropomus* sp.	41	33	114	188
Jack	*Caranx* sp.			4	4
Leatherjack	*Oligoplites* sp.			1	1
Colorado snapper	*Lutjanus colorado*		1		1
Whipper snapper	*Lutjanus jordani*	1		1	2

Common Name	Scientific Name	Above Floors	Floors	Below Floors	Total
Snapper	*Lutjanus* sp.	10	15	90	115
Mojarra	*Eucinostomus* sp.	3			3
Yellowfin mojarra	*Gerres cinereus*	6	4		10
Mojarras	Gerreidae	1	5		6
Grunt	*Microlepidotus* sp.		2		2
Grunt	*Pomadasys* sp.	4	12		16
Bobo	*Polydactylus* sp.	1			1
Queen corvina	*Cynoscion albus*	1	11	18	30
Striped corvina	*Cynoscion reticulatus*		1		1
Yellowtail corvina	*Cynoscion stoltzmani*			1	1
Corvina	*Cynoscion* sp.	28	38	49	115
Blackthroat cichlid	*Amphilophus macracanthus*	30	1	7	38
Threespot cichlid	*Amphilophus trimaculatus*	3		3	6
Cichlid	*Amphilophus* sp.	130	15	59	204
Pacific fat sleeper	*Dormitator latifrons*	2,653	554	146	3,353
Spotted sleeper	*Eleotris picta*	10	2		12
Goby	*Awaous* sp.	5			5
Puffer	*Sphoeroides* sp.			1	1
Bony fish	Teleostei	1,180	603	1,409	3,192
Marine toad	*Bufo marinus*	1	7		8
Spectacled caiman	*Caiman crocodilus*	1	6	2	9
American crocodile	*Crocodylus acutus*	2	11	8	21
Crocodile	Crocodilidae	1	7	4	12
Sea turtle	Cheloniidae		2		2
Red-cheeked mud turtle	*Kinosternon scorpioides*	151	460	181	792
Pacific coast giant musk turtle	*Staurotypus salvinii*	2	1	3	6
Central American wood turtle	*Rhinoclemmys pulcherrima*		12		12
Pond slider	*Trachemys scripta*	35	21	12	68
Turtle	Testudinata	18			18
Red-tailed boa	*Boa constrictor*	9	6	2	17

Table 9.1. Identified Vertebrate Remains from the 2009 Tlacuachero Excavations. *(continued)*

Common Name	Scientific Name	Above Floors	Floors	Below Floors	Total
Indigo snake	*Drymarchon corais*		1		1
Nonvenomous snakes	Colubridae	1		1	2
Black iguana	*Ctenosaura similis*	29	19	1	49
Green iguana	*Iguana iguana*	25	2	8	35
Black/green iguana	*Ctenosaura/Iguana*	44	33	1	78
Lizard, large	Lacertilia, Lg.	1	6		7
Reptiles	Reptilia	4	27		31
Ducks	Anatidae			1	1
Green heron	*Butorides virescens*		1		1
Least bittern	*Ixobrychus exilis*			1	1
Tiger heron	*Tigrisoma* sp.		1		1
Brown pelican	*Pelecanus occidentalis*	1	1		2
Cormorant	*Phalacrocorax* sp.		18		18
Large bird	Aves, Lg.		15		15
Medium bird	Aves, Md.	3	5	1	9
Bird	Aves		11		11
Nine-banded armadillo	*Dasypus novemcinctus*	5	1		6
Human	*Homo sapiens*	9	4	2	15
Domestic dog	*Canis familiaris*	1			1
Raccoon	*Procyon lotor*	6	2	3	11
White-tailed deer	*Odocoileus virginianus*	11	6	5	22
Collared peccary	*Pecari tajacu*	5	5	1	11
Rice rat	*Oryzomys* sp.		4		4
Cotton rat	*Sigmodon hispidus*		5		5
Large mammal	Mammalia, Lg.	12	33	2	47
Medium mammal	Mammalia, Md.	2	2		4
Mammal	Mammalia	5	55		60
	Grand total	4,805	3,245	5,020	13,070

Note: Fish nomenclature follows Page et al. 2013 for all common and scientific names.

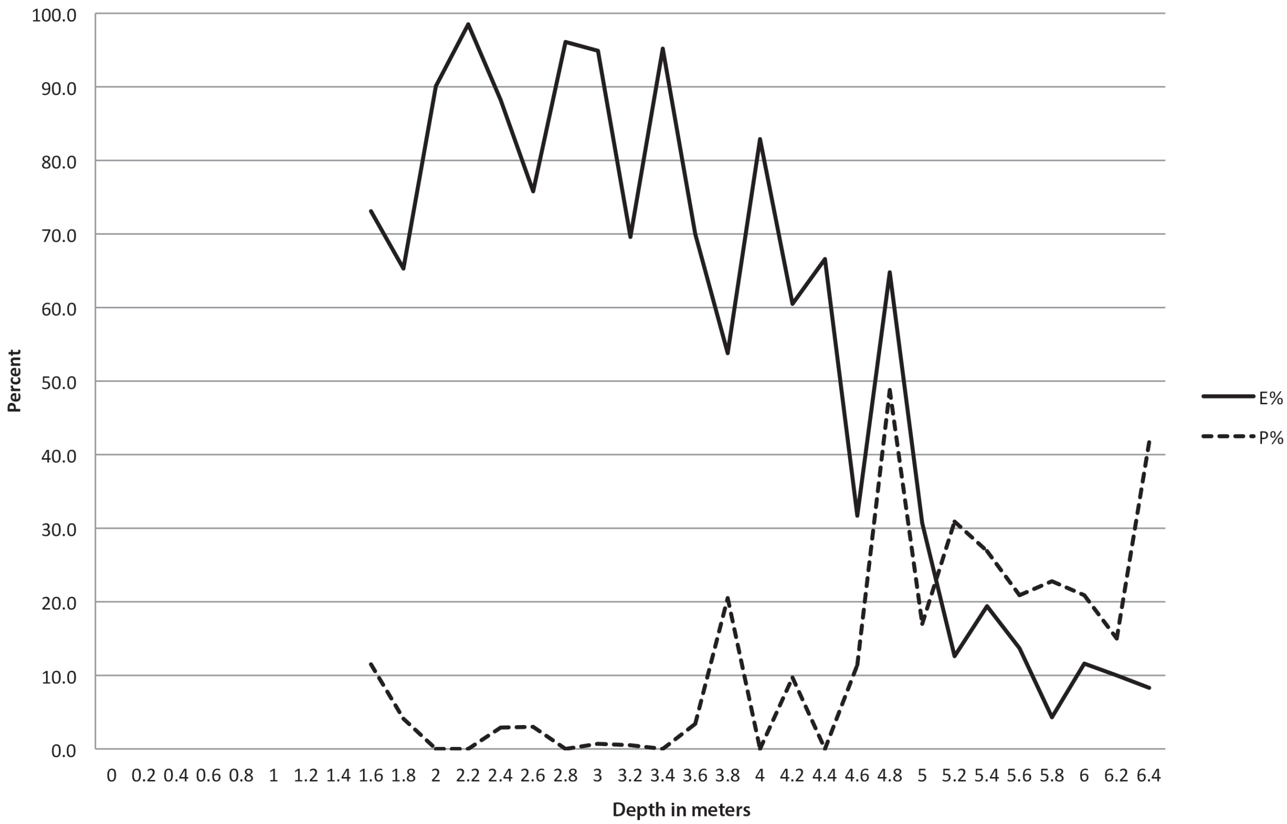


Figure 9.2. Relative frequencies of eleotrid (E) versus predatory (P) fish species through time at Tlacuachero (illustration by Thomas A. Wake).

values per taxon, and divided the resulting total by the total number of individuals for all identified taxa per occupational period.

Figure 9.3 illustrates an overall decline in the mean trophic level of the Tlacuachero fishery over time, with the steepest part of this reduction concentrated in the meter of archaeological deposit overlying the floors. The mean trophic level data correspond well with the numerical data in terms of the fishery shifting from a focus on carnivorous fish to a focus on smaller, lower-trophic-level species, including Pacific fat sleepers, cichlids, smelt, anchovies, and sardines.

Size Reduction of Corvina Through Time

During the earlier period of occupation, below the floors, we found evidence that the Tlacuachero fishery was more strongly focused on high-trophic-level carnivorous fish species (Figure 9.2), such as corvina (*Cynoscion* spp.). There is also an interesting pattern in the fish data from within this earlier period. We identified and analyzed 16 otoliths (saggitae) from the queen corvina, *Cynoscion albus*, all recovered from *beneath* the floors. The mean length of these otoliths declines (two-tailed t, $p = .0584$, $r^2 = 0.2326$) from approximately 22.6 mm at level 60 to 18.3 mm at level 42 (Figure 9.4). Based on research conducted by Mug-Villanueva et al. (1994), this translates to a reduction in mean total length of individual fish by 10 to 12 cm.

Kennett et al. (2011:255) provide a date range for the excavated strata below the floors of roughly 5000 cal B.P. to 4850 cal B.P. (see also Chapter 2, this volume). Based on the radiocarbon and otolith data, it appears that the 10- to 12-cm size reduction occurred over a mere 200 years at most. Our sample size is small, but we conjecture that a heavy fishing focus on the *Cynoscion* resource may be responsible for this size reduction. *Cynoscion* are a preferred fish today and likely were in the past due to their large size and good-quality meat—a result of their predatory habits and high trophic level.

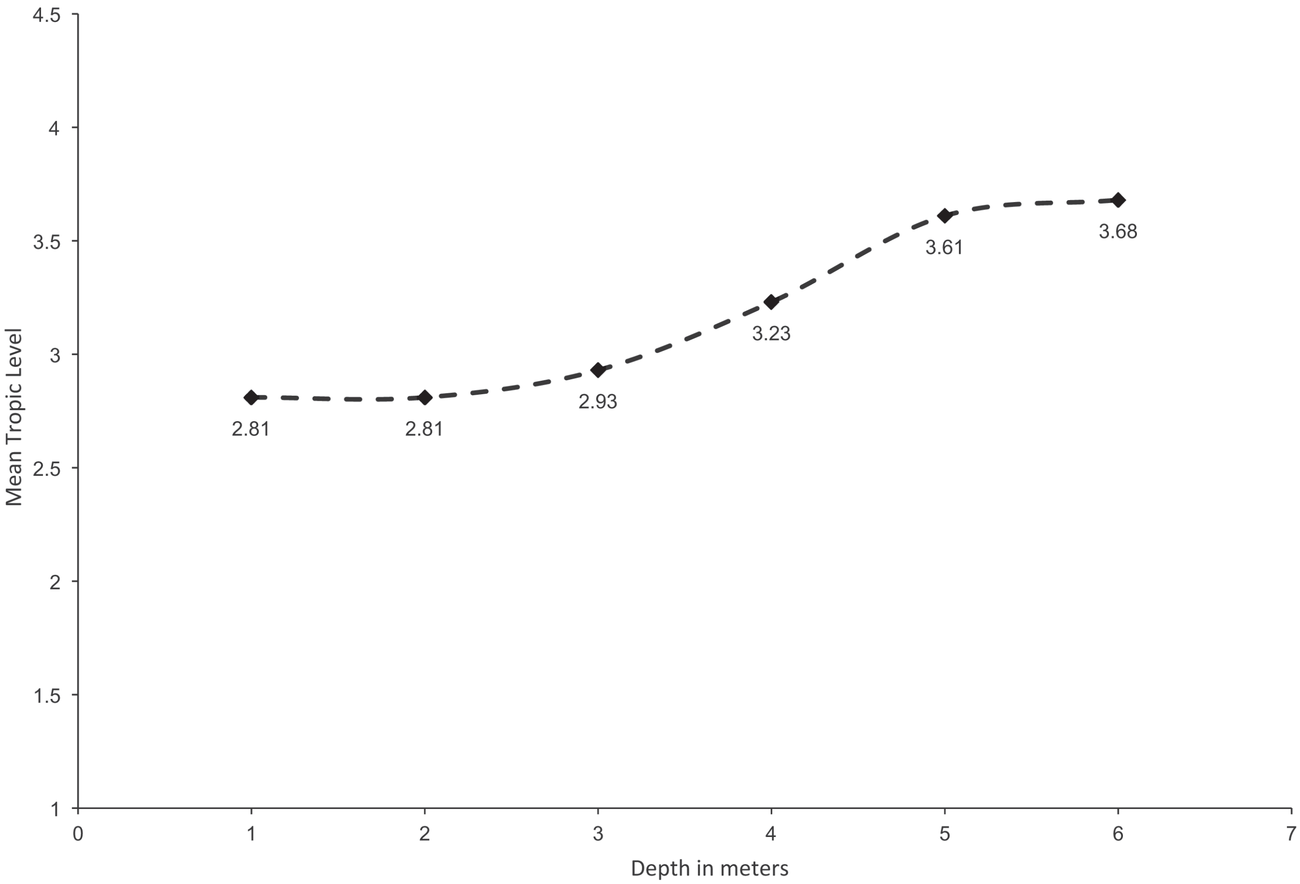


Figure 9.3. Mean fishery trophic level through time at Tlacuachero (illustration by Thomas A. Wake).

Large and Small Fish: Vertebrae Diameters by Species Through Time

The 2009 excavations at Tlacuachero are the first to probe the lower levels of the site since Voorhies's first test pit in 1973. Previous work at the site, using data collected in 1973, had demonstrated significant differences in the contents of the lower and upper bedded shell deposits in terms of: (1) seasonality as determined from isotope studies of clamshells; (2) vegetation as documented by phytoliths; (3) frequency of chipped stone fragments; and, less securely, (4) frequency of ground stone tools (Voorhies 2004). In addition, during the 2009 excavations Voorhies began to suspect that there were differences in the fish bone recovered from the upper and lower bedded shell deposits. Voorhies's casual field observations suggested that vertebrae from large fish, which were present in the lower deposits, were absent in the upper deposits, whereas vertebrae from small fish were present throughout the stratigraphic column. Since the large and small vertebrae seemed to be from different kinds of fish, the field observations hinted at changes in fishing practices during the time of site formation. Therefore we undertook various analyses to see if the suspected differences could be verified.

Methods. To investigate possible changes in fish size and fish taxa, we compared fish bones from Unit S2W1 with those from Unit N1W1—that is, from the shell deposits above and below the levels of the floors, respectively. In each case, the bones came from both the unit (screened and unscreened) and from the fine-screened column samples, which were combined for each excavation level. The matrix volumes from the two units are significantly different, with the volume of excavated material from S2W1 being very much greater than that from N1W1. We have not found it necessary to correct for volumetric differences in the presentation of fish size

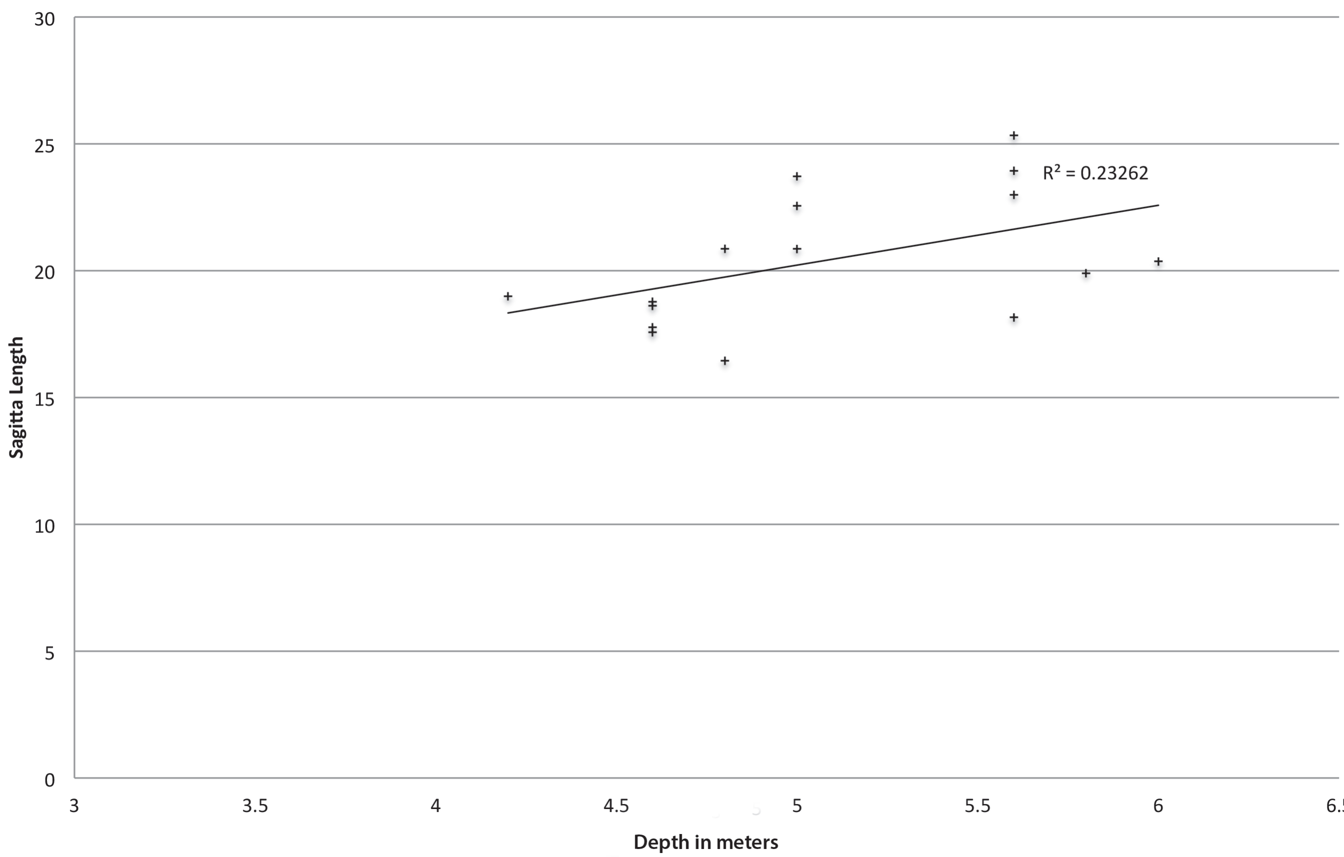


Figure 9.4. *Cynoscion albus* sagitta (otolith) length through time at Tlacuachero (illustration by Thomas A. Wake).

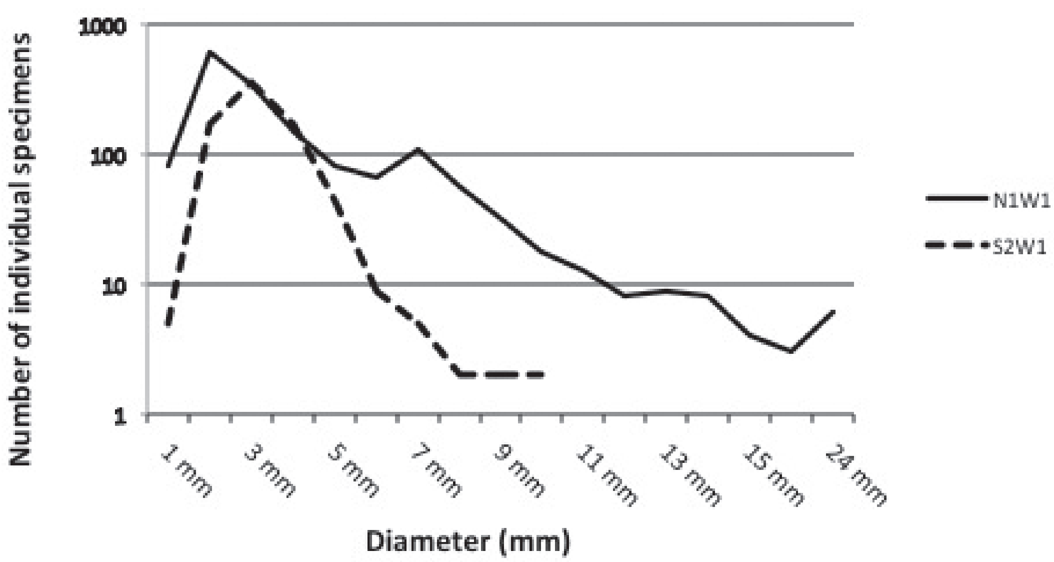


Figure 9.5. Plot of number of measured vertebrae from Late Archaic period deposits per size class for excavation units S2W1 and N1W1 at Tlacuachero. Unit S2W1 (dashed line) penetrated the upper, bedded shell deposits whereas Unit N1W1 (solid line) penetrated the lower bedded shell deposits (illustration by Barbara Voorhies).

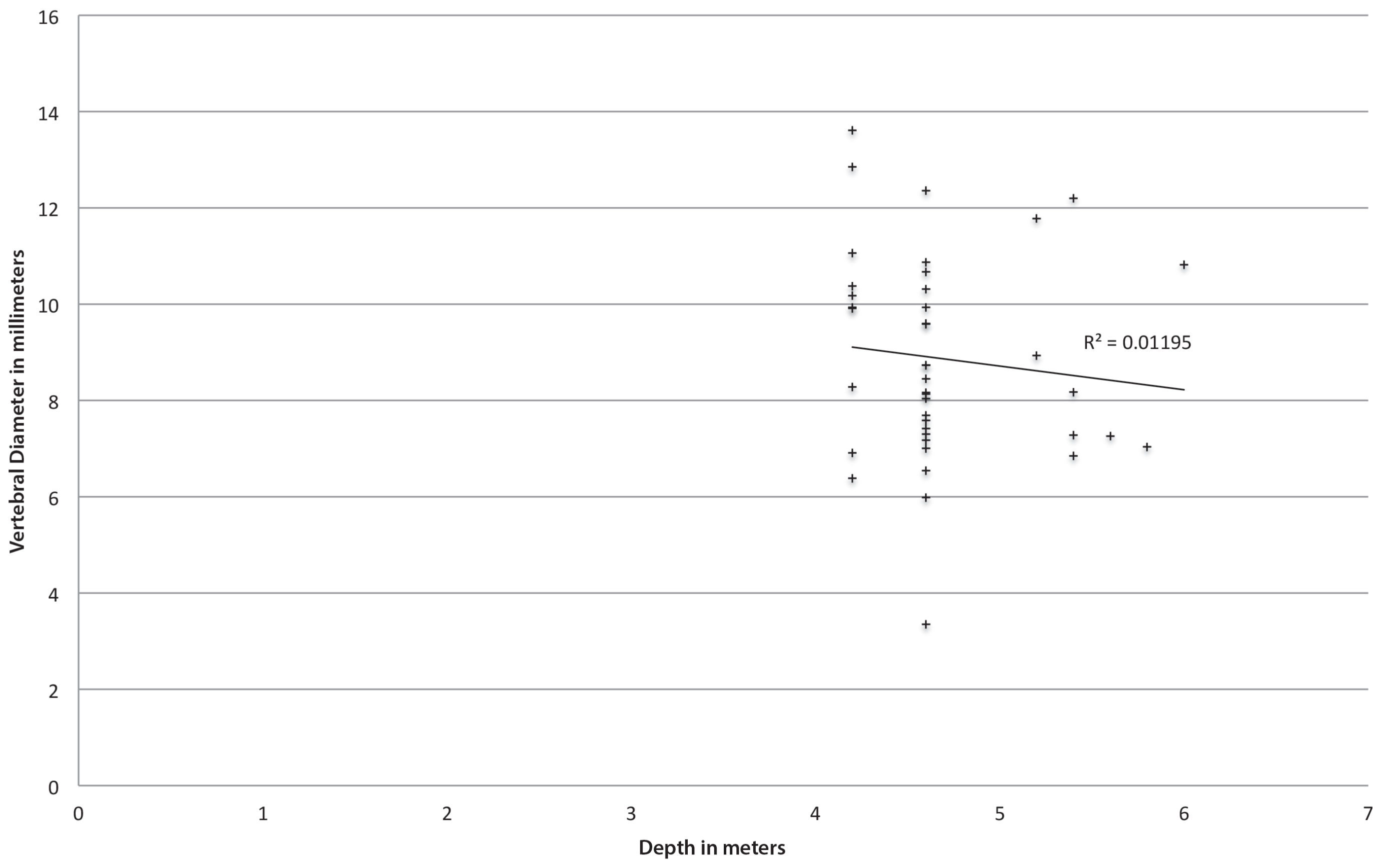


Figure 9.6. Corvina (*Cynoscion* sp.) average vertebral diameter through time (illustration by Thomas A. Wake).

and fish taxa, but the reader needs to keep in mind that to compare relative frequency of fish bones, it is necessary to correct for differences in volume excavated.

Size of Fish over Time. One thousand five hundred and sixty vertebrae from Archaic period contexts were measured to investigate the size of captured fish over time. We studied 540 bones from S2W1 and 1,020 bones from N1W1. The results of our analysis of sizes of fish bones are presented in Figure 9.5, which compares the number of vertebrae from each excavation unit in size increments of 1 mm. Each size class contains measurements that are smaller than the corresponding number plotted on the graph but larger than the preceding size class number. For example, the column labeled 4 mm contains all measurements from 3.0 mm to 3.99 mm.

The total range of diameters of measured fish vertebrae falls between 1 mm and 24 mm. The range of diameters of analyzed vertebrae from S2W1 falls between 1 mm and 13 mm, whereas the diameters of analyzed vertebrae from N1W1 are between 0.5 mm and 24 mm. The graph shows clearly that small vertebrae are present in both of the analyzed assemblages but that the lower deposits (Unit N1W1) have significantly more large vertebrae compared with the upper deposits. In fact, there is a striking drop-off of number of vertebrae in the S2W1 deposits with diameters greater than 10 mm, and there were no vertebrae in this sample with diameters above 13 mm. In both samples the greatest number of fish bones falls between 2 mm and 4 mm. These data support Voorhies's field observations that the vertebrae from larger fish are absent from the upper deposits that we excavated.

To examine size trends in individual genera or species through time, Wake charted vertebral diameter per species for each excavation level in the sequence. The results are presented below in the sections on large and small fish.

We note also that the types of fish represented by the large and small vertebrae are different, as was previously found by Cooke et al. (2004) in the archaeofauna

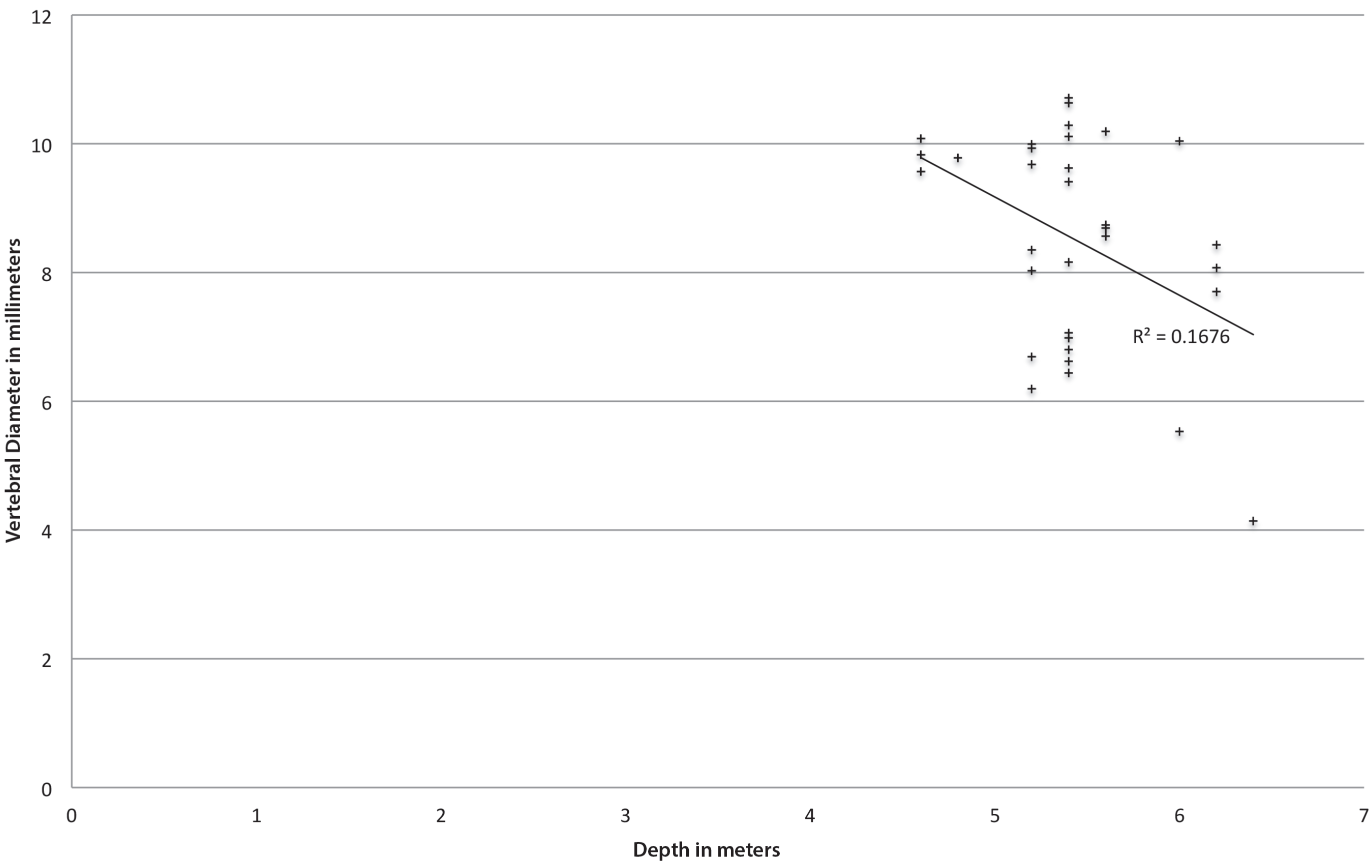


Figure 9.7. Mullet (*Mugil* sp.) average vertebral diameter through time at Tlacuachero (illustration by Thomas A. Wake).

at the Zapotillo shellmound. Small vertebrae are overwhelmingly from the Pacific fat sleeper and a few cichlids, whereas the large vertebrae are from gar, weakfish, snapper, mullet, and snook.

Large Fish. The fish species present in the Tlacuachero bone assemblage discussed here can be broken into two broad size classes—large and small. The large fish tend to be carnivorous, with the notable exception of mullets (*Mugil* sp.), filter feeders that can get quite large (Fischer et al. 1995a). The small fish tend to be lower-trophic-level detritivores and generalists, such as the Pacific fat sleeper and cichlids.

The large fish present in the Tlacuachero assemblage discussed here can be further broken into two categories: those genera that disappear relatively early in the stratigraphic sequence (*Cynoscion* and *Mugil*) and those that continue to appear, although in much lower relative frequencies, throughout the sequence (*Atractosteus*, *Centropomus*, and *Lutjanus*).

The two genera of large fish that virtually disappear early in the stratigraphic sequence, *Cynoscion* (Figure 9.6) and *Mugil* (Figure 9.7), both show what appears to be a trend of increasing average vertebral diameters before they disappear from the sequence. However, given either the small sample sizes or the weak correlation coefficients of these trend lines, no statistically valid pattern of size change is present in the sampled vertebrae.

The larger high-trophic-level fish genera that occur throughout the sequence (*Atractosteus*, *Centropomus*, and *Lutjanus*) all illustrate little change in vertebral diameters, suggesting minimal longer-term effects of human predation on local stocks. Snook (Figure 9.8), gar (Figure 9.9), and snapper (Figure 9.10) show little change through time, as indicated by the relatively flat regression lines and low correlation coefficients.

Small Fish. In terms of small fish, a large sample of measured vertebrae of Pacific fat sleeper shows no statistically valid trends in overall size through time, as

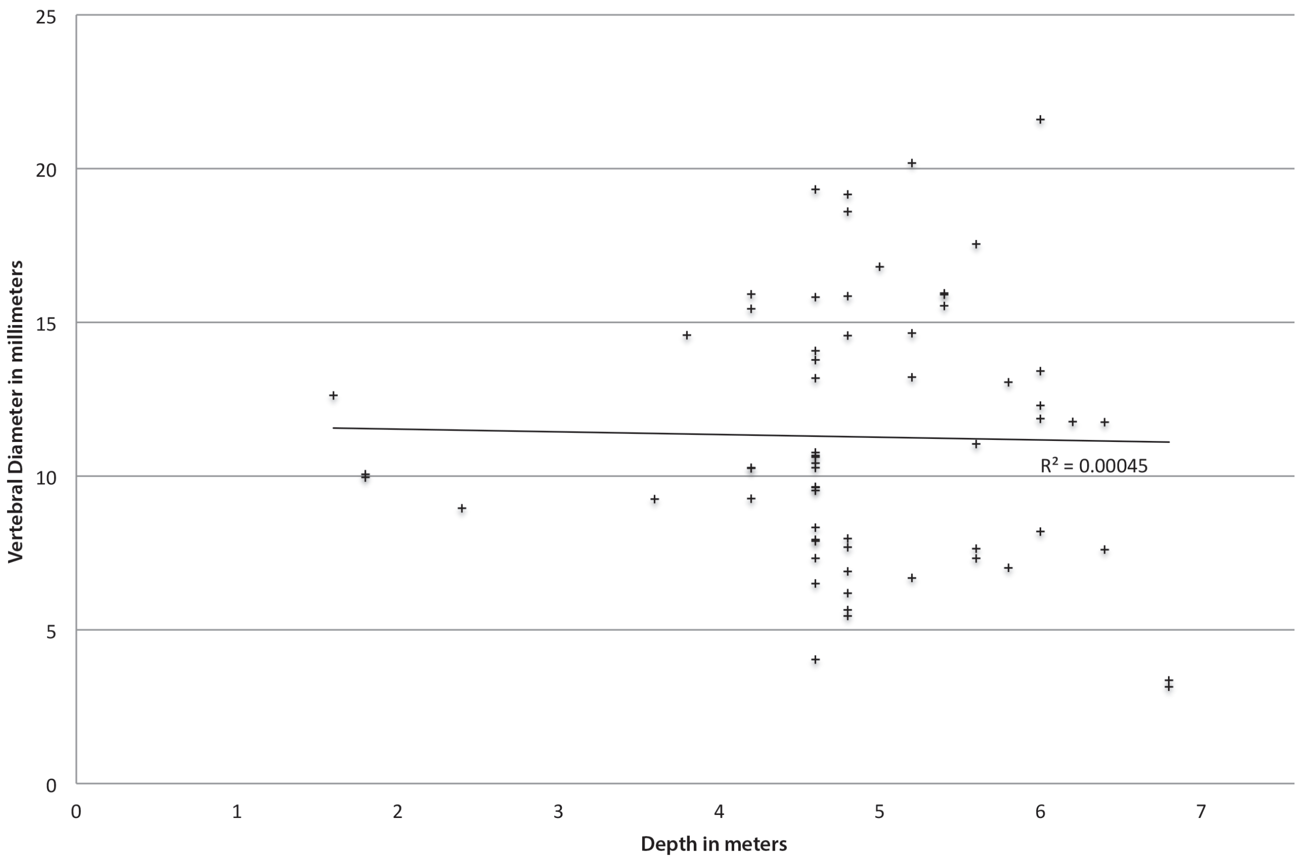


Figure 9.8. Snook (*Centropomus* sp.) average vertebral diameter through time at Tlacuachero (illustration by Thomas A. Wake).

indicated by the relatively flat regression line and low correlation coefficient (Figure 9.11). Too few cichlid vertebrae were measured to provide information concerning any trends in their size.

Conclusions

Analysis of the 2009 Tlacuachero vertebrate archaeofauna focuses on the most common bones in the collection: fish. All the identified fish taxa are representative of the broader estuarine systems found along southern Mexico's Pacific coast (Amezcua-Linares 1996; Díaz-Ruiz et al. 2004; Miller et al. 2005; Wake 2003). The preferred microhabitats of these fish indicate that various zones of the estuary were exploited for their piscine resources, ranging from freshwater swamps and upper estuary zones to tidal river channels and mangroves and into more open coastal lagoons. While Cooke et al. (2004) argue that up to 200 fish species are available in the overall coastal estuarine ecosystem, only a fraction of them (approximately 30) are represented in the Tlacuachero collection. Based on relative species frequencies, it appears that fishing efforts shifted from a broader mixed lagoon–mangrove–swamp exploitation strategy early in the sequence to one more focused on lower-salinity waters found in upper estuaries and swamps, where *Dormitator*, gar, and cichlids dominate. This shift is indicated by the reduction in relative frequency of larger carnivorous fish species more common in the older layers of the site that are found more commonly in lower estuary zones and the increase in smaller, lower-trophic-level species more commonly found in upper estuary zones in the younger layers.

The other vertebrate species identified in the assemblage discussed here are all associated with estuary systems in one way or another. The amphibians and reptiles are associated with freshwater swamps and rivers, as well as mangroves and lower estuaries in the case of the

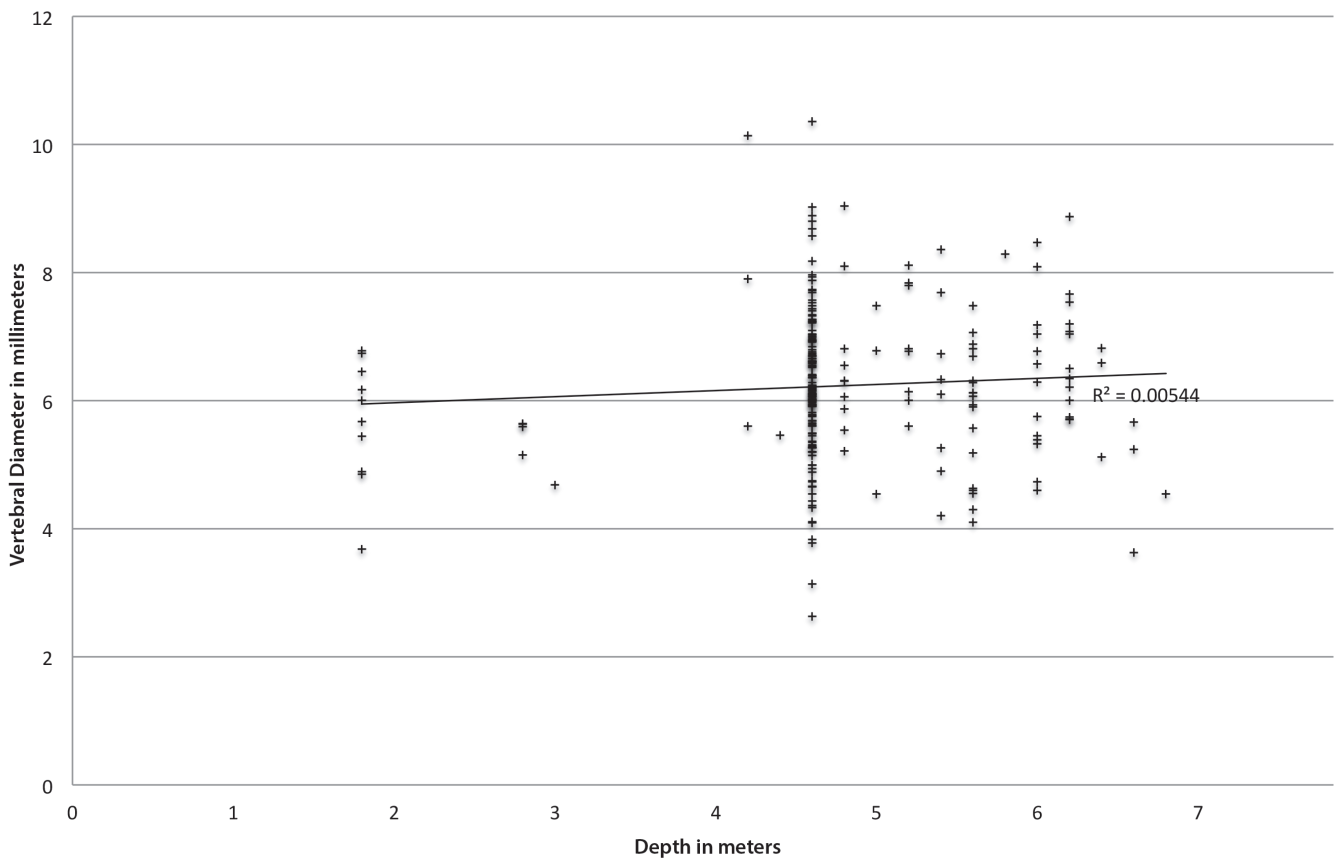


Figure 9.9. Tropical gar (*Atractosteus tropicus*) average vertebral diameter through time at Tlacuachero (illustration by Thomas A. Wake).

crocodiles. The green and black iguanas can be found in the foliage over or near the waterways. The habitats of the identified bird species are primarily marine (cormorants and pelicans) or swamp- and inland waterway–associated (ducks, herons, and bitterns). The identified mammals are associated in general with the edges of estuarine systems. While few in number, the peccary and deer bones represent the most common local large mammals and an important, if episodic, source of meat.

The primary source of vertebrate protein represented by the vertebrate faunal remains at Tlacuachero was fish. The earlier inhabitants of Tlacuachero may have focused so strongly on high-trophic-level (large carnivorous) fish that they gradually affected the quality of their fishery resource. Figures 9.2 and 9.3 clearly illustrate a shift in relative frequency from larger, high-trophic-level fish below and at the level of the floors to smaller, lower-trophic-level fish in the upper Archaic occupation.

The most efficient way to extract fish from the mixed estuarine system around Tlacuachero was through the use of static techniques such as weirs or set nets (e.g., Cooke and Tapia 1994a, 1994b). However, a few large, circular turtle-plastron fishhooks were recovered from Cerro de las Conchas (Voorhies et al. 2002), and two similar fishhooks were found in the lower bedded shell deposits at Tlacuachero. Accordingly, angling was one fishing technique used for procuring the large, carnivorous fish during the Middle Archaic and early Late Archaic time periods.

The reduction in size of *Cynoscion albus* by approximately 10 cm in less than 200 years suggests heavy harvesting pressure on this species. The subsequent disappearance of the species from the assemblage above the floors may indicate that white corvina were reduced to prereproductive sizes and ages and their specific fishery collapsed.

One alternative that could explain the changes in fish representation at Tlacuachero is environmental change.

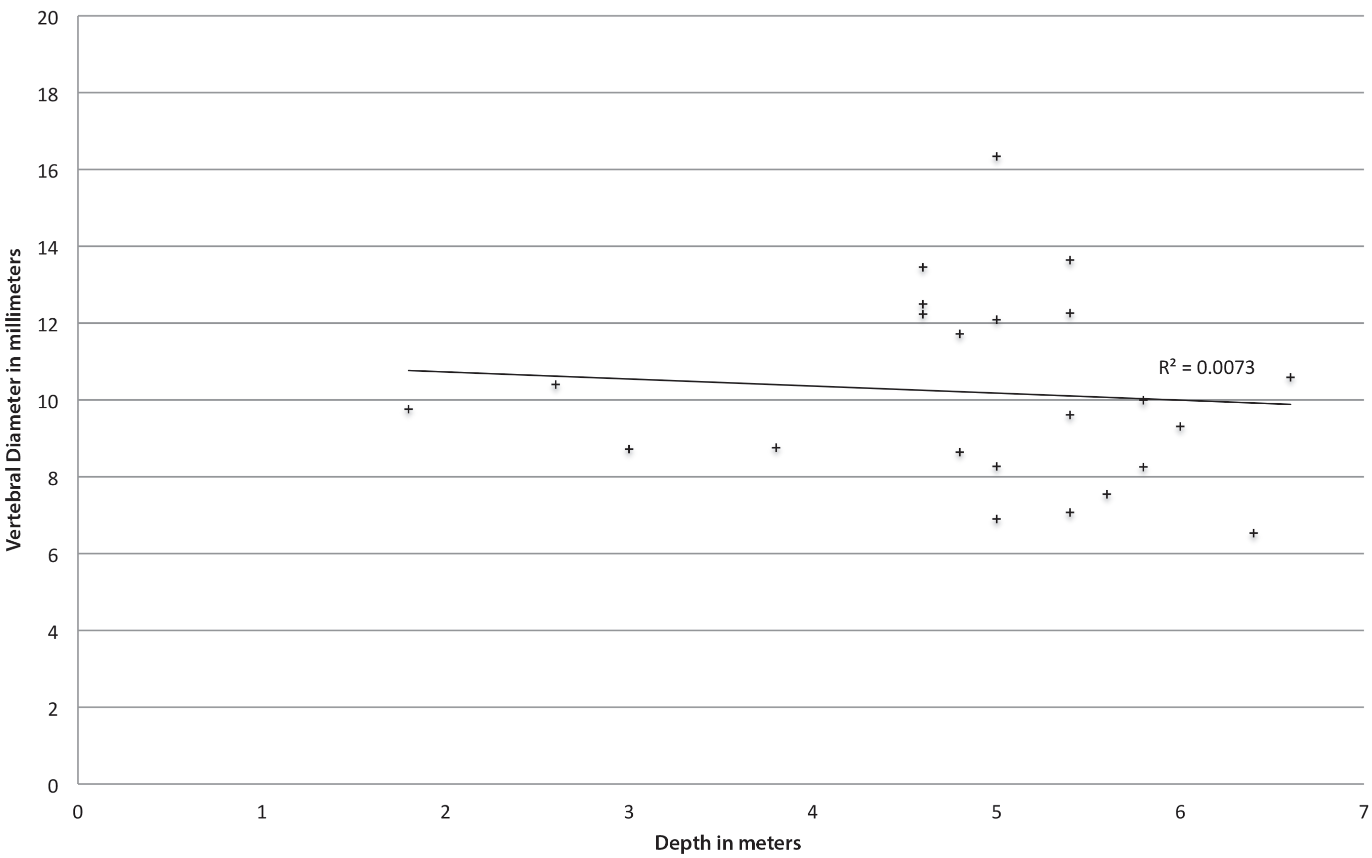


Figure 9.10. Snapper (*Lutjanus* sp.) average vertebral diameter through time at Tlacuachero (illustration by Thomas A. Wake).

Estuaries are dynamic hydraulic environments that can be affected by seasonal flooding, hurricanes, and occasional tectonic events, such as earthquakes that in 1902 essentially destroyed the Guatemalan Pacific port of Ocos (Coe 1961) and debris flows from the subsequent eruption of the Santa Maria volcano, which reconfigured the coastline (Anderson 1908). It is possible also that a shift from a more open, lagoonal environment to an upper estuary, swampier zone, due to coastal progradation, could explain the reduction in numbers of high-trophic-level fish species. However, the dominance of a single mollusk species (*Polymesoda radiata*) throughout the entire sequence indicates a general lack of strong environmental change.

The most logical explanation for the patterns seen in the Tlacuachero fish remains above and below the surfaces is a shift in fishing methods. The disappearance of some and the reduction in relative abundance of other high-trophic-level predatory fish species indicate an increased focus on methods that yield larger amounts of lower-trophic-level fish, such as the use of more nets, smaller net gauges, and a gradual shift away from angling for larger predatory fish.

Sustainability?

The fact that the fish species most common in the Tlacuachero deposit show little to no change in overall size throughout the sequence has important implications. This pattern suggests that the fishing strategy employed by the inhabitants of Tlacuachero was sustainable. Their practice of net and/or weir fishing captured large numbers of small fish over several hundred years. The high-trophic-level fish present throughout the sequence are low in relative abundance when compared to the more numerous lower-trophic-level species such as *D. latifrons* and the Cichlidae. This is what one would expect in a natural environment where predators are outnumbered by their prey. The lack of change in the sizes of higher-trophic-level species such

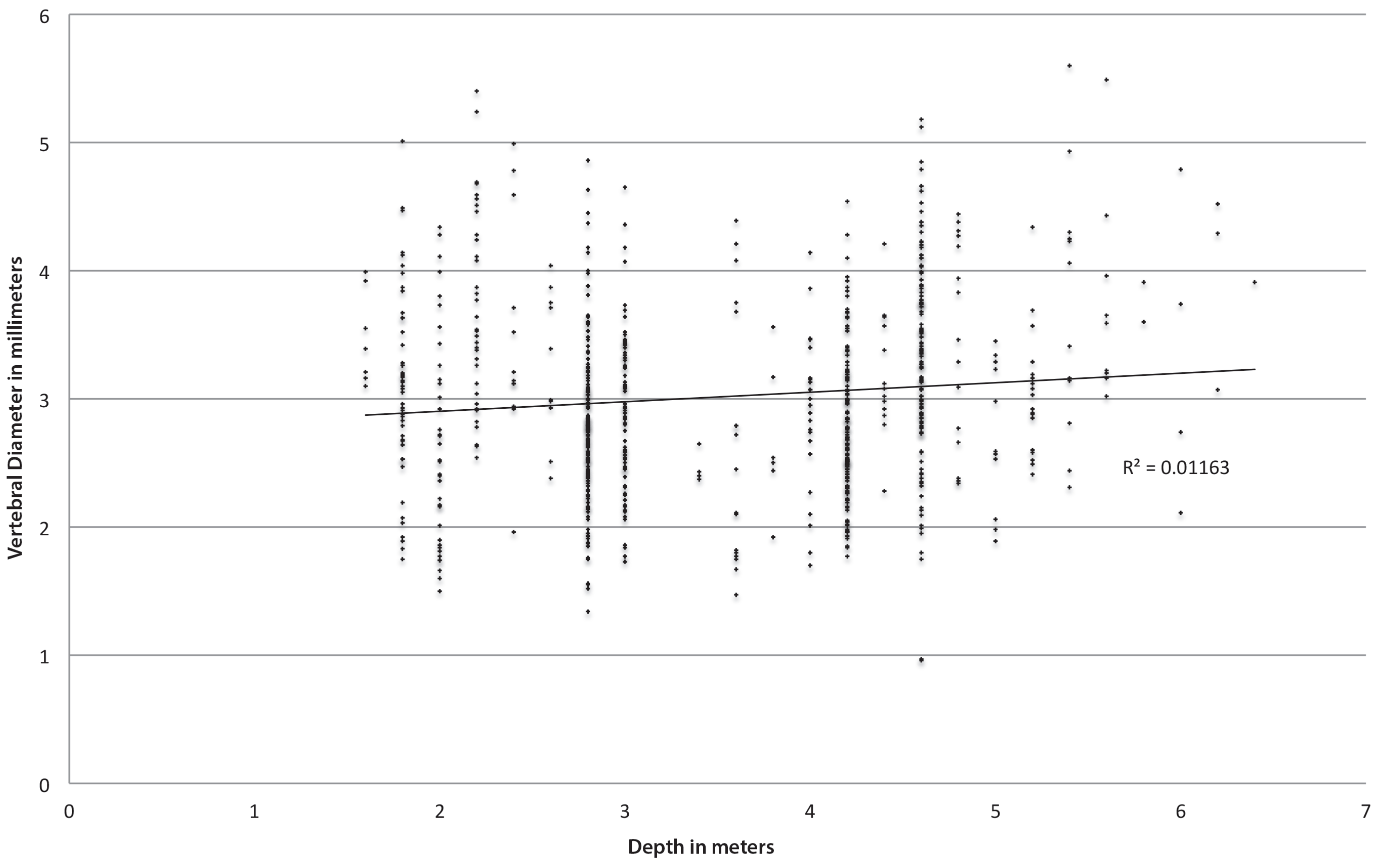


Figure 9.11. Pacific fat sleeper (*Dormitator latifrons*) average vertebral diameter through time at Tlacuachero (illustration by Thomas A. Wake).

as snook, gar, and snapper through time at Tlacuachero suggests a level of stability with respect to the possible effects of harvesting pressure.

The past occupants of Tlacuachero clearly made the site and its local environment a primary focus in their proposed seasonal round (Voorhies 2004:414–417). The protein resources provided by the rich estuarine system were heavily exploited over hundreds of years. The predictability of these resources, especially the shellfish and probably the fish as well, made Tlacuachero a linchpin in terms of foodways sustainability and survival of the Chantuto people who formed the site.

The size of the shellmound itself is testimony to the amount of resource-extraction effort undertaken at the site. It could be argued that the size and depth of the shell deposits at Tlacuachero are indicative of the relative stability and predictability of the estuary system in terms of supporting a local human population for several millennia. However, the vertebrate remains within the shellmound, especially the fish, tell a somewhat different story—a story about the fragility of individual species and the potential for fishery sustainability in coastal estuarine ecosystems.

Estuarine systems such as those found around Tlacuachero are resilient and appear stable. The data concerning high-trophic-level species that we present illustrates that when resource extraction efforts are focused on a few species, such as *Cynoscion albus*, negative results can occur. The presumably simple yet focused resource-extraction techniques used by the preceramic, preindustrial Chantuto inhabitants of Tlacuachero resulted in the depression of the high-trophic-level fishery near the site. Larger predatory fish virtually disappear from the record in the deposit above (younger than) the series of floors. The size of individual weakfish decreases by over 10 cm in less than 200 years. The result is a lower-quality fishery consisting of smaller, less preferred fish species.

Modern industrial fisheries have had a profound negative effect on fisheries and ecological systems in both

the nearshore and offshore environments and are now heavily managed (Jackson et al. 2001; Lotze et al. 2006). At Tlacuachero, a preceramic, preindustrial society living "close to the land" negatively affected one fish species, presumably by focused overfishing. Based on the data presented here, the representatives of this lower-quality fishery do not appear to have been affected, in relative size or numbers, by the fishing techniques employed. The results presented here serve as a yet another warning concerning the potential fragility of coastal ecosystems and fisheries focusing on high-trophic-level species in the face of growing populations and rising sea levels. Perhaps more importantly, these findings suggest that some degree of sustainability was achieved during the Late Archaic by focusing bulk harvesting techniques on specific portions of the estuarine system that provided stable populations of lower-quality fish.

Acknowledgments. Identification and analysis of the Tlacuachero vertebrate archaeofauna was supported in part by a grant to Wake from the National Science Foundation (BCS-1026834).

Notes

1 Comparisons of estimated meat biomass for clams versus vertebrate fauna in Late Archaic period deposits at Tlacuachero and Campón (Voorhies 2004:Figure 3.1) produce the astonishing fact that 99 percent of meat represented by surviving remains comes from the small marsh clam, *Polymesoda radiata*, with the remainder from all other fauna.

References Cited

Alvarez del Toro, Miguel

1977 *Los mamiferos de Chiapas*. Universidad Autónoma de Chiapas, Tuxtla Gutiérrez, Chiapas.

1983 *Los reptiles de Chiapas*. 3rd ed. Publicación del Instituto de Historia Natural, Tuxtla Gutiérrez, Chiapas.

Amezcua-Linares, Felipe

1996 *Peces demersales de la plataforma continental del Pacífico Central de México*. Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Mexico City.

Anderson, Tempest

1908 The Volcanoes of Guatemala. *Geographical Journal* 31:473–485.

Anikouchine, Natalie

1990 An Analysis of Vertebrate Faunal Remains from Chiapas, Mexico. Unpublished master's thesis, Department of Anthropology, University of California, Santa Barbara.

Bussing, William A.

1998 *Peces de las aguas continentales de Costa Rica*. 2nd ed. *International Journal of Tropical Biology and Conservation* 46 (Supplement 2). Editorial de la Universidad de Costa Rica, San José.

Campbell, Jonathan A., and Jay P. Vannini

1989 Distribution of Amphibians and Reptiles in Guatemala and Belize. *Proceedings of the Western Foundation of Vertebrate Zoology* 4:1–21.

Castro Rivera, Rigoberto, Gisela Aguilar Benítez, and José de la Paz Hernández G.

2005 Conversión alimenticia en engordas puras y mixtas de Popoyote (*Dormitator latifrons* Richardson) en tanques de cemento. *Revista AguaTIC* 23:45–52.

Cheung, William W. L., Tony J. Pitcher, and Daniel Pauly

2005 A Fuzzy Logic Expert System to Estimate Intrinsic Extinction Vulnerabilities of Marine Fishes to Fishing. *Biological Conservation* 124:97–111.

Clark, John E.

1994 The Development of Early Formative Rank Societies in the Soconusco, Chiapas, Mexico. Unpublished Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.

Coe, Michael D.

1961 *La Victoria: An Early Site on the Pacific Coast of Guatemala*. Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. 53. Peabody Museum, Cambridge, Massachusetts.

Cooke, Richard G.

1992 Prehistoric Nearshore and Littoral Fishing in the Eastern Tropical Pacific: An Ichthyological Evaluation. *Journal of World Prehistory* 6:1–49.

Cooke, Richard G., Máximo Jiménez, Conrado Tapia, and Barbara Voorhies

2004 A Closer Look at the Late Archaic Fish Fauna. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 207–299. University Press of Florida, Gainesville.

Cooke, Richard G., and Gonzalo Tapia R.

1994a Marine and Freshwater Fish Amphidromy in a Small Tropical River on the Pacific Coast of Panama: A Preliminary Evaluation Based on Gill-Net and Hook and Line Captures. In *Fish Exploitation in the*

Past, *Proceedings of the Seventh Meeting of the ICAZ Fish Remains Working Group*, edited by Wim Van Neer. *Annales du Musee Royal de l'Afrique Centrale, Sciences Zoologiques* 274:99–106.

1994b Stationary Intertidal Fish Traps in Estuarine Inlets on the Pacific Coast of Panama: Descriptions, Evaluations of Early Dry Season Catches and Relevance to the Interpretation of Dietary Archaeofaunas. *Offa* 51:287–298.

Díaz-Camacho, Sylvia P., Maria del Carmen de la Cruz-Otero, Magda L. Zazueta-Ramos, Angel Bojórquez-Contreras, Josefina Sicairos-Félix, Samuel Campista-León, Roberto Guzmán-Loreto, Francisco Delgado-Vargas, Virginia León-Règagnon, Yukifumi Nawa

2008 Identification of Estuarine Fish *Dormitator latifrons* as an Intermediate Host and *Eleotris picta* as a Paratenic Host for *Gnathostoma binucleatum* in Sinaloa, Mexico. *Parasitological Research* 103:1421–1425.

Díaz-Ruiz, Sylvia, Enrique Cano-Quiroga, Arturo Aguirre-León, and Raúl Ortega-Bernal

2004 Diversity, Abundance and Icthyofaunistic Groups of the Chantuto Panzacola Lagoon-Estuarine System, Chiapas, México. *Revista de Biología Tropical* 52:187–199.

Emmons, Louise H., and François Feer

1990 *Neotropical Rainforest Mammals: A Field Guide*. University of Chicago Press, Chicago.

Fischer, W., F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter, and V. H. Niem

1995a *Guia FAO para la identificación de especies para los fines de la pesca: Pacífico Centro-Oriental: 2. Vertebrados—Parte I*. Organización de las Naciones Unidas para la Agricultura y la Alimentación, Rome.

Fischer, W., F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter, and V. H. Niem

1995b *Guia FAO para la identificación de especies para los fines de la pesca: Pacífico Centro-Oriental: 3. Vertebrados—Parte II*. Organización de las Naciones Unidas para la Agricultura y la Alimentación, Rome.

Froese, R., and D. Pauly (editors)

2012 FishBase. Electronic document, www.fishbase.org, accessed September 20, 2012.

Gobalet, Kenneth W.

2005 Comment on "Size Matters: 3-mm Sieves Do Not Increase Richness in a Fishbone Assemblage from Arrawarra I, an Aboriginal Australian Shell Midden on the Mid-North Coast of New South Wales, Australia" by Vale and Gargett. *Journal of Archaeological Science* 32:643–645.

Grayson, Donald K.

1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press, New York.

Howell, Steve N. G., and Sophie Webb

1995 *A Guide to the Birds of Mexico and Northern Central America*. Oxford University Press, Oxford.

Hudson, Jean, Barbara Voorhies, and Philip L. Walker

1989 Changing Patterns of Faunal Exploitation. In *Ancient Trade and Tribute: Economies of the Soconusco Region of Mesoamerica*, edited by Barbara Voorhies, pp. 133–154. University of Utah Press, Provo.

Iverson, Jonathan B.

1992 *A Revised Checklist with Distribution Maps of the Turtles of the World*. Green Nature Books, Homestead, Florida.

Jackson, Jeremy B. C., Michael X. Kirby, Wolfgang H. Berger, Karen A. Bjorndal, Louis W. Botsford, Bruce J. Bourque, Roger H. Bradbury, Richard G. Cooke, Jon M. Erlandson, James A. Estes, Terence P. Hughes, Susan M. Kidwell, Carina B. Lange, Hunter S. Lenihan, John M. Pandolfi, Charles H. Peterson, Robert S. Steneck, Mia J. Tegner, and Robert R. Warner

2001 Historical Overfishing and the Recent Collapse of Coastal Ecosystems. *Science* 293(5530):629–637.

Jantzen, Daniel H.

1983 *Costa Rican Natural History*. University of Chicago Press, Chicago.

Kailola, P. J., and W. A. Bussing

1995 Bagres Marinos. In *Guia FAO para la identificación de especies para los fines de la pesca: Pacífico Centro-Oriental: 3. Vertebrados—Parte II*, edited by W. Fischer, F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter, and V. H. Niem, pp. 860–886. Organización de las Naciones Unidas para la Agricultura y la Alimentación, Rome.

Kennedy, Alison B.

1982 Ecce Bufo: The Toad in Nature and in Olmec Iconography. *Current Anthropology* 23:273–290.

Kennett, Douglas J., Brendan J. Culleton, Barbara Voorhies, and John R. Southon

2011 Bayesian Analysis of High-Precision AMS ^{14}C Dates from a Prehistoric Mexican Shellmound. *Radiocarbon* 53:245–259.

Kennett, Douglas J., Barbara Voorhies, John G. Jones, Hector Neff, Dolores R. Piperno, Thomas A. Wake, Karry L. Blake, Brendan Culleton, Josué Augusto Gómez García, and Natalia Martínez Taqueña

2007 Informe técnico final del "Proyecto Arcaico-Formativo: Costa de Chiapas (Temporada 2005)." Submitted to the Instituto Nacional de Antropología e Historia, Mexico City. Manuscript on file, Archivo Ténico del Consejo de Arqueología, Mexico.

Lotze, Heike K., Hunter S. Lenihan, Bruce J. Bourque, Roger H. Bradbury, Richard G. Cooke, Matthew C. Kay, Susan M. Kidwell, Michael X. Kirby, Charles H. Peterson, and Jeremy B. C. Jackson

2006 Depletion, Degradation, and Recovery Potential of Estuaries and Coastal Seas. *Science* 312(5781):1806–1809.

Lyman, R. Lee

1994a Quantitative Units and Terminology in Zooarchaeology. *American Antiquity* 59(1):36–71.

1994b *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.

2008 *Quantitative Paleozoology*. Cambridge University Press, Cambridge.

Miller, Robert R., Wendell L. Minckley, and Steven M. Norris

2005 *Freshwater Fishes of Mexico*. University of Chicago Press, Chicago.

Mug-Villanueva, M., V. F. Gallucci, and Han-Lin Lai.

1994 Age Determination of Corvina Reina (*Cynoscion albus*) in the Gulf of Nicoya, Costa Rica, Based on Examination and Analysis of Hyaline Zones, Morphology and Microstructure of Otoliths. *Journal of Fish Biology* 45:177–191.

Page, Lawrence M., Héctor Espinoza-Pérez, Lloyd T. Finley, Carter R. Gilbert, Robert N. Lea, Nicholas E. Mandrak, Richard L. Mayden, and Joseph S. Nelson

2013 Common and Scientific Names of Fishes from the United States, Canada, and Mexico, 7th ed. Special Publication 34. American Fisheries Society Bethesda.

Pilo-Guzmán, T.

2003 Evaluación de los parásitos metazoarios que atacan a *Mugil curema*, *Dormitator latifrons*, *Ariopsis guatemalensis*, *Eleotris pictus*, *Cichlasoma trimaculatum*, *Gobiomorus maculatus*, *Centropomus robalito* y *Centropomus nigrescens*, especies de mayor consumo local, que se capturan en la laguna de Tres Palos, Guerrero, México. Unpublished master's thesis, Universidad Autónoma de Guerrero, Chilpancingo.

Reid, Fiona A.

1997 *A Field Guide to the Mammals of Central America and Southeast Mexico*. Oxford University Press, New York.

Reitz, Elizabeth J., Irvy R. Quitmyer, S. Hale, Sylvia J. Scudder, and Elizabeth Wing

1987 Application of Allometry to Zooarchaeology. *American Antiquity* 52:304–317.

Rojas-Molina, Norma, Sigifredo Pedraza-Sánchez, Balfre Torres-Bibiano, Hector Meza-Martínez, and Alejandro Escobar-Gutiérrez

1999 Gnathostomosis, an Emerging Foodborne Zoonotic Disease in Acapulco, Mexico. *Emerging Infectious Diseases* 5:264–266.

Rojo, Alfonso L.

1991 *Dictionary of Evolutionary Fish Osteology*. CRC Press, Boca Raton, Florida.

Vale, Deborah, and Robert Gargett

2002 Size Matters: 3-mm Sieves Do Not Increase Richness in a Fishbone Assemblage from Arrawarra I, an Aboriginal Australian Shell Midden on the Mid-North Coast of New South Wales, Australia. *Journal of Archaeological Science* 29:57–63.

Violante-González, Juan, Augustín Rojas-Herrera, and Maria Leopoldina Aguirre-Macedo

2008 Seasonal Patterns in Metazoan Parasite Community of the "Fat Sleeper" *Dormitator latifrons* from Tres Palos Lagoon, Guerrero, Mexico. *Review of Tropical Biology* 56:1419–1427.

Voorhies, Barbara

1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico*. Papers of the New World Archaeological Foundation, No. 41. Brigham Young University, Provo, Utah.

2004 *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

Voorhies, Barbara, and Douglas J. Kennett

2011 A Gender-Based Model for Changes in Subsistence and Mobility During the Terminal Late Archaic Period on the Coast of Chiapas, Mexico. In *Early Mesoamerican Social Transformations: Archaic and Formative Lifeways in the Soconusco Region*, edited by Richard G. Lesure, pp. 27–66. University of California Press, Berkeley.

Voorhies, Barbara, Douglas J. Kennett, John G. Jones, and Thomas A. Wake

2002 A Middle Holocene Archaeological Site on the West Coast of Mexico. *Latin American Antiquity* 13:179–200.

Wake, Thomas A.

2003 Prehistoric Fisheries of the Greater Soconusco Region, Pacific Coastal Chiapas and Adjacent Guatemala. In *Presencia de la arqueoloictiología en*

México, *Precedings of the 12th Meeting of the Fish Remains Working Group of the International Council for Archaeozoology*, edited by Alfonso F. Guzmán, Oscar J. Polaco, and Fernando J. Aguilar, pp. 161–166. Instituto Nacional de Antropología e Historia and Museo de Paleontología de Guadalajara "Federico A. Solórzano Barreto," Guadalajara.

2004 On the Paramount Importance of Adequate Comparative Collections and Recovery Techniques in the Identification and Interpretation of Vertebrate Archaeofaunas: A Reply to Vale and Gargett (2002). *ArchaeoFauna* 13:173–182.

Wake, Thomas A., Natalie Anikouchine, and Barbara Voorhies

2004 Food Procurement and Processing: Fish and Game Remains at the Shellmound Sites. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 158–206. University Press of Florida, Gainesville.

Zohar, Irit, and Miriam Belmaker

2005 Size Does Matter: Methodological Comments on Sieve Size and Species Richness in Fishbone Assemblages. *Journal of Archaeological Science* 32:635–641.

Chapter 10

Some Considerations of Site Formation Processes and Functions of Tlacuachero

Barbara Voorhies

In this penultimate chapter I review and evaluate some of the more salient findings of our recent fieldwork at the Tlacuachero shellmound. This fieldwork and the present monograph are concerned with site formation processes and function of core deposits that consist of unconsolidated bedded shells, which began to accumulate before approximately 5000 cal years B.P., the age of the earliest dated deposits currently available, and continued to accumulate for at least another 600 to 800 years. This time span falls within the Late Archaic period in the general Mesoamerican chronology, a time when many people across the Mesoamerican landscape were shifting their economies away from total dependency on wild resources toward a greater reliance on cultivated plants, ultimately leading to the adoption of agro-economies. Our data from Tlacuachero likewise indicate that various changes were under way in the lifeways of the people who formed that site.The principal focus of the book is a series of superimposed occupation surfaces in a limited area at the center of the island site and deeply entombed within the unconsolidated bedded shell deposits of Archaic age. Our most recent work at Tlacuachero investigated these floors with almost forensic detail. Prior archaeological work at the site had revealed that the level of the floors, located about midway between the top and bottom of the penetrated Archaic-age deposits, marks detectable changes in the archaeological record. These observed changes in turn imply significant shifts in various aspects of the lifeways of the Chantuto people. These include changes through time in:

- Seasonality of shellfish gathering (Kennett and Voorhies 1996; see also Voorhies 2004)
- Relative dependency on wild versus cultivated plant resources (Jones and Voorhies 2004)
- Types and sizes of procured fish (Cooke et al. 2004; Voorhies and Kennett 2011)
- Ground stone tool technology (Voorhies 2004)

Accordingly, these findings suggest that the time when the floors were in use was pivotal for the Chantuto people and that our focused investigation of the floors might provide further insight into these detected changes. Moreover, these findings led me to view the time of floor formation and use as a tipping point in the culture history of the Chantuto people. However, recent data regarding the time span of floor formation and use puts this situation into an entirely new perspective: the floors were formed and used over a very long period, from 450 to 650 years or even

longer (Chapter 2), which means that change may have occurred at a slower pace than the tipping-point analogy might imply.

Additional information about diachronic change detectable in the archaeological record of Tlacuachero is offered in two chapters of the present monograph. In Chapter 8 Elizabeth Paris presents data on stability and change in the technology of chipped stone tools over the course of the Late Archaic period at the site. This new study complements what was previously known about changes in ground stone technology at the site. In Chapter 9 Thomas A. Wake and Barbara Voorhies present new data concerning fishing practices over time. This new work complements and expands the previously obtained data about fishing at Tlacuachero. Thus these studies, taken together, indicate that during the time that Tlacuachero was forming in the Archaic period, the Chantuto people, the agents of site formation, were making archaeologically discernable adjustments in their behavior, presumably in response to changes in their biosocial environments. The final outcome of these kinds of adjustments throughout Mesoamerica eventually became so great in the material record that archaeologists designate a new cultural-temporal category, the Early Formative period, which follows the Archaic period in the general Mesoamerican chronology of prehistory.

As mentioned above, in this monograph the authors are most concerned with the enigmatic floors found within the Archaic age deposits. Chapter authors investigate the questions of when the floors were formed (Chapter 2), how they were formed (Chapter 5), and why they were formed (Chapters 4, 6, and 7). The question of how the floors were formed is a concern with site formation process, whereas the question of why they were formed is related to but not exactly the same as asking about their functions. I return to this important distinction in Chapter 11.

Accordingly, in this summary chapter I first recapitulate some high points of work reported in earlier chapters about the floors, with an emphasis on the what, when, where, and why questions about their formation and use. Then I turn to the high points of the two chapters focused on our most recent data about diachronic change, which should be considered together with earlier studies about other changes at the site (Voorhies 2004)

Forming the Tlacuachero Floors

At least three and conceivably more superimposed floors are positioned under the summit of the Tlacuachero island shellmound. I encountered one of these floors, now dubbed Floor 1, at 4.60 m below the summit in the first test pit I dug at the site in 1973. Subsequent investigations at Tlacuachero and neighboring shellmounds (Voorhies 1976, 2004) have failed to locate similar floors, but we know now that at least two additional floors are positioned below Floor 1. None of these floors has been exposed in its entirety and their complete shapes are unknown, but we do know that the entire horizontal area where floors occur is approximately 900 m^2 and that the floors are not spatially congruent (Chapter 4). In this section I summarize what we know about how and when the floors were formed.

Floor Material

The geochemical study of samples from floors 1 and 2 was undertaken to investigate if there was evidence of organic residues on the surfaces of the floors, as indeed proved to be the case (discussed in Chapter 5 and further below). However, this study also produced the surprising result that the matrix of the floors was not clay as I had previously assumed but rather carbonate hydroxylapatite. Here I will discuss the implications for our understanding of the occupational history of Tlacuachero of the unanticipated finding that the floor matrices are composed of carbonate hydroxylapatite.

The original assessment that clay constituted the fine-fraction of the floor material was based upon its fine particle size, reddish brown color, and plasticity when wet, characteristics that strongly resemble those of clay. In addition, clay was widely used in prehistoric times as building material, including its common use to construct floors. The previous untested assumption that clay was the building material used to create smooth floors at the Tlacuachero shellmound led me to conjecture that there had to have been a significant amount of labor expended to build the uppermost floor (Voorhies 2004:52–54). I reasoned that the clay had been mined, most likely from the mouth of the river nearest to the site; transported to the shellmound; carried to the site summit; mixed with broken and unbroken shell available on the shellmound; and finally laid out to form a floor. Another erroneous assumption

was that Floor 1 extended over the entire area where deep probes had detected floor material, an inference we now know is incorrect. This large, approximately 900 m^2 area, is actually the area where floor material is demonstrably present, but it is not necessarily only from Floor 1, since we know now that at least two lower floors are present in the same general area (Chapter 4).

The finding that the fine-fraction of the floors in reality consists of carbonate hydroxylapatite requires a rethinking of the human behavior that accounts for the floors' presence.

It is not likely that the original construction material for the floors was carbonate hydroxylapatite ($Ca_5[PO_4,CO_3]_3[OH]$), as explained by Neff and colleagues in Chapter 5. This mineral is found in bone, and from a chemical standpoint the floor samples compare favorably with bone (Figure 5.2). However, we have ruled out bone as the starting material of the floors because there are no small bone fragments throughout the floor strata, as would be expected if pulverized bone had been used for the fine-fraction of the floor material.[1]

Carbonate hydroxylapatite also commonly forms in sediments when calcium carbonate ($CaCO_3$) reacts with phosphate in solution (Wiener 2010:84). In Chapter 5 Neff and colleagues convincingly argue that at Tlacuachero, the carbonate hydroxylapatite of the floors was formed diagenetically. They argue that the carbonate mineral calcite ($CaCO_3$) likely was the starting material from which the floors were formed. One analyzed floor sample (09-433; location H-8 on Floor 1), chosen because of its especially prominent carbonate peaks and low phosphate peaks as compared to other floor samples, was shown to be chemically very similar to wood ash calcite (Figure 5.7), but it would be equally similar to geogenic and biogenic calcite. The authors conclude that this sample comes from an area of Floor 1 that was minimally altered by organic residues and thus most closely approximates the original starting material. This finding raises the question about the ultimate source of the calcite, and the coauthors of Chapter 5 point to three possibilities: geogenic calcite, biogenic calcite, and wood ash calcite. Of course, a combination of two or more of these potential starting materials also is a theoretical possibility. Although Neff et al. (Chapter 5) leave open the question about exactly how the floors were formed initially, I pursue this question further here.

One possibility: geogenic calcite, such as is found in limestone, would be a very unlikely source of the Tlacuachero floor material for the simple reason that there is no ready source of limestone or other calcium-rich sedimentary rocks on the Chiapas coast. In fact, there are no rocks on the soft outer alluvial coast, and the nearest rock outcrops to the site are igneous and metamorphic in origin. Moreover, no small rock particles are present in the floor material as would be expected if the original calcite were geogenic. So we can rule out a geogenic source of calcite as the starting material of the Tlacuachero floors.

In contrast, biogenic calcium carbonate is readily available at Tlacuachero, a shellmound that consists almost solely of molluscan shells. For shell-derived calcium carbonate to be workable, the shells would either have to be mechanically ground into a fine powder or, even more likely, burned to produce a powder. In the latter scenario, the shells must be well heated (perhaps around 900°C [Turkeysong 2009] or more [Discovery Communications 2013], depending on various factors) to produce calcined shell. When this occurs, carbon dioxide (CO_2) is released, leaving quick lime (CaO). When water (H_2O) is added to the quick lime, slaked lime or calcium hydroxide ($Ca[OH]_2$) results. Then when this material is exposed to air, water is released and carbon dioxide is added, resulting in dry, powdered calcium carbonate, which is dry shell lime plaster (Colonial Williamsburg Foundation 2008). Thus it is entirely possible that the fine-fraction of the floor material originated as shell lime.

Finally, the abundant evidence on the site of repeated burning and the chemical similarity of wood ash calcite to the abovementioned floor sample (Figure 5.7) provide compelling evidence for wood ash being present as a starting material for the floors. Accordingly, both shell lime and wood ash are very likely the materials from which the floors were formed, and I suspect that both materials rather than one or the other are involved.

Whatever the starting material—wood ash, shell lime, or a combination of both—this calcite binder must have become mixed with water and aggregates consisting of broken and unbroken molluscan shells before forming the floors. The upper floor surfaces are planar, but in some areas where Floor 1 was laid directly on unconsolidated shells, there was no attempt to level the preexisting surface. In these locations the contact is sharply defined between the lower floor and the upper unconsolidated shells.

The floors of carbonate calcite were subsequently chemically transformed as a result of human activities carried out on their surfaces. The phosphate that reacts to calcium carbonate to form carbonate hydroxylapatite is released from degrading organic materials (Weiner 2010:60). Several ethnoarchaeological studies have verified that high phosphate concentrations are related to the presence of organic remains (Dahlin et al. 2007; Knudson et al. 2004; Weiner 2010:244; Wells et al. 2007), and chapter authors have produced ample evidence of the former presence of organic material on the surface of the Tlacuachero floors. This material includes varying amounts of small fish bones (Chapter 6), phytoliths remaining from several kinds of degraded plants (Chapter 7), and patterned high concentrations of phosphorus and zinc (Chapter 5), major constituents of food. The presence of phosphorus is particularly relevant here as it is an important element in phosphates.

What the above scenario leaves unexplained, however, is whether the production of the floor starting material was an unintentional consequence of extensive human activity, including the pulverizing of shells and/or burning of wood on preexisting shell substrates, or whether the Chantuto people actually fabricated a lime plaster, which they spread out as a constructed floor surface on unprepared shell substrates. Unfortunately, at the present time we are unable to definitively answer this question, which of course has implications for the following debate about the formation processes responsible more generally for Archaic period deposits at Tlacuachero.

Time of Formation and Duration of Floor Use

Newly acquired radiocarbon dates and their interpretation by means of Bayesian modeling (Chapter 2) have produced the surprising result that the formation and use of the three identified floors spanned as much as 600 years. I find this result surprising because the floor material is unbedded, which suggests that each floor was formed as a single event, and their surfaces lack the characteristics I would expect if they had been exposed to the elements over protracted periods of time.

The currently available data suggest that Floor 3 was formed between 4935 and 4835 cal B.P., that Floor 2 was formed between 4855 and 4655 cal B.P. and was used for an estimated 220 to 475 cal years, and that Floor 1 was formed between 4415 and 4320 cal B.P. and was used for as much as 70 years.

Using the Tlacuachero Floors

In this section I examine available spatial information for each of three superimposed floors at Tlacuachero. For the two uppermost floors, existing information includes cultural features described by Thakar in Chapter 4, geochemical data reported by Neff et al. in Chapter 5, and the color of the matrix of floor material and the frequency of microrefuse reported by Thakar in Chapter 6. In addition, the spatial distribution of selected phytoliths is available for Floor 1, as reported by Drake in Chapter 7. For Floor 1 there are also a few ecofacts and artifacts to be considered. The discussion of spatial patterns on the surface of Floor 3 is limited to informal fire features, clusters of animal bones, and chipped stone artifacts.

Spatial Patterns on Floor 1

I begin with a brief consideration of the artifacts and ecofacts on the surface of Floor 1. Figure 10.1 shows these items, along with cultural features, plotted on the floor plan. A fire-altered hammerstone and a chipped stone flake are the only artifacts recovered from the floor surface. The hammerstone is located in the northwestern area (near the N1W2 intersection) of the floor exposure, outside the limit of the floor and resting on a patch of isolated floor material. The chipped stone flake is positioned on the floor surface within a rock emplacement ring. The flake is near a single rock that formed part of the encircling stone ring, but the rock was not removed when the other rocks were retrieved in ancient times.

Ecofacts are more prevalent than artifacts on the surface of Floor 1. A heavy concentration of small fish bones was present in the area approximated by the ellipse shown with a dashed line in the central part of the exposure. This is the only area where the field crew found a heavy concentration of small fish bones just above the surface of the floor. Surprisingly, it does not coincide with the areas of high density of embedded fish vertebrae in the floor (Figure 6.1a). This could mean that the Chantuto people uniquely used this particular area to either process or consume small fish just prior to the burial of the floor, but they had not done so earlier.

Two other ellipses indicate areas on Floor 1 where the crew recovered an unusually high frequency of turtle shells, which are associated spatially with the rock

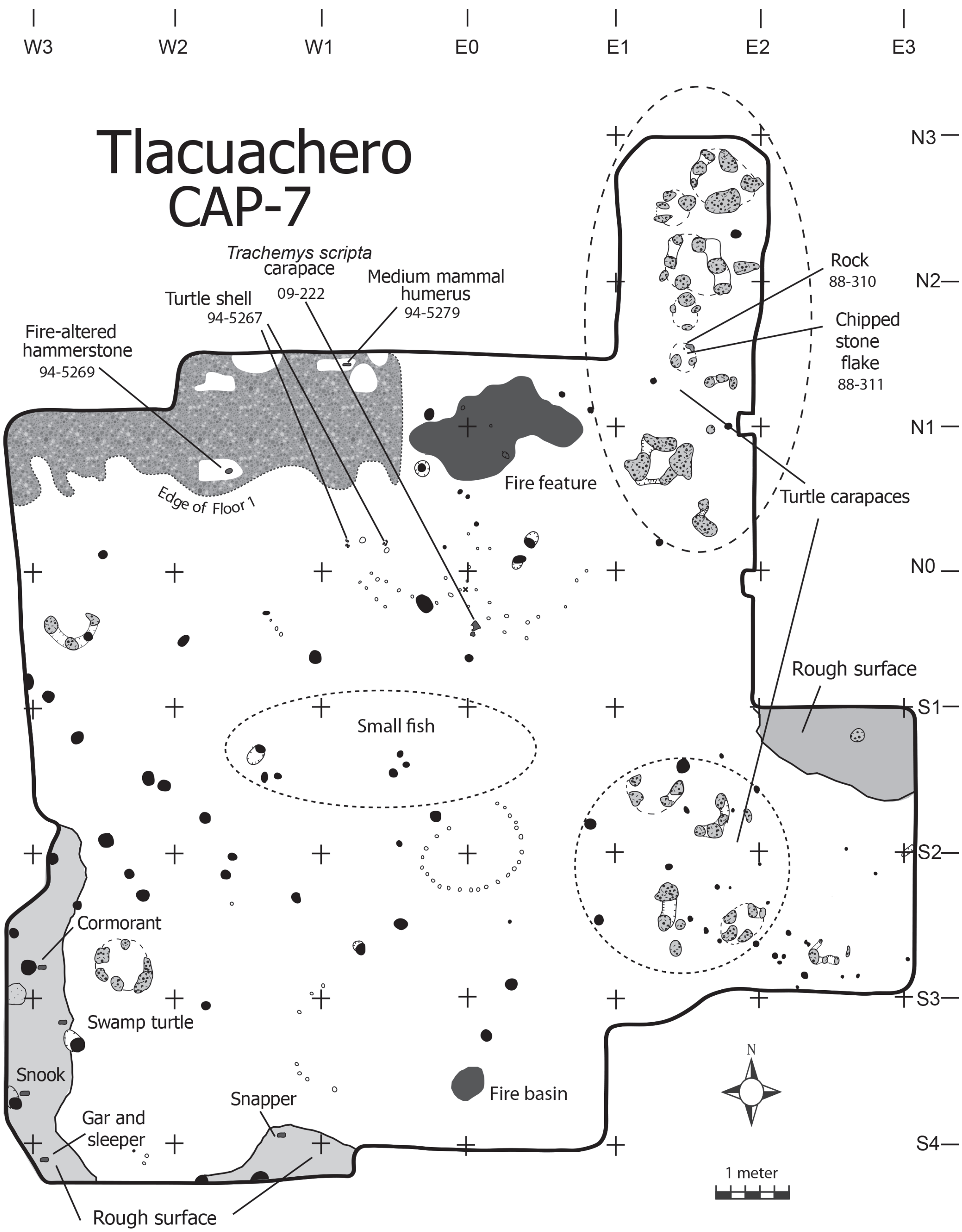


Figure 10.1. Plan view of Floor 1 showing cultural features, artifacts, and ecofacts (illustration by Heather B. Thakar and Barbara Voorhies).

emplacement circles. Isolated turtle shell fragments are also present at the north end of the floor exposure. Along the southwestern edge of our exposure, the floor surface is irregular, with clusters of bone from cormorant, fish, and swamp turtle. A similar irregular surface is near the S1E3 grid intersection in the southeastern area of the floor exposure. It is possible that areas with irregular floor surfaces are near the edge of Floor 1, where they functioned as disposal areas.

Obviously, the spatial arrangement of artifacts and ecofacts alone does not shed much light on activities the Chantuto people carried out on the surface of Floor 1. For this reason I now consider the spatial arrangement of cultural features on Floor 1 (Figure 4.7). Two salient observations are immediately apparent. One observation is that there is a discernible spatial separation among three sets of cultural features: rock emplacements are concentrated in a north–south strip along the eastern side of the floor exposure; finger-molded holes are present in the central area; and large postholes are concentrated in a diagonal alignment in the southwestern area of the exposure. Although the separation of these sets of features is not perfect, the deviations may be due to the palimpsest factor. In general, the observation of spatial separation of sets of cultural features indicates that the Chantuto people reserved certain areas of the prepared floor for particular activities. In Binford's terms (1983b:144) the Chantuto people organized their life space while actively using Floor 1.

The second general observation is that some of these cultural features exhibit multiple iterations or redundancies. For example, the many closely spaced and aligned large postholes in the southwestern sector of the floor exposure suggest that posts were erected in the same area more than once, although it is not clear how many episodes may have occurred. Even more convincing are iterations of features consisting of finger-molded holes, especially in the north-central part of the exposure of Floor 1 and even on the central semicircle of finger-molded holes (Voorhies 2004:Figure 2.16). Thus it seems probable that the same people were returning repeatedly to reuse the infrastructure of Floor 1. To put it differently, there is evidence for the maintenance of structured activities on the surface of Floor 1 over time. This finding is entirely consistent with my general interpretation of Tlacuachero as a logistical site that was revisited repeatedly during the course of its formation. Binford (1983a:330) notes that logistical sites tend to be more fixed geographically and redundant in their contents compared to residential sites. But what can we say about the actual activities carried out on this floor?

To address this question, we can examine how the spatial arrangement of cultural features on Floor 1 compares with the spatial patterns of variables determined from analyses of floor samples. The available data sets are color of the sediment matrix, as well as relative frequencies of selected chemical elements, microrefuse, and several types of phytoliths.

For Floor 1, the overall spatial patterns of matrix color (Figure 6.1), ratios of zinc and phosphorus (figures 5.12 and 5.11, respectively), and microrefuse of small fish vertebrae (Figure 6.2) are broadly similar. The darkest floor areas, highest ratios of zinc to calcium and phosphorus to calcium, and greatest frequency of embedded fish vertebrae all occur in the northeastern portion of the floor exposure and from there extend southward to the approximate center of the floor exposure, in the vicinity of the undisturbed semicircle of finger-molded holes. Together these observations suggest that within this defined area we find the most chemical alteration of the original floor material, the greatest concentration of two specific elements associated with animal metabolism (phosphorus and zinc), and the greatest density of small fish vertebrae compared to elsewhere on the exposed surface of Floor 1. These patterns, while broadly similar, are not precisely congruent, but they are close enough to make a strong argument for the interpretation that this is where the greatest amount of activity involving the presence of animal food, including but perhaps not limited to small fish, occurred.

Another area of Floor 1 where corresponding patterns occur is in the southeastern sector of the floor exposure in the area around the cluster of rock emplacements. In that area, the pattern of zinc (Figure 5.12) and phosphorus (Figure 5.11) forms an isosceles triangle with its base to the south; within it there is a relatively low concentration of each element. A very similar triangular pattern occurs in the same area on the map of small bone microrefuse (Figure 6.1a), within which there was a very low density of fish vertebrae. Thus, according to the available evidence, relatively little activity involving animal foods took place within this southern triangular area associated with rock emplacements. On the other hand, the comparable map of color values (Figure 6.2a) lacks a similarly shaped pattern in this area of the floor exposure. Instead,

three different color zones transect this area, but all are within the light-colored end of the spectrum. This might mean that in this particular area, the rock emplacements were not used to process animal flesh but that whatever activities did occur resulted in some minor alteration of the original light-colored sediment.

A similar situation occurs in the western third of the Floor 1 exposure in that the relative amounts of zinc and phosphorus are low (figures 5.12 and 5.11, respectively) and the frequency of embedded fish vertebrae is also low (Figure 6.1a), as might be expected. In contrast, the map of sediment color (Figure 6.2a) indicates that the floor sediment is very dark along the southwestern and western edge of the excavation exposure. The tentative conclusion is that the presence of animal-based food was relatively low in this area but that the floor color was altered because of some other, currently unknown process.

The above discussion is based on a general consideration of the spatial patterns on Floor 1. I now turn to a consideration of the spatial patterns on Floor 2.

Spatial Patterns on Floor 2

The much more limited areal exposure of Floor 2 compared to Floor 1 makes it even more difficult to detect meaningful spatial patterns, but I offer a few salient observations.

The Floor 2 cultural features are limited only to large postholes and finger-molded-hole features. Even with the more limited areal exposure, it seems likely that space was organized somewhat similarly on Floor 2 as compared to Floor 1. For example, one can argue that the large postholes are aligned along a similar compass bearing as those in the overlying floor, but they are shifted farther northward. More convincing is that the finger-molded holes in the southern end of the floor exposure are positioned nearly below a cluster of finger-molded holes on the overlying Floor 1. There are two or possibly three iterations of the finger-molded-hole features on Floor 2. These observations suggest continuity of occupation during the construction and use of these two floors.

A second important observation is that several lines of evidence suggest that Floor 2 was used more intensively than Floor 1. In the field it was quite obvious that Floor 2 was darker in hue than Floor 1, although this reality is not apparent in the color maps in figures 6.2a and 6.2b because the spectra used are specific to each individual map. The analysis of bone microrefuse revealed much denser bone frequency overall on the lower floor compared to the upper one (figures 6.1a and 6.1b). Moreover, the net intensities of both phosphorus and zinc are higher on Floor 2 than on Floor 1 (Figure 5.5). The available information about the relative age of these two floors suggests that these differences in use intensity may be due to the fact that Floor 2 was in use for a longer period of time (220–475 cal years) than Floor 1 (70 cal years), as is demonstrated in Chapter 2.

Finally, it is noteworthy that the archaeological team did not recover a single artifact or noteworthy bone concentration from the surface of Floor 2. Nor were rock emplacements or fire features found in the area exposed by excavation. If I am right in speculating that a similar organization of life space was practiced on Floor 2 as on Floor 1, rock emplacements might be present in the unexcavated area east of the existing Floor 2 exposure and below the rock emplacements on Floor 1.

I now turn to three propositions about the possible functional significance of three sets of cultural features found on the floors at Tlacuachero. The focus is on the large postholes, finger-molded-hole features, and rock emplacement rings.

Proposition 1: Large Postholes Are Signatures of Fish-Drying Racks

Archaeologists almost reflexively assume that postholes result from the vertical supports of buildings, but it is important to recognize that many structures other than buildings incorporate vertical posts, so facilities other than buildings may be indicated by posthole patterns at archaeological sites. Thus it is incumbent upon the archaeologist to consider a range of possible facilities that might account for the presence of posthole features at a site.

At Tlacuachero we have every reason to initially expect the presence of buildings, even if people used the site for short periods only. Shelter from the sun during the dry season and from the rain in the wet season would be essential necessities for people lingering for any length of time on the island. The simplest likely shelter would be a ramada, a roofed but wall-less structure providing a sunshade. For protection from wet-season storms, a more substantial building with walls would be required.

The fish rack is another facility that requires vertical support posts and is a likely candidate to be found at Tlacuachero. The idea that fish racks were present at the site is worth considering for both socioecological considerations and because drying fish has a known long historical depth in the region. As has been amply demonstrated here and in previous studies (Cooke et al. 2004; Voorhies 1976; Voorhies et al. 2002; Wake et al. 2004), fishing was a focal activity of the Chantuto people while they sojourned at the shellmound sites. Because fish spoil extremely readily in this hot, tropical setting, some form of preservation is imperative unless fish are eaten immediately after their procurement. The time-honored and widespread preservation technique in this region is to dry fish in the sun. In recent times, local residents achieve this is by splitting large fish and drying them on racks, whereas small fish are left whole and are merely spread out, often on mats, on a flat surface.

Here I want to pursue the proposition that the postholes result from the former presence of fish-drying racks. The alternative proposition, that the posts were elements of buildings, seems to me less likely, simply because the expected supporting information is absent. Various authors, myself included, have proposed that particular arrangements of postholes on Floor 1 mark the perimeter of a former building. For example, Thakar (Chapter 4) proposes that there was a building in the southwest corner of the Floor 1 exposure; Drake (Chapter 7) proposes that a building encircled the central finger-molded-hole feature; and I proposed previously (Voorhies 2004:Figure 2.14) that an oblong building extended from the center of the floor exposure toward the northwest. However, in none of these proposed building footprints is there any indication on the floor of the former presence of a wall or any other indication to demarcate the inside from the outside of the purported structures. Thakar has proposed that the relatively uneven surface of Floor 1 at the southwestern corner of the exposure marks the outside of a hypothetical building, but it seems to me significant that all other potential sides of the proposed building lack a similar uneven surface (see Figure 4.8).[2] Moreover, I have become particularly persuaded by the fact that there are no drip lines imprinted into the floor, as would be expected if a thatched roof was in place during a rainy season. Any roofed building standing during the rainy season in this area, with its high seasonal amount of rainfall, would inevitably form a drip line. However, it must be conceded that a roofed building used only during the dry season and then dismantled would not produce a drip line. Nor would there be a drip line if a single roof spanned the whole exposed floor, a somewhat unlikely but still possible situation.

Finally, I remain persuaded that buildings were not present by the negative evidence that all expected artifacts and features commonly associated with household complexes are seriously lacking on the floor exposures. Take, for example, data recovered from Early Formative household complexes at San José Mogote (Flannery and Marcus 2005), where abundant artifacts and features are reported for every house and house yard investigated. This is exactly to be expected for residential buildings, but the expected archaeological evidence is lacking on the Tlacuachero floors.

Although for various reasons we cannot conclude with absolute certainty that buildings were not present on Floor 1, given the available evidence, it is likely that they were not. Accordingly, it is instructive to consider further the fish rack proposition.

Archaeological Expectations. Coastal peoples in southern Mexico dry large fish, as opposed to small fish (whose drying methods I will discuss separately), by exposing them to the hot sun after preparation by butchering and salting. They usually use a pole scaffold or sometimes a table-like structure, as Thakar discusses in Chapter 4. These techniques are not limited to the area of the Panzacola-Chantuto Estuary but are generally similar to those used by other coastal peoples elsewhere in southern Mexico and beyond. I suspect that drying racks were common structures among indigenous societies where fish, sometimes shellfish, and other meats were dried for later consumption. Perhaps the most elaborate and widely known fish-drying racks documented ethnographically are those of various coastal peoples of the Pacific Northwest (e.g., Drucker 1951:63; Stein 2000:35–37; Stewart 1982:128,135–136). In that region anadromous fish are a principal focal resource, which means that the sharply seasonal availability of fish must be culturally buffered by methods of food preservation. However, drying fish and other animal and plant foods is widespread among traditional people and has been practiced in many different ecological situations. To give just a few examples, fish-drying racks were used by the Chumash (Hudson and Blackburn 1983:170) and

Pomo (Loeb 1926:172) in coastal California; the Ainu of northern Japan (Ohnuki-Tierney 1974:27); the Seri of Sonora, Mexico (Felger and Moser 1985:86–87); the Shipibo of the Amazon (Bergman 1980:171); the Barama River Carib of British Guiana (Gillin 1936:44); the Chipewyans in northwest Canada (Sharp 1981:232); and the Ojibwa in northern Ontario (Rogers 1962:c6; Rogers and Black 1976:13; Vennum 1988:116). Even the very distant Nunamiuts in Alaska use both tripod-pole racks and platforms as meat-drying facilities (Binford 1978:97–101). Closer to our study area, the Huave of the Isthmus of Tehuantepec were using table fish-drying racks at the end of the 19th century (Starr 1899:plates CXI and CXVIII), and they are used today on a more industrial level at Puerto Madero, Chiapas (Alcalá Moya 1999:figures 7 and 8).

Given these considerations, what are archaeological expectations for fish racks?

- Racks should be positioned in the open air, away from shade-producing objects such as tall buildings or trees.
- The pattern of postholes should form rectangles (platform and scaffold racks) or be linear (scaffolds).
- The spaces under the racks should be free of evidence of "permanent" features.
- The ground or floor surface under the racks should manifest concentrations of chemical elements that are proxies for organic material, especially elements that occur in fish (Knudson et al. 2004).

Before assessing how the archaeological evidence at Tlacuachero compares to the expectations listed above, it is worthwhile to examine the reasons for them. The first listed expectation, that fish racks should be positioned in unshaded, open-air spaces, is based on my observations of present-day fish racks in the study area. The Acapetahua region is located within the tropics, where the sun is hot and evaporation is rapid. Thus drying occurs swiftly. In climatically different regions, such as the Arctic or the Pacific Northwest, the process of drying fish is beset by problems such as low insolation, moisture, and unpredictable weather. In such locations, fish racks are sometimes placed under a roof (Knudson et al. 2004; Stewart 1982), where wind accomplishes the drying process. Alternatively, fish are preserved by smoking (Stewart 1982:135). Another adaptation in northern climes is to build fish racks with slanted sides to maximize sun exposure. However, fires and smoking are also used in low latitudes, in places where humidity is high. For example, the Cayapa Indians of Ecuador, who live in a warm humid climate, dry surplus meat and fish by smoking them over a fire (Barrett 1925:75). These various responses are not needed in our study area, where long hot days are common and fish sun-dry very quickly.

The second listed expectation, that posthole patterns should conform to the shape of ethnographically known fish racks, is reasonable but is not necessarily that easy to determine in the field because of the palimpsest factor discussed in Chapter 4. Ethnographically, scaffold fish racks that I have observed in the study area have vertical posts that in plan view form linear or rectangular patterns. The table or platform fish racks, which in the Acapetahua area are used for butchering fish more often than for drying them, are always rectangular and are smaller than the scaffolds. They are often positioned at the water's edge, as depicted in Figure 4.5. However, the large platform drying tables of the Huave depicted by Starr (1899) are dedicated to drying fish and other aquatic foods.

The third listed expectation, that no "permanent" features should be positioned below the fish racks, is based in part on my observations of actively used fish racks. It seems reasonable that if a fish rack is being used, it would be both awkward and unpleasant for people to carry out some other activity below the rack, even if there is sufficient space to do so, because freshly hung fish drip smelly liquid. Moreover, some fish racks, such as some reported from the Northwest Coast (Stewart 1982:142, 144), extend so close to the ground that it would be impossible to work beneath them. However, I recognize that fire features might be positioned below fish racks in areas where fire is used for drying. Binford (1983b:145) notes how the arrangement of certain facilities on a site provides a skeleton around which activities are organized. If standing scaffolds were present at Tlacuachero, they would have influenced activities at the site and therefore the archaeological patterning of material remains.

The fourth listed expectation is that there should be a chemical signature of the presence of organic material under the racks. This is based on the assumption that newly butchered fish drip liquid charged with chemical

elements found in body fluids. A study of soil chemical characterization was carried out at two fish camps in Alaska where anthropogenic chemical signatures were found in samples collected at the camps but were not present in the immediate area outside the camps. In addition, investigators found enrichment of calcium, iron, potassium, magnesium, sodium, phosphorus, and selenium in samples from below and adjacent to a covered fish rack at one of the camps (Knudson et al. 2004:451).

The Tlacuachero Data. Here I examine the proposition that the layout of the large postholes on Floor 1 marks the positions of vertical elements in a scaffold-type fish rack. According to the first listed expectation, we expect that the original racks would be in the open air in an unshaded location. Given the areal exposure of Floor 1 that is available for examination, these conditions are met. That is, there is no indication of a nearby tall structure or trees that would cast shadows on the hypothetical racks. Admittedly, however, we do not know if trees were once located just beyond the limits of our excavations.

With respect to the second listed archaeological expectation, the spatial pattern of the large postholes on Floor 1 remains somewhat in the eye of the beholder. Thakar, for example, posits in Chapter 4 that some postholes in the southwest corner of the excavated area mark the perimeter of a building (Figure 4.8), but I am not convinced. Rather, I see a linear pattern of postholes trending southeast–northwest, with two additional linear sets of postholes at right angles to the first, forming three sides of a rectangle that is open on the northeast side (Figure 10.2). Such a rectilinear pattern is consistent with the proposition that iterations of scaffold fish racks might have been present there. The area of postholes on Floor 2 is located at the northern end of the excavated area. Once again, no absolutely clear pattern is discernible, although a linear or rectangular arrangement is certainly possible. Thus, in my opinion, the second mentioned expectation listed above is possibly met, or more correctly it has not been falsified.

The third listed expectation, that there should not be features below the posited position of horizontal cross poles, does seem to be met, at least partially, by the evidence available on Floor 1. There are no cultural features positioned directly beneath the posited cross poles. Such features are, however, present adjacent to the alignments, where they would be expected.

The fourth listed archaeological expectation is that there should be elevated chemical markers of biogenic alteration of the floors below the fish racks as a result of fluids dripping from fish onto the ground surface below. In an ethnoarchaeological study at a Yup'ik fish camp in Alaska, investigators found high concentrations of a suite of elements below a fish rack (Knudson et al. 2004). Magnesium, phosphorus, and selenium were elevated by an order of magnitude compared to samples away from the rack, and barium, calcium, potassium, and sodium were elevated to a slight degree (Knudson et al. 2004:450). In the geochemical study of the Tlacuachero floors, Neff and colleagues (Chapter 5) chose zinc and phosphorus as indicators of the presence of fish or meat; there is a much sounder reason for believing these two elements to be directly related to the processing of animals than some other elements chosen in the Yup'ik study, since we know that both phosphorus and zinc are essential nutrients in animal metabolism (Neff, personal communication 2013). In fact, the specific elements measured in the Yup'ik study (Knudson et al. 2004) would not be good choices at Tlacuachero. Calcium would be useless, as it is determined by shell or ash calcite, which was there to begin with. Magnesium similarly would not reflect fish processing on this particular substrate. Sodium is not determined well enough by XRF to be of any use, but it, like potassium and iron, would show approximately the same patterning as phosphorus and zinc, which Neff and colleagues have plotted. Neff knows this because of the pattern of interelement correlations shown in both the ICP and the XRF data; in effect the PC1 map (Figure 5.10) shows what the iron and other maps would look like (Neff, personal communication 2013).

A comparison of the PC1 map and the positions of the postholes that I hypothesized mark the position of fish-drying racks on Floor 1 shows that areas beneath the hypothesized cross poles have elevated amounts of phosphorus and zinc when compared with the presumed starting material. As can be seen in figures 5.11–5.13, the spatial pattern of element concentrations generally follows the proposed U-shaped alignment of potential fish racks, except in one area (S3W1) in the south-central position of the U. However, the concentrations of phosphorus and zinc are relatively less, not more, than in the areas outside the U. This indicates only that whatever activities were taking place in those

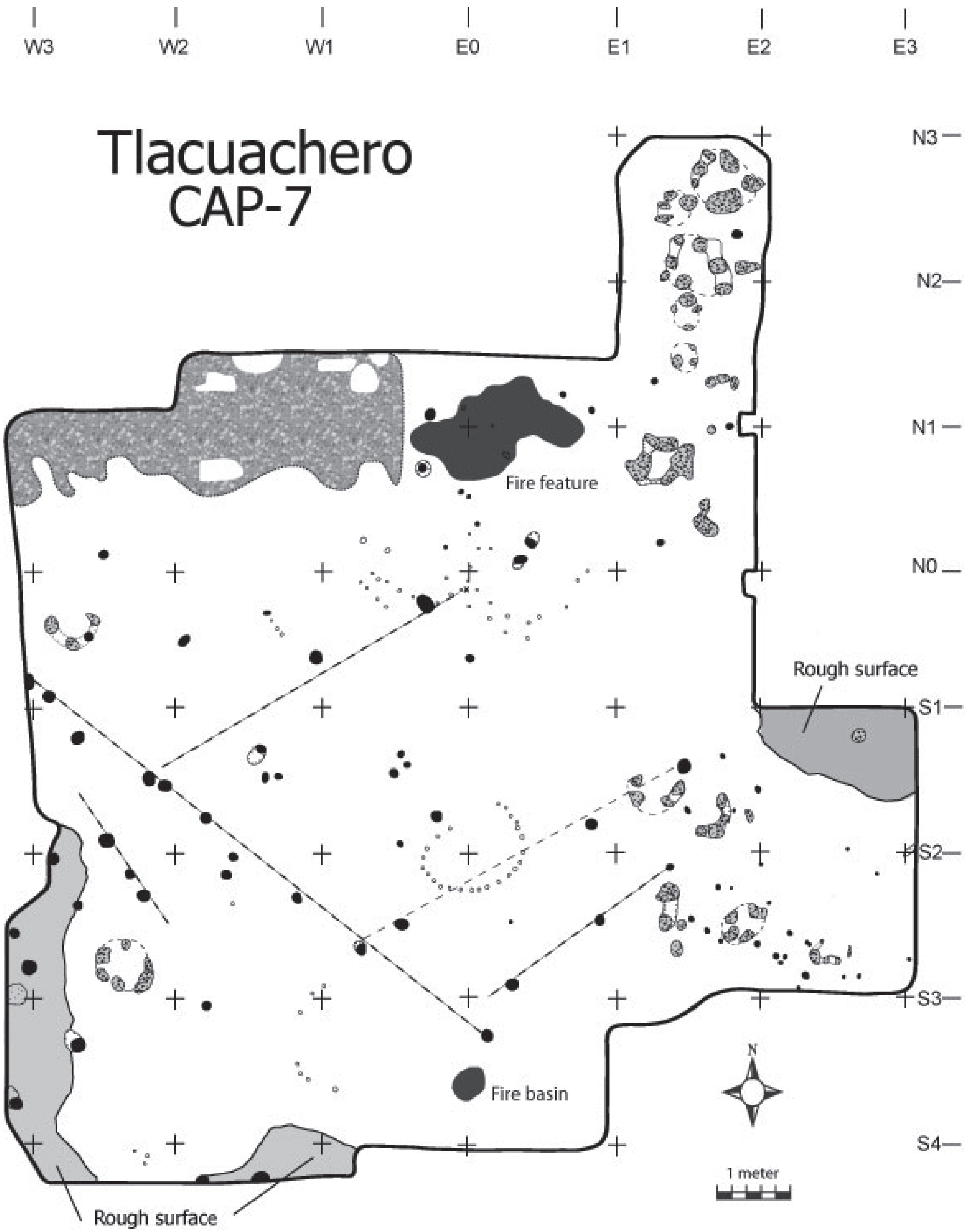


Figure 10.2. Plan view of Floor 1 showing cultural features and proposed alignment of possible fish racks (dashed line) (illustration by Heather B. Thakar and Barbara Voorhies).

surrounding areas resulted in more intense diagenesis than in the area that I have postulated as being under fish racks.

In summary, it remains a possibility that one set of large postholes on Floor 1 marks iterations of scaffold fish racks because I have been unable to falsify four expectations associated with the drying rack proposition. At the same time, the case for this interpretation remains open for debate.

Proposition 2: Finger-Molded Features Are Game Boards

Elsewhere (Voorhies 2013) I have proposed that the finger-molded holes forming semicircular patterns on the prepared floors are the remains of improvised game boards, possibly associated with a dice game. This unusual interpretation is based upon a comparison with game boards from various ethnographically known groups, particularly some in the Greater Southwest. In the present section I consider the archaeological expectations of this proposition and how data from Tlacuachero compares to them.

Archaeological Expectations. In a remarkable study, Stewart Culin (1907) compiled ethnographic data on dice games as played widely by traditional native societies. Based on his information, I generate three archaeological expectations, in addition to the presence of game boards, for identifying the presence of dice games played in a particular location in the prehistoric past. Accordingly, archaeologists could expect to find the following:

- Objects that could have served as dice
- Objects that could have served as counters to mark a player's position on the game board
- Evidence of the presence of food in the vicinity of the player's position adjacent to the game board

Regarding the first listed expectation, that an archaeologist could expect to recover objects that could have served as dice, I turn to the ethnographic record to determine the characteristics of dice used by indigenous societies. Culin (1907) identified a wide variety of materials that have been used for dice by traditional societies in North America, but almost all are two-sided objects that are clearly differentiated on one side from the other. Split reeds or wooden objects were most common, but seeds, nuts, shells, bone, animal teeth, stone, and ceramics were also used. Some of these types of dice, such as those of reed, wood, nuts, and seeds, have very low potential for archaeological preservation. In most archaeological sites, these organic remains would never survive unless charred. If such objects were recovered as charcoal, it would be nearly impossible to detect any original markings that differentiate one side of an object from the other, so their original use as dice would not be detectable. Dice crafted from other durable materials, such as bone, teeth, stone, and ceramics, have a much greater potential for archaeological recovery.

Considering the second listed expectation, that archaeologists could expect to find game board counters as evidence for a prehistoric dice game, the ethnographic record is much less informative than it is about aboriginal dice. Culin (1907) and other scholars rarely provide information about objects used by aboriginal North American dice players as counters to mark scores on their game boards. Evidently, almost anything could be used. The Kekchi (Q'eqchi') Maya of northern Guatemala play a dice game (*bool-ik*) that uses maize dice and a game board formed of dried maize kernels. "The board and dice being ready, the players select their counters, five for each. Any small articles will do, but preference is shown for five similar twigs, leaf stems, or split sticks, or different lengths and kinds of these. Fragments of leaves of different colors or structure are often used and where there are many players bits of grass, muslin or paper; even thread is pressed into service" (Culin 1907:142). Verbeeck (1998:85) notes that in the similar dice game of *bul*, played in the 20th century by Mopan Maya using a game board formed of dried maize kernels, each player marks his score using "five similar pieces of twig, leaf stem or grass, different from the counters of the other players." Sticks are the counters mentioned most often in Culin's survey. In some Plains Indian societies, women use awls as game board markers.

Most pertinent here, however, is that the Tarahumara of Chihuahua, Mexico, use little stones dropped into the holes that form their game boards: "The sticks (dice) count in accordance with the way they fall. The point of the game is to pass through a figure outlined by small holes in the ground between the two players. The movements, of course, depend upon the points gained in throwing the sticks, and the count is kept by means

of a little stone which is placed in the respective hole after each throw" (Culin 1907:152).

The third listed expectation, that evidence of food should be found around but not on the features posited as game boards, is based on Culin's finding that gambling, raucous behavior, and eating commonly accompany North American native dice games. If the consumption of food was typical of dice players at Tlacuachero, we would expect evidence of food to be found in the vicinity of the game boards but significantly not on the boards themselves.

The Tlacuachero Data. In the first expectation listed above, I suggested that an archaeological expectation in support of the proposition that the semicircular features of small holes imprinted in the floors at Tlacuachero would be the recovery of objects that might have been used as dice. I have not found any such objects in the Late Archaic period deposits at the site. If dice had been made of wood, reeds, or other material with low preservation potential, they would have had no chance of surviving in this particular archaeological situation. Ceramic dice are also not to be expected, since the Chantuto people did not use pottery. Thus the only hypothetically possible materials with preservation potential at this particular site are dice crafted of bone, stone, or teeth. I held out the greatest hope to find dice-like objects crafted out of turtle shells, since turtle shell fishhooks are present in the Archaic deposits at Tlacuachero. However, despite very careful examination of the turtle-shell fragments from Archaic period deposits at the site, we did not find any likely candidates for dice.

I have proposed that several worked potsherds that we recovered from the younger, ceramic-bearing deposits at the site nicely fit the expectations of dice (Voorhies 2013), but of course, these are not contemporary with the features that I propose were game boards.

The chances of finding objects that might have served as counters are even less likely than the chances of finding dice. In most ethnographic cases reported by Culin (1907), aboriginal dice game players used sticks as game board counters. If the Chantuto people used sticks for counters, there is no chance that archaeologists would identify them. However, as I mentioned above, the Tarahumara, who had game boards formed out of little holes, used pebbles as counters. However, in the field, no pebbles were recovered from either Floor 1 or Floor 2, the surfaces on which the proposed game boards are located. Of course, it is possible that players took their pebble counters with them at the end of the game.

Intriguingly, small water-worn pebbles were found at Floor 3, but they were not associated with any finger-molded holes and for reasons discussed below do not seem to be particularly good candidates as game board counters. In short, we have no certain evidence of counters that would support the proposition that the semicircles of finger-molded holes were dice game boards.

The last listed archaeological expectation is that evidence of organics, presumably derived from food, should be present surrounding the proposed game boards but not on or within them. On Floor 2 there are two iterations of finger-molded-hole features in the southern area of the exposed area of the floor. All the geochemical maps (figures 5.15–5.19) show relatively high indicators of the presence of organics outside this feature and relatively low indicators within the feature. Perhaps the most compelling map is Figure 5.19, which shows the areas across Floor 2 that are most altered diagenetically by the conversion of calcite to carbonate hydroxylapatite. In this map, the scores of the Principal Component 1 data map onto the finger-hole features with the lowest scores (least alteration), shown as a bull's-eye in the center of the iterated features.

On Floor 1, the comparable map showing the degree of diagenetic alteration of calcite to carbonate hydroxylapatite (Figure 5.14) also supports the proposition. Considering the best-preserved finger-molded-hole feature in the middle of the floor exposure, the area of most diagenesis occurs at the opening of the semicircle, exactly where two players are expected to be seated if the proposed dice game was played like that of the Walapai (Hualapai) in Arizona, who used a similarly shaped game board (Culin 1907:208; Voorhies 2013). The other maps of geochemical elements on Floor 1 (figures 5.10–5.13) show evidence of organically derived elements, especially around the exterior of the feature, with somewhat lesser evidence in the middle of the feature, but these patterns are not as clearly supportive of the proposition as with the case of Floor 2, discussed previously. I have not discussed the area at the northern end of the Floor 1 exposure where there are several finger-molded-hole features with various iterations, because all the available evidence suggests that this area witnessed different activities, including those

associated with the informal fire feature. Thus no clear pattern is to be expected.

In summary, the proposition that the iterations of finger-molded-hole features are dice game boards has been supported to some extent by the proposed expectations and has not been falsified. No objects that are good candidates as either dice or score counters have been recovered from Archaic period deposits at the site. However, the absence of evidence is not evidence of absence, as is widely known. The geochemical data do seem to support the proposition to a significant extent. Most significantly, these data do not clearly refute the proposed expectations.

A final observation is necessary here. Drake (Figure 7.3) found that grass phytoliths, which were otherwise scarce across Floor 1, were very high in a circular area that mapped directly on the central finger-molded-hole feature in the center of the exposed floor. Significantly, this association did not occur with any of the other finger-molded-hole features on Floor 1, all of which were partially damaged, unlike the central one. This suggests to me that grass was piled over the feature before it became buried with shell deposits. There are a number of possible reasons why prehistoric people might pile up grass, including for bedding (e.g., De Laguna 1972:306; Pennington 1969:226) or other padding (Felger and Moser 1985:305), as a surface upon which to dry little fish (Dubin and Tolley 2008:14), as a way to keep food clean (e.g., Firth 1959:164; Yellen 1977:140), or for tinder (Felger and Moser 1985:305). However, the apparent exact positioning of the grass on the only finger-molded-hole feature that has survived completely intact suggests to me that this was done to protect the feature, as Drake proposed.

Proposition 3: Rock Emplacement Circles Are Signatures of Elevation Stone Rings

As Thakar describes in Chapter 4, circular features consisting of stone emplacements are concentrated in the eastern portion of Floor 1. In addition, two more isolated features are located on the western side of the Floor 1 exposure (Figure 4.7). The Chantuto people removed the original stones when they abandoned Floor 1 for the final time, except for one small stone that was still in place at the time of archaeological discovery. Evidently, the stones were either set into the floor substrate when it was wet or the features were used in some way that involved water, since the imprints clearly were made in a wet substrate. Since no charcoal or other evidence of fire is associated with the stone emplacement rings, it is certain that these features are not fire features.

Archaeological Expectations. Thakar (Chapter 4) proposes that the stone ring features were used to elevate objects off the floor, an idea that I proposed earlier (Voorhies 2004:60) by speculating that the stone rings might have supported basket or gourd receptacles. This is an attractive idea, but it remains to be determined what might have been so raised. Since the Chantuto people were not ceramic users, the stone rings could not have been used to raise or stabilize large water storage jars, as I have seen in modern homes in this study area. Although it is likely that the Chantuto people used nets, skins, gourds, and baskets for storage containers, the last two mentioned items, which are rigid, are the most logical types of containers to have rested upon or within the stone circles. But is there any ethnographic evidence for such associations?

Regrettably, I have been able to find only limited ethnographic evidence of elevation or stabilizing stone rings that would yield fruitful analogies to be tested by the archaeological evidence. I strongly suspect that this lack of evidence is due more to the mundane nature of the features than to their actual scarcity in traditional societies. Seymour (2011:Figure 8.4) illustrates a photograph of a large basketry granary of the Tohono O'odham that rests on a circular solid rock platform. She also identifies rock rings in the archaeological record in southeastern Arizona as container support rings (Seymour 2011:108; figures 5.5 and 6.6). The contents of the pictured granary are not identified but likely would have been seeds, possibly maize. Modern Maya in the Puuc area (Smyth 1991:87) use boulders to elevate maize granaries located either inside or outside buildings. Archaeologically, the signature of these particular Maya features should combine postholes from the vertical support posts with elevating stones supporting the heavy crib-like container. Smyth notes that over time these elevating stones become embedded into the soil, causing the addition of new stones. These limited observations inspire the further archaeological expectation that botanical evidence of a stored plant food should co-occur with the stone ring features.

I propose an additional storage function for the stone rings for consideration here. Because survival in this

intensely hot climate requires a large amount of water to be drunk daily, one possibility is that drinking water was stored in containers that were either raised or stabilized by stone circles. One possible type of container is the bottle gourd, a natural receptacle that has been in the Americas since the beginning of the Holocene (Kistler et al. 2014). Clark and Gosser (1995) have made a persuasive case for widespread use of gourds in the Soconusco region prior to the adoption of pottery. This argument is based on the fact that the earliest pottery was apparently not used for cooking on direct fire and that the earliest forms are skeuomorphs of gourd shapes. For formal reasons, these authors assert that gourds are especially appropriate to store and serve liquids (Clark and Gosser 1995:215–216). This view bolsters the case that the Chantuto people may have had access to gourds, despite the fact that no direct evidence of gourds has actually survived in the botanic record from Tlacuachero. However, botanical evidence of bottle gourds (*Lagenaria siceraria*) shows that they have an early appearance in the archeological records of Mexico, Peru, and the southwestern United States (MacNeish 1967:293).

It can also be shown that ethnobotanical evidence supports the assertion that gourds make excellent containers for liquids. For example, present-day Tzotzil Maya of Zinacantán, Chiapas (Breedlove and Laughlin 2000:136), use particular types of gourds to hold water and holy water, despite the fact that they have porcelain, enamelware, and stoneware readily available for waterproof containers. Spherical forms of gourds today may be as large as 30 cm in diameter and 30–40 cm high (Berlin et al. 1974:423), and narrow-waisted bottle-shaped gourds used as canteens may hold as much as 5 liters of liquid apiece (Breedlove and Laughlin 2000:136). Logically, earlier gourds would likely have been smaller.

The Tlacuachero Data. There is no evidence to either support or refute the proposition that the stone rings supported gourd containers for water or any other substance. There is no direct evidence for the presence of gourds or stored water other than the certainty that the stones rested on a wet substrate that produced the surviving imprints. Another possibility worth considering is that the stone rings supported containers holding plant or animal foods.

If the stone circles at Tlacuachero had functioned to support some kind of container for storing plant foods, possibly even including maize, we should expect to find botanic evidence of the stored foods. At Tlacuachero the only available data set available is that of phytoliths; macrobotanical remains of economic plants have not been recovered from the site, despite the fact that burned plant material is abundant but small and fragmentary, and pollen does not survive in this alkaline environment. Jones found evidence of phytoliths of maize at Tlacuachero from the level of Floor 1 and above (Jones and Voorhies 2004:Figure 6.4) in a diachronic study of plant use at the site, but Drake (Chapter 7) curiously found no maize phytoliths in the floor samples he examined from Floor 1 and Floor 2. Neither did he find clusters of any identified phytoliths in association with the rock emplacements, but phytoliths of *Sabal* sp. were relatively high in frequency around most rock emplacements (Figure 7.2). The genus *Sabal* sp. contains palms of economic importance to be discussed shortly, but no palm seeds have been identified. Accordingly, the limited botanical evidence available is inconsistent with the proposition that the stone ring emplacements were elevation stones for some kind of granary.

Other evidence now suggests the possibility that turtle-shell carapaces might have been set upon the rocks and used as containers for some unknown substance. Zooarchaeologist Thomas A. Wake observed that in the area of the rock emplacements on Floor 1 there is an unusually high frequency of turtle carapace fragments. Significantly, other turtle body parts, such as bones and plastron fragments, are conspicuously absent. Wake identified the carapace fragments as those from the Mesoamerican slider (*Trachemys scripta*) and the scorpion mud turtle (*Kinosternon scorpioides*).

The Mesoamerican slider was formerly a subspecies of *T. scripta* but now has been elevated to full species, *T. venusta* (Bonin et al. 2006:407). The subspecies *T. v. grayii* is found today on the coastal plain of Chiapas southward to La Libertad, Guatemala. It is known locally as *jicotea* (Alvarez del Toro 1972:24). This turtle is the largest in the study area, with a carapace length that may reach 50 cm (Alvarez del Toro 1972:24; Bonin et al. 2006:407) or 60 cm (Ernst and Barbour 1989:204). It is hunted today for its meat (Alvarez del Toro 1972:27) and eggs.

The scorpion mud turtle is a medium-size turtle with an elongated, oval, and high-domed carapace (Ernst and Barbour 1989:82). Locals refer to this turtle as *casquito*.

The carapace of males is usually about 20 cm long, although it may reach 27 cm (Bonin et al. 2006:175). The length of the female's carapace is approximately 18 cm. Today it is hunted for both its meat and eggs (Fernando Girón Campero, personal communication 2013).

The third type of turtle whose remains have been identified in the assemblage from Tlacuachero, but not in the vicinity of the rock emplacements, is the Pacific coast giant musk turtle (*Staurotypus salvinii*). Locally it is known as *la crucilla* (Alvarez del Toro 1972:23). This turtle has an elongate, oval carapace that may reach a length of 25 cm (Bonin et al. 2006:181; Ernst and Barbour 1989:71). The dorsal shell of this turtle appears to be slightly less domed than that of the other two turtles discussed above. This turtle is hunted today for its meat (Alvarez del Toro 1972:23).

At Tlacuachero the imprints of stone circles appear to be within the size range that could accommodate the carapaces of these locally available turtles. Of course, since only rock imprints remain in the archaeological record, it is impossible to determine accurately the size of the space that might have accommodated a turtle carapace within any original stone circle. Table 10.1 lists the dimensions of eight rock emplacements on Floor 1. The measurements, taken from the field map, are the diameters on the inner and outer margins of imprints of rock emplacements positioned at opposite sides of a rock emplacement circle.

Many different groups of traditional people have discovered that turtle carapaces make convenient and suitable containers that remain sturdy and intact as long as they are not burned. Moll and Moll (2004:236) state, "The concave, overturned carapaces of hard-shelled species (of turtles) have been commonly used as stepping stones, basins, fruit and cassava bowls, agricultural tools, planter and containers for animal feed and products." Judging from the references cited, these authors relied heavily on the ethnographic record from South America, upon which the foregoing statement was based. However, turtle shells have been used for containers in a much wider area. For example, turtle-shell plates or dishes were made by the Belau in Oceania (Barnett 1949). In North America the Ojibwa also made turtle-shell plates (Jenness 1935); the Iroquois made turtle-shell cups (Speck 1945), as did the Navajo (Haite 1943); and the Mescalero Apache used turtle shells as water containers (Basehart 1974).

Table 10.1. List of Maximum Dimensions of Eight Rock Emplacements on Floor 1.

Inner (cm)	Outer (cm)
50	90
50	80
60	90
30	90
60	80
20	50
20	40
60	90

Note: The measurements were taken between the inner and outer margins of imprints of rocks positioned on opposite sides of each rock emplacement.

However, one need not look so far afield for ethnographic examples of the use of turtle carapaces as containers. For example, the Seri of Sonora, Mexico, traditionally used the sea turtle principally for food, but other sea turtle products had economic value as well (Felger and Moser 1985). The carapaces served as multipurpose containers (Felger and Moser 1985:49), being used for transporting food and for processing and holding oil, and even as mortars for pounding foods. McGee (1898:185–186) provides more detailed information about the traditional Seri: "Larger bowls or trays are improvised from entire carapaces of the tortoise (probably *Gopherus agassizii*), which are carried considerable distances; and still larger emergency water-vessels consist of carapaces of the green turtle (*Chelonia agassizii*),[3] laid inverted in the *jacales*; these shells also being used in a natural condition."[4] Elsewhere, McGee reports turtle shells being used as shields in warfare (the green turtle; McGee 1898:233, 265) and as containers during the preparation of poison for arrows (probably the Sonoran mud turtle, *Kinosternon sonorense*; McGee 1898:257).

Nevertheless, I have not found any evidence that the Seri positioned turtle carapaces on elevation stones. It is worth mentioning in this regard that archaeological stone circles have been reported for the Seri area (Bowen 2000:328–333), but they are larger (mean diameter: 1.7 m long and 1.6 m wide) than those at Tlacuachero and often encircle areas of wood ash. Accordingly, these particular stone circles do not provide a direct comparison with the rock emplacement circles at Tlacuachero. Container-support rock rings

have been identified both ethnographically and archaeologically for the Sobaipuri and the Tohono O'odham of southern Arizona, who live just north of the Seri (Seymour 2011). In one photograph the rocks support a basketry granary (Seymour 2011:Figure 8.4), as I mentioned above.

In summary, the prevalence of fragments of turtle carapaces in the vicinity of the rock emplacements at the northern portion of the Floor 1 exposure at Tlacuachero raises the possibility that they were raised on elevation stones and used as containers. If the carapaces were so used, it is likely that they were associated with food, because there is a high concentration of both zinc and phosphorus in the area around the northern group of rock emplacements on Floor 1. I am unable to hazard a guess as to whether food was prepared, stored, or consumed at this location.

Spatial Patterns on Floor 3

As Thakar noted in Chapter 4, although archaeologists exposed only a very small area (4 m^2) of Floor 3, there are some striking differences between what little we know about this floor and the better-known, overlying floors 1 and 2. Cultural features such as postholes, finger-molded holes, and rock emplacements are absent on the Floor 3 exposure, but three areas with evidence of burning indicate the presence of informal fire features in proximity to one another. These fires must have been single events, as there is no indication that the locations had been repeatedly cleaned, thus producing a fire basin.

Moreover, the surface of Floor 3 was littered with more bone than was usually the case on the surfaces of the other two floors. The bone from the surface of Floor 3 is concentrated within each of the three fire features (Figure 4.10; features 1, 3, and 4). With the exception of a few small fragments, all bone recovered from these fire features was unburned, which suggests disposal after the fires were extinguished. In addition, an unburned fragment of a peccary maxilla rested on the floor surface near two of the fire features. Fish bones were recovered from the patch of whole shell valves, labeled Feature 2, but this is part of the underlying stratum and not contemporaneous with the floor itself.

Another striking difference about Floor 3 compared to the other floors is the relatively large numbers of chipped stone on its surface: 4.75 pieces per square meter on Floor 3 compared to 0.21 pieces per square meter on Floor 1 and none (zero pieces per square meter) on Floor 2. All but one of the recovered chipped stone pieces (n = 19) from Floor 3 are flakes made from the Tajumulco source of ignimbrite (Table 8.5); the remaining piece is a chunk from a bipolar core. Most or perhaps all of the flakes were fabricated either by direct percussion or bipolar percussion (Table 8.1). More than half (58 percent) are whole, and some of these flakes (37 percent) have been used for cutting purposes (Table 8.4). We recovered no other types of artifacts from Floor 3.

In summary, the small area of Floor 3 that we have investigated appears to be an activity area where Chantuto people likely butchered and cooked a diversity of animals. The field archaeologists did not find any comparable activity areas on either of the two overlying floors.

Diachronic Changes at Tlacuachero

Our previous work at Tlacuachero revealed subtle diachronic changes during the occupational history of the site. These changes initially came as a surprise because of the apparent uniformity of the unconsolidated bedded shells, a characteristic of the site stratigraphy that immediately strikes an archaeologist. Thus my initial interpretation/reaction was that the Tlacuachero shellmound formed under highly stable conditions. Now we know that this is not exactly correct.

We first became aware of diachronic change in the archaeological record at Tlacuachero as a result of seasonality studies based on isotopic analysis of clamshell margins from samples taken in sequence from the bottom to the top of the bedded shell deposits (Kennett and Voorhies 1996). The study of the season of procurement of clams was undertaken so that the results could be used as a proxy for the season of site occupancy. The basic finding was that analyzed clamshells from samples taken from the lower shell deposits were procured throughout the annual wet/dry seasonal cycle, but most analyzed clams from the upper shell deposits were procured during the wet season. A comparable subsequent study on clamshells from an earlier Middle Archaic site (Cerro de las Conchas) yielded the result that clams were collected throughout the year, thus supporting the finding for the early occupational phase at Tlacuachero (Voorhies et al. 2002; Voorhies

2004:Figure 3.13). At Tlacuachero, the point of change in seasonality of clam collection coincides with the level of the floors.

A second line of evidence for diachronic change during the history of site formation at Tlacuachero derives from John G. Jones's analysis of phytoliths, used as a proxy for the presence of plants at or near the site (Jones and Voorhies 2004:318–324). The phytolith record shows a decrease of forest phytoliths and a comparable increase of disturbance phytoliths over Late Archaic time (Jones and Voorhies 2004:Figure 6.4). In addition, maize phytoliths are present at the floor level and above it but were not found in the lower bedded shell deposits that were analyzed. Accordingly, the diachronic phytolith record from the site indicates an increasing presence of indicators of agricultural practices and the presence of one cultigen, maize. Once again, it is the level of the floors that marks the change in the data produced by Jones. Note, however, that Doug Drake (Chapter 7) did not find maize phytoliths in his study of samples from the two floors.

There is also the possibility that the artifact record changes concomitantly over time. I have previously noted that expedient manos and metates have been recovered from the upper shell deposits but not the lower ones at Tlacuachero. This would suggest an increasing emphasis over time on the processing of substances that require grinding to be used as food—most likely hard seeds such as dried maize. This interpretation is based on slender evidence, however, and may be due to sampling error: tool frequency is very low in shellmounds generally and specifically at Tlacuachero, where only a small volume of lower shell deposits has been investigated, in contrast to a much larger volume of upper shell deposits. It is noteworthy also that the only fishhook fragments recovered from our excavations (n = 2) came from deposits below the level of the prepared floors. This observation, admittedly of a very small artifact sample, coincides with the finding that bones from carnivorous fish that would take baited hooks are found with much greater frequency in the lower shell deposits and associated with the floors, compared to Archaic period deposits above the floors (Chapter 9).

Paris (Chapter 8) found that chipped obsidian tools at Tlacuachero may not have changed appreciably over Late Archaic time, although her analysis is hampered by small sample sizes. For example, a comparison of the mean size and weight of chipped stone objects from the upper and lower shell deposits (Table 8.2) does not show any significant change. The data regarding use-wear are so small as to be inconclusive when comparing chipped stone objects from the two stratigraphic units of bedded shells. The same may be said of the sourcing data. One detectable difference, however, is in the frequency of chipped stone per excavated volume of shell deposits: below the floors there are 1.8 pieces of chipped stone per cubic meter, but this drops to only 0.17 pieces per cubic meter in the deposits above the floor. These data suggest that chipped stone tool use decreased over time or alternatively that shell built up at a faster rate in the upper deposits compared to the lower ones.

A final data set that addresses diachronic change is that stemming from the faunal analysis reported here by Wake and Voorhies (Chapter 9). As has been reported previously, all fauna whose remains have been identified in the Archaic period deposits at Tlacuachero are from animals that live within the coastal wetlands; however, fish dominate the Tlacuachero faunal assemblage. The newly reported data clearly document a shift in relative frequency of larger, high-trophic-level fish below and at the level of the constructed floors to smaller, lower-trophic-level fish in the upper Archaic deposits. More accurately, bones of high-trophic-level fish become scarce or disappear entirely from the younger Archaic deposits, whereas bones of low-trophic-level fish, especially the Pacific fat sleeper (*Dormitator latifrons*; Figure 9.11), a low-trophic-level detritivore, continue to be strongly present throughout the sequence. The early focus on high-trophic-level game fish may have had adverse effects on the white corvine, whose otolith remains show a reduction in size prior to their disappearance from the archaeological record (Figure 9.4). This suggests a collapse of the corvine fishery due to overfishing.

These same data on the kinds of fish caught over time at Tlacuachero also reveal changes over time in the microhabitats of the estuary being fished by the Chantuto people and in their fishing techniques. Larger, high-trophic-level fish are more commonly found in lower, high-salinity estuarine zones, and while they are most effectively captured using stationary devices such as weirs, angling was definitely used. In contrast, the smaller, low-trophic-level fish are present in the higher, low-salinity zones of an estuary and must be captured using traps or nets. Thus it appears that fishing efforts shifted from a broader mixed lagoon-mangrove-swamp exploitation strategy early in the sequence to one focused on lower-salinity waters found in upper estuaries.

To explain the piscine data, Wake and Voorhies posit an environmental change involving a shift from a more open, mixed estuarine system to a more closed, upper estuarine zone. Estuarine systems are highly dynamic and prone to sudden and dramatic changes, but as Wake and Voorhies note, the continued dominance of the marsh clam throughout the sequence argues against environmental change.

Previously, Voorhies and Kennett (2011) proposed that a switch away from game fish could be explained by shifts in gender-based fishery practices at the site. In that scenario, the authors assume that men practiced fishing techniques targeting high-trophic-level fish, whereas women practiced fishing techniques targeting low-trophic-level fish. Early in the archaeological record at Tlacuachero, bones from both classes of fish are present, suggesting that both men and women were fishing at Tlacuachero, although their activities were out of phase (Cooke et al. 2004). In the late archaeological record, evidence for the kinds of fish targeted by men disappears, whereas fish targeted presumably by women continue to be present. Coupled with evidence for changes in seasonality of site use and presumptions about the increasing commitment to agriculture, the authors suggest that men were drawn away from the estuary because of their increased involvement in farming.

In summary, our most recent work at Tlacuachero has expanded knowledge about how site users were making changes in their lifeways over the time the site was used during the Late Archaic period. As with the earlier acquired data from the site, the time when the floors were in use marks a kind of turning point in the archaeologically observed record, but we know now that this may have been a more gradual process than previously assumed. In addition, in this chapter I have evaluated several specific propositions about activities that might have been carried out on the floors, using data from individual investigations presented in foregoing chapters. In the next chapter I consider the broader issue of formation processes and the function of large shellmounds generally.

Notes

1 The fish vertebrae recovered from the floors and discussed in Chapter 6 are generally unbroken and form inclusions within the matrices of the floors.

2 I agree with Thakar that this is probably a discard area similar to another area depicted in Figure 10.1. Both areas may be close to the edges of the prepared floor, but our excavations are too limited to determine whether or not this is the case.

3 Now classified as *Chelonia mydas agassizii*.

4 McGee (1898:187) gives a summary of the economic importance of the green turtle. "The flesh of the turtle yields food; some of its bones yield implements; its carapace yields a house covering, a convenient substitute for umbrella or dog-tent, a temporary buckler, and an emergency tray or cistern, as well as a comfortable cradle at the beginning of life and the conventional coffin at its end." Felger and Moser deny that the turtle carapaces were used as cradles (1985:49).

References Cited

Alcalá Moya, Graciela
1999 *Con el agua hasta los aparejos: Pescadores y pesquerías en el Soconusco, Chiapas.* Centro de Investigaciones y Estudios Superiores en Antropología Social, Tlapan, Mexico.

Alvarez del Toro, Miguel
1972 *Los reptiles de Chiapas*. Instituto de Historia Natural, Gobierno del Estado de Chiapas, Tuxtla Gutiérrez, Mexico.

Barnett, H. G.
1949 *Paluan Society: A Study of Contemporary Native Life in the Palau Islands*. University of Oregon, Eugene.

Barrett, Samuel Alfred
1925 *The Cayapa Indians of Ecuador*. Heye Foundation, Vol. 1. Museum of the American Indian, New York.

Basehart, Harry W.
1974 *Mescalero Apache Subsistence Patterns and Socio-Political Organization.* Garland Publishing Company, New York.

Bergman, Roland W.
1980 *Amazon Economics: The Simplicity of Shipibo Indian Wealth*. Ph. D. dissertation, Department of Geography, Syracuse University. University Microfilms International, Ann Arbor, Michigan.

Berlin, Brent, Dennis E. Breedlove, and Peter H. Raven
1974 *Principles of Tzeltal Plant Classification: An Introduction to the Botanical Ethnography of a Mayan-Speaking People of Highland Chiapas*. Academic Press, New York.

Binford, Lewis R.
1978 *Nunamiut Ethnoarchaeology*. Academic Press, New York.
1983a Evidence for Differences Between Residential and Special-Purpose Sites. In *Working at Archaeology*, edited by Lewis R. Binford, pp. 325–336. Academic Press, New York.
1983b *In Pursuit of the Past: Decoding the Archaeological Record*. Thames and Hudson, New York.

Bonin, Franck, Bernard Devaux, and Alain Dupré
2006 *Turtles of the World*. Translated by Peter C. H. Pritchard. Johns Hopkins University Press, Baltimore.

Bowen, Thomas
2000 *Unknown Island: Seri Indians, Europeans, and San Esteban Island in the Gulf of California*. University of New Mexico Press, Albuquerque.

Breedlove, Dennis E., and Robert M. Laughlin
2000 *The Flowering of Man: A Tzotzil Botany of Zinacantán*. Abridged edition. Smithsonian Institution Press, Washington, D.C.

Clark, John E., and Dennis Gosser
1995 Reinventing Mesoamerica's First Pottery. In *The Emergence of Pottery: Technology and Innovation in Ancient Societies*, edited by William K. Barnett and John W. Hoopes, pp. 209–221. Smithsonian Institution Press, Washington, D.C.

Colonial Williamsburg Foundation
2008 Lime Burn. Electronic document, research.history.org/Coffeehouse/Blog/index.cfm/2009/3/4/Lime-Burn, accessed May 27, 2013.

Cooke, Richard G., Máximo Jiménez, Conrado Tapia, and Barbara Voorhies
2004 A Closer Look at the Late Archaic Fish Fauna. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 207–299. University Press of Florida, Gainesville.

Culin, Stewart
1907 *Games of the North American Indians*. Twenty-Fourth Annual Report of the Bureau of American Ethnology to the Smithsonian Institution, 1902–1903, by W. H. Holmes. Government Printing Office, Washington, D.C.

Dahlin, Bruce H., Christopher T. Jensen, Richard E. Terry, David R. Wright, and Timothy Beach
2007 In Search of an Ancient Maya Market. *Latin American Antiquity* 18:363–384.

De Laguna, Frederica
1972 *Under Mount Saint Elias: The History and Culture of the Yakutat Tlingit*. Smithsonian Institution Press, Washington, D.C.

Discovery Communications
2013 Chemical Lime, How Stuff Works. Electronic document, http://science.howstuffworks.com/chemical-lime-info.htm, accessed May 27, 2013.

Drucker, Philip
1951 *The Northern and Central Nootkan Tribes*. U.S. Government Printing Office, Washington, D.C.

Dubin, Margaret, and Sara-Larus Tolley
2008 *Seaweed, Salmon and Manzanita Cider: A California Indian Feast*. Heydey Books, Berkeley, California.

Ernst, Carl H., and Roger W. Barbour
1989 *Turtles of the World*. Smithsonian Institution Press, Washington, D.C.

Felger, Richard Stephen, and Mary Beck Moser
1985 *People of the Desert and Sea: Ethnobotany of the Seri Indians*. University of Arizona Press, Tucson.

Firth, Raymond F.
1959 *Economics of the New Zealand Maori*. Government Printer, Wellington, New Zealand.

Flannery, Kent V., and Joyce Marcus
2005 *Excavations at San José Mogote I: The Household Archaeology*. Memoirs of the Museum of Anthropology, University of Michigan, No. 30. Museum of Anthropology, Ann Arbor.

Gillin, John
1936 *The Barama River Caribs of British Guiana*. Peabody Museum, Cambridge, Massachusetts.

Haite, Berard
1943 *Origin Legend of the Navaho Flintway*. University of Chicago Press, Chicago.

Hudson, Travis, and Thomas C. Blackburn
1983 *The Material Culture of the Chumash Interaction Sphere: 2. Food Preparation and Shelter*. Ballena Press and Santa Barbara Museum of Natural History, Novato, California.

Jenness, Diamond
1935 *The Objibwa Indians of Parry Island: Their Social and Religious Life*. National Museum of Canada, Ottawa.

Jones, John G., and Barbara Voorhies
2004 Human and Plant Interactions. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, edited by Barbara Voorhies, pp. 300–343. University Press of Florida, Gainesville.

Kennett, Douglas J., and Barbara Voorhies
1996 Oxygen Isotopic Analysis of Archaeological Shells to Detect Seasonal Use of Wetlands on the Southern Pacific Coast of Mexico. *Journal of Archaeological Research* 23:689–704.

Kistler, Logan, Álvaro Montenegro, Bruce D. Smith, John A. Gifford, Richard E. Green, Lee A. Newsom, and Beth Shapiro
2014 Transoceanic Drift and the Domestication of African Bottle Gourds in the Americas. *Proceedings of the National Academy of Sciences* 111(8):2937–2941.

Knudson, Kelly J., Lisa Frink, Brian W. Hoffman, and T. Douglas Price
2004 Chemical Characterization of Arctic Soils: Activity Area Analysis in Contemporary Yup'ik Fish Camps Using ICP-AES. *Journal of Archaeological Science* 31:443–456.

Loeb, Edwin Meyer
1926 *Pomo Folkways*. University of California Press, Berkeley.

MacNeish, Richard S.
1967 A Summary of the Subsistence. In *The Prehistory of the Tehuacan Valley: 1. Environment and Subsistence*, edited by Douglas S. Byers, pp. 290–309. University of Texas Press, Austin.

McGee, William J.
1898 *The Seri Indians*. Seventeenth Annual Report of the Bureau of American Ethnology. Smithsonian Institution, Washington, D.C.

Moll, Don, and Edward O. Moll
2004 *The Ecology, Exploitation and Conservation of River Turtles*. Oxford University Press, Oxford.

Ohnuki-Tierney, Emiko
1974 *The Ainu of the Northwest Coast of Southern Sakhalin*. Waveland Press, Prospect Heights, Illinois.

Pennington, Campbell W.
1969 *The Tepehuan of Chihuahua: Their Material Culture*. University of Utah Press, Salt Lake City.

Rogers, Edward S.
1962 *The Round Lake Ojibwa*. Ontario Department of Lands and Forests for the Royal Ontario Museum, Toronto.

Rogers, Edward S., and Mary B. Black
1976 Subsistence Strategy in the Fish and Hare Period, Northern Ontario: The Weagamow Ojibwa, 1880–1920. *Journal of Anthropological Research* 32:1–43.

Seymour, Deni J.
2011 *Where the Earth and Sky Are Sown Together: Sobaipuri-O'odham Contexts of Contact and Colonialism*. University of Utah Press, Salt Lake City.

Sharp, Henry S.
1981 The Null Case: The Chipewyan. In *Woman the Gatherer*, edited by Frances Dahlberg, pp. 221–244. Yale University Press, New Haven.

Smyth, Michael P.
1991 *Modern Maya Storage Behavior: Ethnoarchaeological Case Examples from the Puuc Region of Yucatan*. Memoirs of Latin American Archaeology 3. Department of Anthropology, University of Pittsburgh, Pittsburgh.

Speck, Frank Gouldsmith
1945 *The Iroquois: A Study in Cultural Evolution*. Cranbrook Institute of Science, Detroit.

Starr, Frederick
1899 *Indians of Southern Mexico: An Ethnographic Album*. Lakeside Press, Chicago.

Stein, Julie K.
2000 *Exploring Coast Salish Prehistory: The Archaeology of San Juan Island*. Burke Museum of Natural History and Culture, University of Washington Press, Seattle.

Stewart, Hilary
1982 *Indian Fishing: Early Methods on the Northwest Coast*. Douglas and McIntyre, Vancouver; University of Washington Press, Seattle.

Turkeysong
2009 Lime Squad! I: A Photo Essay on Lime Burning. Electronic document, http://turkeysong.wordpress.com/2011/03/06/lime-squad-i-a-photoessay-on-lime-burning, accessed May 27, 2013.

Vennum, Thomas
1988 *Wild Rice and the Ojibway People*. Minnesota Historical Society Press, Saint Paul.

Verbeeck, Lieve
1998 Bul: A Patolli Game in Maya Lowland. *Board Games Studies* 1:82–100.

Voorhies, Barbara
1976 *The Chantuto People: An Archaic Period Society of the Chiapas Littoral, Mexico*. Papers of the New World Archaeological Foundation, No. 41. Brigham Young University, Provo, Utah.
2004 *Coastal Collectors of the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

2013 The Deep Prehistory of Indian Gaming: Possible Late Archaic Game Boards at the Tlacuachero Shellmound, Chiapas, Mexico. *Latin American Antiquity* 24:98–115.

Voorhies, Barbara, and Douglas J. Kennett

2011 A Gender-Based Model for Changes in Subsistence and Mobility During the Terminal Late Archaic Period on the Coast of Chiapas, Mexico. In *Early Mesoamerican Social Transformations: Archaic and Formative Lifeways in the Soconusco Region*, edited by Richard Lesure, pp. 27–46. University of California Press, Berkeley.

Voorhies, Barbara, Douglas J. Kennett, John G. Jones, and Thomas A. Wake

2002 A Middle Archaic Archaeological Site on the West Coast of Mexico. *Latin American Antiquity* 13:179–200.

Wake, Thomas A., Natalie Anikouchine, and Barbara Voorhies

2004 Food Procurement and Processing: Fish and Game Remains at the Shellmound Sites. In *Coastal Collectors in the Holocene: The Chantuto People of Southwest Mexico*, by Barbara Voorhies, pp. 158–206. University Press of Florida, Gainesville.

Weiner, Stephen

2010 *Microarchaeology: Beyond the Visible Archaeological Record*. Cambridge University Press, Cambridge.

Wells, E. Christian, Claire Novotny, and James R. Hawken

2007 Quantitative Modeling of Soil Chemical Data from Inductively Coupled Plasma-Optical Emission Spectroscopy Reveals Evidence for Cooking and Eating in Ancient Mesoamerican Plazas. In *Archaeological Chemistry: Analytical Techniques and Archaeological Interpretation*, edited by Michael D. Glascock, Robert J. Speakman, and Rachel S. Popelka-Filcoff, pp. 210–230. American Chemical Society, Washington, D.C.

Yellen, John

1977 *Archaeological Approaches to the Present: Models for Reconstructing the Past*. Academic Press, New York.

Chapter 11

Site Formation Process and Function at Mega-Shellmounds: Refuse Heaps or Platform Mounds?

Barbara Voorhies

"By far the majority of these monuments of a past race are mere refuse heaps, the debris of villages of an ichyophagous population, showing no indications of having been designedly collected in heaps, true analogues of the *kjokkenmoedding*s (kitchen middens) of the age of stone; but in other instances it would appear that the Indians collected them into artificial mounds, forming a class of antiquities heretofore unnoticed by archaeologists" (Brinton 1867:356).

The present monograph is focused primarily on investigations of formation process and function of a series of floors positioned under the summit of the Tlacuachero shellmound but now deeply buried within unconsolidated shell deposits dating to the Late Archaic period. In this final chapter I briefly comment on a separate but related topic: formation process and function of the unconsolidated shell deposits that entomb these floors. Previously I have discussed this topic in some detail (Voorhies 2004), and since I have no additional evidence or revisions in my interpretations it is unnecessary here to reiterate the argument. However, some additional discussion is warranted in light of the fact that John E. Clark and John Hodgson (2009) have proposed that some early shell mounds of the Chiapas coast, including Tlacuachero, were constructed intentionally as platform mounds rather than having been formed by the incremental accretion of waste resulting from food preparation activities, as I have inferred. Unfortunately, the article expressing this counter interpretation by Clark and Hodgson remains unpublished at the time I am writing.

The view of Clark and Hodgson (2009) is that most clamshells in the shellmounds were laid down as construction material in order to build platform mounds within the coastal wetlands. In contrast, the view of Voorhies and colleagues (Voorhies 2004; Voorhies et al. 2002) is that the clamshells are by-products of food-processing activities. Although these two interpretations seem diametrically opposed, it must be noted from the start that they are not absolutely so, in that Clark and Hodgson admit that some of the shellmounds' contents may have derived from food consumption, and I acknowledge the value of artificial mounds in an inundated landscape as providing elevated places not subject to flooding, where people could carry out specific activities. The crux of the difference in the two interpretations is whether live clams (or perhaps only their shells) were brought to these sites specifically as construction material or in order to cook them so as to procure their meat.

It is helpful to consider how Clark and Hodgson arrived at their interpretation before I present evidence that this emerging debate about how the known shellmounds of the Chiapas coast were formed and used in the prehistoric past parallels similar debates in various other regions.

During an archaeological survey within a previously unstudied section of the coastal wetlands of Chiapas, situated between my study area to the northwest and Clark's study area to the southeast, John Hodgson discovered a large, elongated flat-topped mound. Hodgson named the new site Alvarez del Toro, after the famous Chiapas naturalist Miguel Alvarez del Toro. Hodgson discovered that looters previously had breached the mound, thus exposing some of its contents and structure. Hodgson observed that the mound had repetitive layers that upon subsequent laboratory analysis were determined to consist "of a mixture of both crushed and burned shell, animal bone fragments, lime putty, and predominantly volcanic aggregate" (Clark and Hodgson 2009:11). Since these investigators thought that this combination of substances could not occur naturally, the floors were determined to have been "man-made cement floors." The "cement floors" are separated by layers of "crushed marsh clamshells" (Clark and Hodgson 2009:11), by which may be meant unconsolidated, heat-fractured shells.

The looters' pit exposed only the upper 3 m of the mound, but Hodgson took six samples of charcoal from exposed sidewalls, which were then radiocarbon dated. The dates are in correct stratigraphic sequence and indicate that the upper part of the mound formed between 5,960 to 5,120 years ago (3960–3120 BCE) (Clark and Hodgson 2009:10). This puts this site squarely within the time span of the Middle Archaic period in the general Mesoamerican chronology, thus antedating Tlacuachero. Because the available dates do not span the entire vertical depth of the mound, it is certain that the mound began even earlier than the earliest date.

Accordingly, the available description of the structure of the Alvarez del Toro site indicates a situation considerably different from that at Tlacuachero, despite the fact that both sites share similarities such as being mounds within the coastal wetlands, Archaic in age, formed largely by clamshells, and exhibiting internal bedding. At Alvarez del Toro, at least in the cut where observations were made, the stratigraphy consists of alternating "cement floors" and crushed shell. In contrast, the bedded shell layers at Tlacuachero consist of alternating layers of unconsolidated whole shell valves and unconsolidated shell gravel caused by in situ burning. In addition, a very notable feature of the visible contents of the Tlacuachero site is the abundance of burned plant material dispersed throughout the strata. The small, thin flecks of charcoal appear to derive from burned grass and leaves for the most part, but occasionally tiny twigs are found. The shell gravel layers have more small pieces of burned plant material compared with the layers of whole shell valves.

The emerging debate about whether the Chiapas shell mounds formed as a gradual accumulation of waste from food processing or were intentionally constructed platform mounds (Clark and Hodgson 2009) has parallels in several other regions and perhaps just about everywhere where monumentally large, high shellmounds have been reported. In fact, as the late-19th-century quote at the beginning of this chapter indicates, these two opposing views about shellmounds have a long-standing history. And, as I have indicated, this debate continues unabated to the present day. To highlight this issue, I will briefly discuss four regions where an analogous debate about the site formation process and function of large shellmounds is under way.

In the following discussion I focus only on colossal shellmounds found in various global coastal environments in order to highlight the recurrent debate about their formation processes. I refer to these shell-bearing sites as mega-shellmounds. This term is inspired by but is not to be confused with the megamiddens reported from the southwest Cape of South Africa (e.g., Henshilwood et al. 1994; Parkington 2006:71, 75). I propose the term *mega-shellmound* term to avoid a priori judgments about site structure, contents, and formation processes, in contrast to implications intended by the originators of the term *megamidden*.

Megamiddens are defined as massive accumulations of shell, consisting overwhelmingly of only one species of mollusk, dispersed small fragments of charcoal, and variable amounts of sand (Henshilwood et al. 1994:103). Their contents are further described by their investigators as depauperate in cultural material (artifacts and animal bone) and "homogeneous," by which I think is meant that contents are similar throughout the site but perhaps also that the deposits are unbedded. In other words, the term is intended by its originators to imply specific attributes of site structure and contents. Field archaeologists interpret this particular type of shellmound as having

been formed by logistically mobile hunter-gatherers who disposed of shells at sites dedicated to shucking and drying mollusks (Henshilwood et al. 1994:104). The deliberate use of the term *midden* is intended specifically to indicate the accretionary formation process of this site type. Incidentally, I have considered Tlacuachero and its neighboring shellmounds as prime examples of megamiddens, but for the present discussion I avoid this term.

Mega-shellmounds, in contrast to megamiddens, are simply huge mounds consisting principally of shell. I am purposefully not restricting this proposed term on the basis of a priori assumptions about either site structure or site contents (other than the presence of abundant shell), which clearly vary. Rather I want to focus this discussion on shellmounds that are imposing features dominating the flat alluvial landscapes where they occur. These types of shellmounds have such high visibility that they were among the earliest archaeological sites to attract attention, and as such they "furnished ample food for antiquarian thought and, indeed, were the subject of some of the earliest scientific archaeology" (Waselkov 1987:93). Initially, these large mega-shellmounds inspired debate over whether their origins were due to nonhuman processes of accumulation or were the result of human activities. As observations increased, the consensus gradually emerged that such sites were definitely the products of human activities, and they became known generally as kitchen middens. Japetus Steenstrup most authoritatively put forth this view in 1851 (Waselkov 1987:139).

Today there is no longer any doubt that shellmounds are the result of human actions, but the debate about their origin has shifted to the actual nature of the site formation process carried out by human agents. Some archaeologists—let's call them accretionalists—think that the high, massive mounds, which are usually the shape of truncated cones, result from the buildup of debris in locations where there are environmental constraints on habitable terrain. A wetland environment is the usual constraint proposed, and under such conditions of formation, the site forms as an island surrounded by water. Other archaeologists—let's call them constructionalists—think that the high mounds were intentionally constructed of shells to provide an elevated landform for residential or ritual purposes. Thus they are equivalent to earthen platform mounds, except the construction material is shell. Below I summarize some of the parallel debates that have arisen in various places where mega-shellmounds occur. My goal is not to attempt to resolve the individual debates but rather to highlight their similarities and some of their methodological weaknesses. I consider the El Calón mound in northwest Mexico, shellmounds in the southeastern United States, shellmounds in the San Francisco Bay region, and shellmounds in southeastern Brazil.

Northwest Mexico

The El Calón shellmound within the Marismas Nacionales of northwest Mexico has been interpreted in different times as both an accretionary mound composed of food by-products and as an intentionally constructed platform mound. This 21-m-high, truncated, conical mound (Grave Tirado 2008:10; see also Shenkel 1974:Figure 2) towers above the surrounding landscape. It is formed of shells of various lagoonal-estuarine mollusks but predominately of articulated valves of the large, heavy-ribbed ark (*Anadara grandis*).[1] Initially the site was brought to the attention of archaeologists during a State University of New York (SUNY) regional survey that centered on the Teacapan Estuary in Sinaloa and Nayarit, during which more than 627 shell-bearing sites were recorded (Shenkel 1971:64).[2] Based upon the untested assumption that these shells were food remains, Richard J. Shenkel (1971) used the project data in his dissertation, in which he calculated the volume of shell deposits in all the inventoried sites. Then, using a mathematical formula, he estimated prehistoric population size. The volume of El Calón was included in these calculations (Shenkel 1971:220), which of course implies that he considered the contents of the site to be food remains. Significantly, at the time Shenkel wrote his dissertation, the site remained unexcavated and he had visited it only once for a mere two hours (Shenkel 1971:109; see also Shenkel 1974:62).

Members of the SUNY project, including Shenkel, later revised the view that the El Calón mound was an aggregation of discarded food remains, although they readily admit that this was the formation process responsible for hundreds of other shellmounds in the region (Scott and Foster 2000:130). Stuart D. Scott (1974:53), the project principal investigator, refers to El Calón as a "temple mound," citing both its monumental size and its truncated pyramidal shape. In an article published in the same volume as Scott 1974, Shenkel reveals that he and others had had the opportunity to revisit El Calón

prior to the time the article went to press. At that time the team mapped the site (Shenkel 1974:Figure 2), and its dimensions were more accurately determined. There is no mention that any excavation was conducted at the time, and this was confirmed in a later article (Scott and Foster 2000:130). However, based upon the new data, Shenkel too was convinced that the mound is a deliberate construction:

> It seems probable that El Calón is not an artifact of aboriginal gastronomy, for the unopened condition of many of the shells precludes their having been eaten. The cleanliness of the deposition, with no build-up of additional organic life maintenance by-product, would seem to eliminate a midden interpretation. This interpretation seems further inappropriate in view of the rather complete lack of cultural debris, other than that which could be ascribed to ceremonialism. Finally, one could seriously question the likelihood of anyone scaling a steep-sided trash heap to an elevation of over 20 meters, just to deposit more trash. Considering these data, El Calón is interpreted as being a temple mound [Shenkel 1974:66].

This view is echoed in a later article by Scott and Foster (2000:132): "There can be little doubt that a 25-m-high platform mound using unopened *Anadara grandis* as a construction medium was not just a heap of shell but rather an artifact of some localized sociopolitical–religious (?) behavior pattern."

Grave Tirado (2008:3) conducted two seasons of fieldwork at El Calón in the early 2000s, during which time he modified the SUNY site map and excavated five test pits (Grave Tirado 2008:12), the first excavations at this site. The amended map reveals two low platforms contiguous with the conical El Calón mound, revised to measure 20.70 m in height (Grave Tirado 2008:10). Grave Tirado (2008:13) confirms the earlier investigators' observation that the mound is composed of molluscan shells and little else, with the principal mollusk being the ark (*Anadara* spp.). He offers the additional observation that the site contents are unbedded and that there are abundant vertebrate remains in the deposits (Grave Tirado 2008:21). The latter finding would seem to cast doubt on the interpretation that the mound was intentionally constructed. However, Grave Tirado (2008) is convinced not only that it was intentionally built but also of its sacred character, an interpretation that as far as I can tell is based solely on the discovery of several clay figurines in the upper deposits, which he encountered in the test pit positioned at the mound's summit.

The age of Cerro El Calón is relevant both to the interpretation of site formation and function and to our research at Tlacuachero, because one investigator, Stuart Scott, contends that it was formed early in the Early Formative period, placing it fairly close to the age of the Acapetahua shellmounds. Scott places the age of El Calón at approximately 1750 B.C., based upon five radiocarbon dates run on shell that average out to 3,700 radiocarbon years (Scott 1999:18, Note 3; Scott and Foster 2000:130) or are calibrated at 1750 BCE The dates, if valid, would place the mound close to the traditional time between the end of the Archaic and beginning of the Early Formative period in the general Mesoamerican chronology. Unfortunately, details about the position of the samples within the mound, which were taken from cleaned profiles in erosional gullies (Scott 1999:18), have not been provided in the material that I consulted. More importantly, there remains the possibility, admitted by Scott (1999:18), that the date of the shells may not be the same as the date of the mound, since old shell beds may have been mined for construction shell. Nonetheless, Scott and Foster (2000:131) think it likely that live mollusks were used in the mound construction, because most remain articulated.

In stark contrast, two other investigators insist that El Calón is much younger than Scott's interpretation. Shenkel (1974:66), the field investigator who did pioneer work at the site, initially estimated its age to be between A.D. 700 and 1000, based only on his understanding of the general archaeology of the numerous shellmounds around the Teacapan Estuary. Similarly, Grave Tirado (2008:5) argues that El Calón could be no earlier than A.D. 750, the customary beginning of the Aztatlán Horizon (A.D. 750-1200), the cultural period with which Grave Tirado posits the mound is affiliated. His reasoning is based upon the faulty assumption that it is only by this time in prehistory that society was sufficiently complex to construct such an imposing monument, as well as the fact that the handful of diagnostic artifacts uncovered at the site date to this time period. Unfortunately, these artifacts were found in the uppermost deposits, so it could be convincingly argued that

they are not in any way representative of the age of the mound's initial formation. In short, it has to be admitted that at present, the age of the El Calón mound remains unverified.

To summarize, research to date at El Calón has failed to address the question of site formation in a focused, systematic way as called for by Schiffer (1983). There is simply insufficient published information about the internal structure and contents of the site to properly address this issue, which means that site formation at El Calón remains unknown. Moreover, the separate but related question of site function has been addressed by applying a priori ideas about the "ideal" shape of Mesoamerican platform mounds, without due consideration of the possibility that a similar shape might be the result of geomorphological processes acting upon a culturally formed shell pile. Finally, even if El Calón was imbued in late times with sacred meaning, it does not necessarily follow that it was originally built for this purpose. I also note the tautological reasoning expressed by the argument that since the mound has the shape of a typical Mesoamerican pyramidal platform mound, it must be relatively late in age, and if late in age, it must be a constructed platform mound.

Southeastern United States

The American Southeast is another region where the formation and function of shellmounds have been the recent subjects of debate. Colossal shellmounds occur in some portions of the coastline, as well as along some principal rivers, for example the Saint Johns River in eastern Florida and the Green River in Kentucky. The first investigators of these imposing shellmounds were not principally concerned with either site formation processes or site function but rather with establishing the age of the sites and describing their artifacts. Nevertheless, the view accrued over time that most large shellmounds in the Southeast were formed by mobile hunter-gatherer-fishers who, it was presumed, did not have the economic base to support permanent settlements such as villages, much less the construction of monumental features (e.g., Russo 1996:260).

The prevailing view among early investigators was that the shellmounds were formed of discarded food remains. Researchers at shellmounds in the upper and middle reaches of the Saint Johns River noted the presence of abundant shells of freshwater mollusks and animal bones, along with domestic implements and hearths, and inferred that these were habitation sites (e.g., Wyman 1875), although the low abundance of tools (e.g., Moore 1894:26) led some archaeologists to propose that occupation was temporary rather than permanent.

Along the Green River of Kentucky, where shellmounds were investigated most intensively between 1937 and 1941 in extensive projects financed by the New Deal (Jeffries 1996:58), the archaeological evidence suggested to investigators that the sites consisted of debris resulting from intense occupation. This evidence consisted of the presence of shells of freshwater mollusks, along with abundant and diverse artifacts (including tools for everyday activities), hearths, storage pits, prepared clay floors, and many human burials, often with grave goods. Significantly, however, there is no pottery in these Green River shellmounds, so from the start they were assumed to be very early—that is, prior to the adoption of pottery and the presumed onset of settled village life.[3] Although the early researchers did not directly address the idea of site function, it seems clear that they usually interpreted these shellmounds as some kind of habitation site: "The caches of heavy artifacts, small piles of objects lying close together, usually consisted of from 2 to 7 implements, including hammer stones showing usage, bell pestles, cylindrical pestles, and occasionally grooved axes. These were the tools used in the daily domestic life about the fires. They were found thus together where they were last used, always in the vicinity of a fire hearth" (Webb 1950:363).

The discovery and subsequent study in the 1960s and 1970s of the permanent village site at Koster, Illinois, in the lower Illinois River valley, thought to have been occupied as early as 8,700 years ago by nonagricultural peoples, may have had the effect of further bolstering the view that the large riverine shellmounds of the southeastern United States might have been relatively permanent occupation sites. That is, if the village site at Koster was based on a nonagricultural economy, then it became increasingly plausible that coeval riverine shellmounds were permanently settled. One explanation for the permanent architecture evident at Koster is that after about 7,000 years ago, the Illinois River floodplain formed biologically productive slack water environments, permitting a low-risk, reliable food source (Brown and Vierra 1983; Sassaman and Ledbetter 1996:77), a logic that may be easily extended to explain the data at riverine shellmounds.

Today it is generally acknowledged that in the Southeast, "permanent" architecture dates to at least 7,000 years before present (Sassaman and Ledbetter 1996:75), prior to the advent of an agricultural way of life. This recognition that sedentary life is possible for hunter-gatherer-fishers led to the claim that riverine shellmounds developed because of a new dependency upon fluvial resources formed during the climatic warming period of the Holocene climatic optimum (Hypsithermal), between 9,000 and 5,000 years ago. This explanation was proposed to explain the timing of the onset of riverside shell heaps of Kentucky, which were also interpreted as habitation sites occupied by nonagricultural people who relied heavily on nearby rich aquatic resources (see Claassen 1991, 2011). Nonetheless, as Claassen (1991:289; 1992:2) notes, even among archaeologists who think these mounds accumulated as a result of habitation, there is a wide diversity of opinion about their degree of occupational permanency, seasonality, and site type.

However, the opposing view—that at least some of the mounded sites in the southeastern United States were intentionally constructed ceremonial mounds—began gathering momentum in the 1990s, although Michael Russo (1996)[4] credits Sherwood Gagliano (1963) as the first to propose that some southeastern Archaic mounds may be ceremonial in function. Cheryl Claassen (1991, 1992, 2011) has been a recent champion of this interpretation by proposing that some southeastern shellmounds were intentionally constructed burial monuments. She focuses particularly on the shellmounds of the Shell Mound Archaic, a cultural phenomenon involving (1) the mounding of shells, (2) the use of mounded shell for burials, and (3) the lack of evidence for permanent housing that took place between 5,500 and 3,000 years ago along certain northeastern tributaries of the Mississippi River (Claassen 1991:287).[5] Her evidence for this proposal is the abundance and density of burials in these shellmounds, the fact that shells are often accorded symbolic significance in ancient societies, and the fact that other regional site types, including possible habitation sites, may be part of the same settlement system (Claassen 1991, 1992:4). It seems entirely plausible that when the mounds functioned as cemeteries, they were imbued with sacred meaning as Claassen posits, but it does not logically follow that the mounds were intentionally constructed for the explicit purpose of being burial mounds. Nor, as Sassaman and Ledbetter (1996:82) have noted, is the conclusion of intentionality supported by any evidence that some deposits formed as a result of mortuary feasting.

In the southeastern region, the issue of formation and function of shellmounds is intertwined with the broader question of whether or not hunter-gatherer-fisher people of the Archaic period constructed platform mounds for ceremonial purposes, no matter what construction material—earth or shell—might have been used. Analogously to the impact that Koster had on how archaeologists thought about the past, the subsequent discovery at Poverty Point (Gibson 1996, 2001) and Watson Brake (Saunders et al. 2005:631–668), both in northern Louisiana, gave further impetus to the view that hunter-gatherer-fishers constructed monumental architecture. The platforms at these two sites are formed of earth, not shells. However, the importance of these sites is that their spatial layouts provide strong, irrefutable evidence for planned, intentional constructions. These and other early mounded southeastern sites show that the frequently assumed link between constructed architecture, even monumental architecture, and sedentary agriculturalists is not inevitable or invariable (e.g., Russo 1996; Sassaman and Ledbetter 1996).

Russo (1996) provides a useful overview of the history of this larger debate. In addition, he presents brief descriptions of mounded landforms suspected as being both Archaic in age and intentional constructions that he infers to have had a ceremonial function. Most of his evidence, as presented in the cited article, is more concerned with making the case for the age of these mounds than for their formation process and function. In only one example, the Horr's Island site in Florida, does Russo even mention supporting stratigraphic evidence: Mound A is described as consisting of alternating sand and shell layers (Russo 1996:272), although the accompanying stratigraphic profile presents a somewhat less clear-cut picture. My main point, however, is that careful presentation of actual stratigraphic evidence is exactly what is needed to address the question of site formation process, as I discuss further below.

How then does an archaeologist determine whether a mega-shellmound is a purposeful or accidental formation? As freely acknowledged by Russo (1996:260), a proponent of the view that at least some of the southeastern riverside shellmounds are purposefully constructed ceremonial mounds, it can be very difficult for archaeologists to distinguish ceremonial mounds from mounded middens:

> Ceremonial mounds are tumuli that may contain human burials, ceremonial objects, tombs, earthen platforms, and structures, reflecting construction episodes and shapes indicating that mound construction was intentional and purposeful for activities unrelated to or beyond the simple disposal of refuse and other mundane activities…. Ceremonial mounds are distinguished from mounded middens, which are usually seen as the incidental accumulations of midden refuse that may include earth, shell, animal bone, and other cultural material associated with daily maintenance activities. As such, mounded middens may include features such as postmolds of domestic structures, hearths, tools associated with food preparation, and storage pits.… Distinguishing ceremonial mounds from mounded middens becomes difficult when characteristic traits of each are found, or are lacking, in a mounded feature [Russo 1996:260].

The various controversies over how certain shellmounds were formed and used that I am briefly summarizing here provide clear support for Russo's contention that these issues present the archaeologist with great difficulty. However, the adoption of improved field methods in the analysis of the internal structure and contents of mega-shellmounds will go a long way to resolve some of the difficulties, as I discuss further below. This is the only way to approach the research problem, because even if a mega-shellmound occurs in a planned site layout, there remains the possibility that it originated as a solitary, conical, or loaf-shaped mound that later became incorporated as part of an intentionally planned site. For this reason, it remains incumbent upon the archaeologist to use internal evidence to make a focused argument about site formation process and function.

San Francisco Bay Region

The area around the San Francisco Bay in central California is another key location where archaeologists have wrestled with the issue of formation processes responsible for large, imposing shell mounds. This misnamed bay, which is actually the largest lagoon-estuary system on the California coast, once was a resource-rich environment that attracted hunter-gatherer populations (e.g., Luby et al. 2006:192). Pioneer archaeology was conducted in the early 20th century at several of the mammoth shellmounds situated on the interior margin of the estuary, such as Emeryville, Ellis Landing, West Berkeley, and Patterson (Lightfoot and Luby 2012:214, Figure 18.1). These irreplaceable archaeological resources are now nearly totally eradicated from the landscape due to urban development, but the largest shellmounds are estimated to have been "five to ten or more meters above the land surface, extending across the equivalent of a couple of football fields" (Lightfoot and Luby 2012:214).[6]

Regional studies have shown many different types of shell-bearing sites in this area that vary greatly in size and contents. The size ranges from thin surface shell scatters to the large and high artificial mounds characterized in the quote by Lightfoot and Luby (above). The principal difference in the contents of the shell-bearing sites seems to be in the relative amount of shell compared to other sediments, such as clay, rocks, ash, and sand. Moving upstream from the northern bay area toward the Sacramento River delta, shells decrease in frequency, until the earthen mounds are composed principally of sand and clay (Luby et al. 2006:194). These considerations have prompted recent investigators to propose a typology of site types (Luby et al. 2006:Figure 3), but my concern here is only on the large shellmounds.

Lightfoot (1997) and Luby, Drescher and Lightfoot (2006:196–197) have provided useful discussions of site types and/or functions of the shellmounds of the San Francisco Bay region, and I draw heavily from these sources in the present summary. These authors note that the earliest investigators, working in the early 20th century, interpreted the formation process of the large shellmounds to have been accretional and unintentional due to the gradual accumulation of "midden" as a result of hunter-gatherers' fishing, gathering, and hunting activities (Gifford 1916; Nelson 1910:380; Schenck 1926:205, 275; Uhle 1907:21). Most early investigators interpreted these shellmounds as village sites used also as cemeteries: "The early excavators interpreted the shell mounds as the remains of large villages created by the accumulation of domestic refuse over hundreds or thousands of years" (Lightfoot 1997:129). This view may be traced back to Nelson's (1910) investigation of the Ellis Landing shellmound (Luby et al. 2006:196), where he interpreted surface circular depressions as house depressions. Lightfoot (1997:134–135) succinctly

and usefully summarizes the architectural features at the large shell mounds, which were found both within the mounds and on their surfaces. This early accretionary view (see Lightfoot 1997:131) was based also on other considerations: the wide variety of domestic and other artifacts found in the deposits, the results of sediment content analysis (Gifford 1916), and the perhaps unconscious assumption that American Indians were not sufficiently advanced to have built monumental architecture (Trigger 1986). In this view, the explanation for many burials found in some shellmounds is that the mounds were used opportunistically as cemeteries. Another related interpretation is that in some instances the mounds functioned as specialized places (logistical sites) for processing specific resources such as fish. This interpretation, derived from the large number of net sinkers and fish bones in some locations (Luby et al. 2006:196; Moratto 1984:236), is a variant of the view of shellmound sediments as unintentionally accretional.

In stark contrast to this earlier traditional view, more recently some archaeologists have argued that the large shellmounds were built "as a planned program of monumental construction on the bay shore landscape" (Luby et al. 2006:196). These constructionalists argue that the mounds were built specifically to serve as cemeteries (Luby et al. 2006:196; Meighan 1987) or as gathering places for large public events, such as performances and feasts, in addition to being built for mortuary functions (Luby 2004; Luby and Gruber 1999). Lightfoot (1997:132) argues that the prevalent view that the mounds consist of domestic refuse needs to be "carefully reconsidered." His two principal reasons are the low artifact density in the investigated shellmounds and that comparable mounds elsewhere, such as in the American Southeast, have been interpreted as specialized burial or ceremonial sites (Lightfoot 1997:133, citing Claassen 1991).

In summary, despite the century-long history of archaeological research in the San Francisco Bay area and the importance of the area for the understanding of North American prehistory, there appears to be no real consensus about the formation process or site function of the massive shellmounds that were once present on the landscape. This is due to many almost insurmountable complicating factors originating principally from the loss of the archaeological resources. (See Luby et al. 2006 for a discussion of this situation.) However, a recent initiative has been launched to take a fresh look at old research and to integrate the newest archaeological work—mostly from piecemeal cultural resource management projects—into a broad regional framework (Luby et al. 2006:198–211). Thus we can look forward to the development of new insights as work progresses.

At the present time, however, it seems to me that archaeologists concerned with the prehistory of the San Francisco Bay area have failed to adequately distinguish between site function and site formation processes. These logical concepts admittedly may be related but must necessarily be kept analytically separate. For example, Lightfoot (1997:139), in his very useful overview of the San Francisco Bay area shellmounds, offers a discussion under the heading "Formation of Early Shell Mounds" in which he presents four reasons why the massive shellmounds "were produced by Bay area peoples beginning in the late Middle Holocene." The reasons that he proposes are (1) to keep villages high above the water level, (2) to provide access to nearby estuarine resources, (3) to provide long-term repositories for the dead, and (4) to serve as territorial symbols for local groups. These four proposed functions, which I think Lightfoot intends to be complementary, address site function rather than site formation process.

The difference between these two concepts is critical. For example, just because a mounded space contains human burials does not in itself explain whether the mound was built specifically for that purpose or had formed in an entirely different way, such as by accretion of discarded materials resulting from human food consumption or even by geologic agents. Archaeologists must use standard geologic methods for interpreting mound stratigraphy and thus inferring the processes of site formation to address the issue of how the hypothetical mound formed. I return to this important point below after surveying one last example, that of the *sambaquis* of southeastern Brazil.

Southeastern Brazil

Similarly to the San Francisco Bay region, the massive shellmounds dominating the coastal landscape of southeastern Brazil were among the first archaeological sites in the area to attract the attention of natural historians (Gaspar 2000:11). These mega-shellmounds are among the most imposing shellmounds of anywhere in the world, and some today are as high as 50

m (Gaspar et al. 2008:320), despite many depredations caused by historic mining of the sites for shells to be used for lime production and construction fill. The earliest debate about the origins of the *sambaquis*, as the shellmounds are called in Brazil (Gaspar 1998:592), focused on whether they were formed by people or nonhuman agents. This debate was dominant in the first phase of Brazilian archaeology, dating to between 1870 and 1930 (Gaspar 2000:11). This debate receded once excavations revealed that many *sambaquis* contained abundant human burials and cultural artifacts, which proved beyond any doubt that humans were the agents of formation.

Once the issue of the principal agents of site formation had been settled, most investigators presumed that the shellmounds were accumulations of food waste, if they contemplated the issue of site formation at all. As Gaspar and colleagues (2008:321) have pointed out, studies during this time tended to focus on artifact typology, the nature of faunal assemblages, and physical traits of human skeletons. For example, the publication resulting from Bryan's early study of the Forte de Marechal Luz shellmound in Santa Catarina, carried out in 1960, presents a detailed description of site structure as well as site contents, but his emphasis and interpretations are focused almost entirely upon cultural affiliations of the artifacts (Bryan 1993; see also Bryan 1961). This focus is typical for the time Bryan was working, of course (e.g., Gaspar et al. 2008:321), but he seems to have considered the shellmound to be an accumulation of food remains, despite the fact that he did not directly address the issue of site formation processes. For example, Bryan refers to the site in several places as a "garbage dump" (Bryan 2000:6,106), a site function designation that implies a particular site formation process (discard). Bryan was working at a time when systematic excavations and radiocarbon dating were just beginning in Brazil, starting perhaps in the 1950s, and a growing awareness of the destruction of these sites was taking hold (Gaspar et al. 2008:322). The general consensus of archaeologists working on *sambaquis*, whether or not explicit, was either that the mounds were habitation sites that increased over time due to the accumulation of domestic garbage or that they functioned primarily as cemeteries where food waste was deposited during funerary rituals.

A more recent stance, proposed by investigators conducting new, state-of-the-art research, has been to interpret the *sambaquis* as intentional, monumental constructions. For example, Afonso and De Blasis 1994 (cited in Gaspar 1998:594) argued that the thick basal deposit of shells from a single species of mollusk in a shellmound in the Santa Catarina region in southern Brazil indicates the shells' rapid accumulation, and thus the mound is interpreted as a constructed platform within a flooded mangrove habitat. The research team in the Santa Catarina project, codirected by Paolo DeBlasis, Paul Fish, Suzanne K. Fish, and Maria Dulce Gaspar, recently worked on the coast of Santa Catarina, where some of the most imposing and intact shellmounds are found (e.g., Gaspar 1998:610–612).[7] They regard some *sambaquis* as monumental constructions, imbued with symbolic meaning, that are "the result of socially articulated effort involving mortuary ritual and a cult of ancestors" (Gaspar et al. 2008:323).

An excellent example is the Jabuticabeira II shellmound, where the team did extensive work. The mound, which had been extensively mined for construction material prior to the onset of the archaeological project, left behind many long, nearly vertical cuts exposing the site structure and contents. In certain locations in the mound, human burials are concentrated both horizontally and vertically. In these funerary areas, the stratigraphy consists of repetitive layers of thin, organic-rich, dark-colored sediment containing abundant charcoal and burned fish bone that alternate with "thicker deposits of relatively clean shell" (Fish and Fish 2010:232). Burial pits and postholes originate from the dark layers. A lateral exposure in one of these dark layers revealed that postholes often encircle burial pits and that the graves were frequently topped with hearths or that hearths were located close by. Fish bone is concentrated especially in these contexts (Gaspar et al. 2008:326). Thus the researchers interpret the dark layers as having been formed as a result of the accumulation of food remains resulting from mortuary feasting. This presumably is an unintentional process of discard.

The researchers do not discuss in detail the intervening layers of shell in the publications that I have consulted, but they imply (Gaspar et al. 2008:326) that the shells were mined as construction material. In other words, the crux of any argument that Jabuticabeira II shellmound was an intentionally constructed platform mound hinges on presenting evidence for these shell layers being construction fill rather than food waste. That is, once again, the only way to address this issue is

to pay careful attention to all the stratigraphic evidence at the site.

Commonalities in These Debates and Future Research Directions

What insights can be gleaned from the foregoing brief review of debates concerning site formation processes and function of mega-shellmounds? To begin, the fact that this issue has arisen repeatedly in different regions is compelling evidence that this is a research topic calling for thoughtful attention. It is evident also that early investigators inclined toward the accretionalist interpretation of site formation, but more recently constructionalists have proposed alternative explanations for formation processes and function of mega-shellmounds, at least in the four regions I reviewed. This shift reflects broader shifts in archaeological research away from a focus on subsistence toward a greater focus on social organization. However, it is my contention that archaeologists need to greatly improve their research methods as employed in specific situations to critically assess these competing interpretations. In particular there appear to be two persistent limitations with current research, at least in the four cases considered here: a confounding of the concepts of formation process and site function, and a failure to precisely observe and describe site stratigraphy.

First, there is a recurrent pattern of archaeologists failing to analytically distinguish formation process and site function. Although in particular circumstances these concepts may be aligned, they are not inevitably so and must be kept separate analytically. For example, the determination of the site function of a mounded landform—of whatever origin—does not automatically reveal how that landform was formed. Thus if a group of people selects a mounded landform as an appropriate location to bury their dead—thus probably imbuing the location with sacred meaning—that tells us nothing about the process by which the landform was formed. An obvious case in point is when naturally formed hills are chosen for the location of cemeteries, as is often the case in our own society. In such an instance, the geologic process by which the hill formed is totally unrelated to the fact that people have selected the hilltop as a burial ground and thus have imbued it culturally with sacred meaning.

In fact, the need for focused studies on the formation process of mega-shellmounds is very great. Claassen (1996:258), for example, has noted that the lack of such studies is among the major handicaps frustrating attempts to interpret the social organization of peoples in the Southeast during the Middle and Late Archaic periods.

However, to adequately address the question of site formation process, it is essential that archaeologists adopt the methods of sedimentary geology, the lack of which is the second limitation that I find with most current research on shellmounds. To adopt the methods of sedimentary geology means that archaeologist must be highly observant of the stratigraphic record and that observations should be both systematic and scientifically objective. It is also valuable in the field to ponder questions regarding how deposits were formed and to consider alternative hypotheses, which will aid the archaeologist in making the necessary observations and in taking the necessary samples needed to further test these hypotheses. All of this critical information should be recorded in the field. It is equally important that relevant information be published to provide evidence that supports or rejects alternative hypotheses.

To recapitulate, at Tlacuachero it is necessary, of course, to investigate individually each of the major stratigraphic units, as well as each of the minor ones. For the site generally there are two major stratigraphic formations: an upper, unbedded stratum consisting of organic-rich, dark brown soil containing shells, potsherds, and other cultural material as inclusions; and a lower, bedded stratum consisting almost solely of molluscan shells alternating between layers of burned shell gravel and unburned whole valves of the marsh clam. Cultural material is notably very scarce in these lower deposits. In the large lateral excavation at the island center, three superimposed floors occur approximately halfway in the known vertical section of the bedded shell formation. But these features are spatially limited and do not extend very far horizontally. For this reason I envision the floors as constituting a large lens positioned within the bedded shell formation. These floors appear unique, since similar floors were not found at Tlacuachero in excavations away from the island center or at other similar, nearby, and approximately coeval shellmounds that I have investigated.

There has been almost no research on the upper formation of dark brown soil other than to establish that the overwhelming bulk of cultural material dates to the Late Preclassic/Early Classic time period and that the

cultural material dating from different time periods is thoroughly mixed and is not in chronologically correct stratigraphic order (Chapter 3). We also know that the people responsible for forming the upper soil deposits constructed platform mounds that may be readily seen on the site map (Figure 1.2).

The lower formation, consisting overwhelmingly of shells from the marsh clam (*Polymesoda* sp.), has now been dated more precisely than in the past (Chapter 2), and in particular the authors of Chapter 2 propose age ranges for the lower section of bedded shells, the individual floors, and the upper section of bedded shells based upon modeling a new set of radiocarbon age determinations. This study revealed the unsuspected finding that the lower and upper bedded shell deposits occurred in relatively short bursts while floor use spanned a significantly longer time. This finding invites a shift in perspective when considering the various data sets—reviewed in Chapter 10—that document discernible change over the duration of Late Archaic period occupation at Tlacuachero. This shift involves only the pacing of events; the nature of the events has not been revised but rather has been expanded by the research reported here.

I want to emphasize here that archaeologists working on shellmounds must adopt the standard field methods and terminology of sedimentary geology to advance our studies of these intriguing sites. My prior descriptions of the bedded shell deposits above and below the Tlacuachero floors (Voorhies 2004:42–51) are fairly detailed, but I now realize they could be much improved. To make the point, I offer the following description of stratigraphy of the bedded shell formation at Tlacuachero hewing to guidelines for observing sedimentary rocks (Stow 2005).

In general the stratigraphy as exposed in excavations at the site center consists of planar, continuous, parallel horizontal beds alternating between (1) medium-thick strata of unconsolidated, disarticulated valves of *Polymesoda radiata* containing small, thin fragments of burned plant material and unburned bone fragments and (2) very thin (1–3 cm) to thin (3–10 cm) strata consisting of burned shell fragments of *P. radiata*, generally in the small (4–8 mm) to medium (8–16 mm) size range, with occasional small fragments of charcoal and burned bone. The contact between an overlying unburned stratum and an underlying gravel stratum is sharp and distinct, whereas the contact between an overlying burned gravel stratum and an underlying unburned stratum and is less distinct and diffuse. The latter situation is due to an increase downward (that is, within the unburned shell stratum) from the contact in particle size and a decrease in discoloration from black to gray to white. These observations show clearly that the formation of the burned shell gravel layers occurred in situ, due at least in part to the presence of fire.

I interpret this stratigraphy as having resulted from a particular mode of cooking clams in large horizontal beds (Voorhies 2004:45–48), but whatever the actual cause, the empirical evidence is unambiguous that broadly extensive firing events repeatedly took place onsite, and resulted in the formation of a layer of burned shell gravel.

Another important point to emphasize here is that archaeologists must observe and describe each stratigraphic unit individually, as I suggested when discussing the Jabuticabeira II site in Brazil. This methodological procedure is elemental for sedimentary geologists, and Schiffer (1983:685) argues that it is equally applicable for archaeologists. I would like to underline this important point with another example.

I had the opportunity to casually observe a stratigraphic profile of a particular shellmound in Santa Catarina, Brazil, while a visiting a research project led by De Blasis, P. Fish, S. Fish, and Gaspar. According to my memory, which may be flawed but will suffice to make my methodological point, the stratigraphic cut revealed parallel planar bedding of strata alternating between beds of internally homogeneous silt and beds of unconsolidated shell gravel containing fish bone inclusions. At the time of my field observation, I thought that this striking stratigraphy might have resulted from repeated seasonal occupation by people who engaged in the onsite processing of fish and shellfish, thus leaving behind shell and bone subsistence debris, and from a seasonal human abandonment, during which time windblown sediment accumulated on the surface of the abandoned mound. In other words, in this case I postulated that the agents of site formation were both human (biotic) and wind (abiotic). A competing hypothesis to account for the silt layers, which conceivably might be favored by some other archaeologist, is that site occupants periodically brought in and laid out the fine sediment for some purpose, perhaps to clean up their site. If this is true, the site formation process would be the result

of both unintentional (subsistence debris) and intentional (construction surfaces) activities on the part of human agents of deposition.

How might we evaluate the merits of these two competing hypotheses of site formation? The answer hinges on careful observations and analyses of each type of bed and in this case especially the beds of fine sediment, since their formation process is what is at issue. In other words, the archaeologist needs to carefully evaluate the likelihood that wind was the agent of deposition of the layers of fine sediment. If this sediment were wind deposited, we would expect the particle size to be within the silt or very fine sand size range, since this is the size of particles usually susceptible to aeolian deposition, and would expect the sediment to consist of well-sorted particles. We also might expect the strata of fine sediment to be internally structureless and without internal grading. Other clues might be the degree of roundness of individual grains (Boggs 2001:79), mineral content, or even small diagnostic fossils if the source of the sediment was seasonally dried coastal lagoons, as I suspected. Other relevant evidence, such as a reconstructed climate regime, would of course be useful.

If all the accumulated evidence failed to falsify the hypothesis of aeolian deposition, it would still not rule out the possibility that people mined the seasonally dry lagoons in order to bring clean material to the shellmound for housekeeping or other purposes, but in my mind it would make this a much less likely possibility. Whatever the outcome, my principal reason for this hypothetical example is to stress the necessity of making the kind of observations that I am advocating.

Another type of observation that is too seldom presented in archaeologists' publications on shellmounds is the horizontal exposure of the upper surfaces of individual strata. This fortunately has been done by the team of the Santa Catarina project in Brazil, where excavators exposed the upper surface of one or more dark-colored strata at Jabuticabeira II (Gaspar et al. 2008:Figure 18.3). Our research team also has done this for portions of the three floors at Tlacuachero. However, this type of exposure is needed for all other strata—for example, the upper surface of the beds of unconsolidated unbroken shell valves at Tlacuachero. It is clear from the available data that these layers of shell gravel are living surfaces, but it is possible that much could be learned if archaeologists exposed large areas of their upper surfaces, which has never been done. This remains a goal for future research.

In conclusion, recent fieldwork at the Tlacuachero shellmound focused on the investigation of the floors encountered within the Late Archaic deposits at the site center, and most of the book chapters address various aspects of these investigations. The authors have presented detailed studies that address questions about when the floors were formed, what they were made of, what activities may have taken place on their surfaces, and why they were constructed. Not surprisingly, we don't have answers to all our questions, but we are confident that our investigations have moved forward the general discussion about the formation processes and function of shellmounds.

Notes

1 Shenkel (1974:64) provides quantified data on molluscan species at Cerro El Calón but does not indicate how many samples were analyzed or where the sample or samples were obtained. In his earlier dissertation, quantified data are provided also, but it is not clear if the single sample came from El Calón or another site with apparently similar contents (Shenkel 1971:109).

2 Scott (1971:52; 1999:17) says that more than 500 shell bearing sites were inventoried.

3 This work was done prior to advent of radiocarbon dating.

4 Russo's (1996) article provides a useful introduction to this persistent debate while privileging his own position on the subject.

5 For example, along the Ohio, Green, and Tennessee valleys.

6 Luby et al. (2006:164) give the dimensions as 9–183 m in diameter and 1–9 m high.

7 These investigators graciously invited me to visit their project, an experience for which I will be forever grateful.

References Cited

Boggs, Sam

2001 *Principles of Sedimentology and Stratigraphy*. Prentice Hall, Upper Saddle River, New Jersey.

Brinton, D. G.

1867 *Artificial Shell Deposits of the United States*. Annual Report of the Smithsonian Institution for 1866. Smithsonian Institution, Washington, D.C.

Brown, James A., and Robert K. Vierra
1983 What Happened in the Middle Archaic? Introduction to an Ecological Approach to Koster Site Archaeology. In *Archaic Hunter-Gatherers in the American Midwest*, edited by James L. Phillips and James A. Brown, pp. 165–195. Academic Press, New York.

Bryan, Alan Lyle
1961 Excavation of a Brazilian Shell Mound. *Science of Man* 1:148–175.
1993 The Sambaqui at Forte Marechal Luz, State of Santa Çatarina, Brazil. In *Brazilian Studies*, pp. vi–114. Center for the Study of First Americans, Oregon State University, Corvallis.

Claassen, Cheryl P.
1991 Gender, Fishing and the Shell Mound Archaic. In *Engendering Archaeology*, edited by J. Geero and M. Conkey, pp. 276–300. Basil Blackwell, Oxford.
1992 Shell Mounds as Burial Mounds: A Revision of the Shell Mound Archaic. *Current Archaeological Research in Kentucky* 2:1–11.
1996 A Consideration of the Social Organization of the Shell Mound Archaic. In *Archaeology of the Mid-Holocene*, edited by Kenneth E. Sassaman and David G. Anderson, pp. 235–258. Florida Museum of Natural History, University Press of Florida, Gainesville.
2011 *Feasting with Shellfish in the Southern Ohio Valley: Archaic Sacred Sites and Rituals*. University of Tennessee Press, Knoxville.

Clark, John E., and John G. Hodgson
2009 Settling Down in Middle America. Manuscript on file, Department of Anthropology, Brigham Young University, Provo, Utah.

Fish, Suzanne K., and Paul R. Fish
2010 Monumentality and Complex Hunter-Gatherers in Southeast Coastal Brazil. In *Monumental Questions: Prehistoric Megaliths, Mounds and Enclosures*, edited by David Calado, Maxiliam Baldia, and Matthew Boulanger, pp. 231–236. BAR International Series 2123. Archaeopress, Oxford.

Gagliano, Sherwood M.
1963 A Survey of Preceramic Occupations in Portions of South Louisiana and South Mississippi. *Florida Anthropologist* 16:105–132.

Gaspar, Maria Dulce
1998 Considerations of the *Sambaquis* of the Brazilian Coast. *Antiquity* 72:592–615.
2000 *Sambaqui: Arqueologia do Litoral Brasileiro*. Jorge Zahar Editor, Rio de Janeiro.

Gaspar, Maria Dulce, Paulo DeBlasis, Suzanne K. Fish, and Paul R. Fish
2008 Sambaqui (Shell Mound) Societies of Coastal Brazil. In *Handbook of South American Archaeology*, edited by Helaine Silverman and William H. Isbell, pp. 319–335. Springer, New York.

Gibson, Jon L.
1996 Poverty Point and Greater Southeastern Prehistory: The Culture That Did Not Fit. In *Archaeology of the Mid-Holocene Southeast*, edited by Kenneth E. Sassaman and David G. Anderson, pp., 288–305. University Press of Florida, Gainesville.
2001 *The Ancient Mounds of Poverty Point: Place of Rings*. University Press of Florida, Gainesville.

Gifford, Edward W.
1916 Composition of California Shellmounds. *University of California Publications in American Archaeology and Ethnology* 12(4):139–194.

Grave Tirado, Luis Alfonso
2008 El Calón, un espacio sagrado en las marismas del sur de Sinaloa. Paper presented at the 73rd meeting of the Society for American Archaeology, Vancouver.

Hensilwood, Christopher, Peter Nilssen, and John Parkington
1994 Mussel Drying and Food Storage in the Late Holocene, SW Cape, South Africa. *Journal of Field Archaeology* 21:103–109.

Jeffries, Richard W.
1996 Hunters and Gatherers After the Ice Age. In *Kentucky Archaeology*, edited by R. Barry Lewis, pp. 39–77. University Press of Kentucky, Lexington.

Lightfoot, Kent G.
1997 Cultural Construction of Coastal Landscapes: A Middle Holocene Perspective from San Francisco Bay. In *Archaeology of the California Coast During the Middle Holocene*, edited by Jon M. Erlandson and Michael A. Glassow, pp. 129–141. Perspectives in California Archaeology, Vol. 4. Institute of Archaeology, University of California, Los Angeles.

Lightfoot, Kent G., and Edward M. Luby
2012 Mound Building by California Hunter-Gatherers. In *The Oxford Handbook of North American Archaeology*, edited by Timothy R. Pauketat, pp. 212–223. Oxford University Press, Oxford.

Luby, Edward M.
2004 Shell Mound and Mortuary Behavior in the San Francisco Bay Area. *North American Archaeologist* 25(1):1–33.

Luby, Edward M., Clayton D. Drescher, and Kent G. Lightfoot
2006 Shell Mounds and Mounded Landscapes in the San Francisco Bay Area: An Integrated Approach. *Journal of Island and Coastal Archaeology* 1:191–214.

Luby, Edward M., and M. F. Gruber
1999 The Dead Must Be Fed: Symbolic Meanings of the Shell Mounds of the San Francisco Bay Area. *Cambridge Archaeological Journal* 9:95–108.

Meighan, Clement W.
1987 Rexamination of the Early Central California Culture. *American Antiquity* 52:28–36.

Moore, Clarence B.
1894 Certain Shell Heaps of the Saint Johns River, Florida, Part II. *Journal of the Academy of Natural Sciences of Philadelphia* 10:129–146.

Moratto, Michael J.
1984 *California Archaeology*. Academic Press, Orlando.

Nelson, Nels C.
1910 *The Ellis Landing Shellmound*. University of California Publications in American Archaeology and Ethnology, Vol. 7, No. 5. University of California, Berkeley.

Parkington, John
2006 *Shorelines, Strandlopers and Shell Middens: Archaeology of the Cape Coast*. Neil Rusch, Living Landscape Project, Krakadouw Trust, Cape Town, South Africa.

Russo, Michael
1996 Southeastern Archaic Mounds. In *Archaeology of the Mid-Holocene*, edited by Kenneth E. Sassaman and David G. Anderson, pp. 259–287. Florida Museum of Natural History, University Press of Florida, Gainesville.

Sassaman, Kenneth E., and R. Jerald Ledbetter
1996 Middle and Late Archaic Architecture. In *Archaeology of the Mid-Holocene Southeast*, edited by Kenneth E. Sassaman and David G. Anderson, pp. 75–95. University Press of Florida, Gainesville.

Saunders, Joe W., Rolfe D. Mandel, C. Garth Sampson, Charles M. Allen, E. Thurman Allen, Daniel A. Bush, James K. Feathers, Kristen J. Gremillion, C. T. Hallmark, H. Edwin Jackson, Jay K. Johnson, Reca Jones, Roger T. Saucier, Gary L. Stringer, and Malcolm F. Vidrine
2005 Watson Brake, a Middle Archaic Mound Complex in Northeast Louisiana. *American Antiquity* 70:631–668.

Schenck, W. E.
1926 *The Emeryville Shell Mound Final Report*. University of California Publications in American Archaeology and Ethnology Vol. 23, No. 3. University of California, Berkeley.

Schiffer, Michael B.
1983 Toward the Identification of Formation Processes. *American Antiquity* 48:677–706.

Scott, Stuart D.
1974 Archaeology and the Estuary: Researching Prehistory and Paleoecology in the Marismas Nacionales, Sinaloa and Nayarit, Mexico. In *The Archaeology of West Mexico*, edited by Betty Bell, pp. 51–56. Sociedad de Estudios Avanzados del Occidente de México, A. C., Ajijic, Jalisco.
1999 The Marismas Nacionales Project, Sinaloa and Nayarit, Mexico. In *Pacific Latin America in Prehistory: The Evolution of Archaic and Formative Cultures*, edited by Michael Blake, pp. 13–24. Washington State University Press, Pullman.

Scott, Stuart D., and Michael S. Foster
2000 The Prehistory of Mexico's Northwest Coast: A View from the Marismas Nacionales of Sinaloa and Nayarit. In *Greater Mesoamerica: The Archaeology of West and Northwest Mexico*, edited by Michael S. Foster and Shirley Gorenstein, pp. 107–135. University of Utah Press, Salt Lake City.

Shenkel, J. Richard
1971 Cultural Adaptation to the Mollusk: A Methodological Survey of Shellmound Archaeology and a Consideration of the Shellmounds of the Marismas Nacionales, Mexico. Unpublished Ph. D. dissertation, Department of Anthropology, State University of New York, Buffalo.
1974 Quantitative Analysis and Population Estimates of the Shell Mounds of the Marismas Nacionales, West Mexico. In *The Archaeology of West Mexico*, edited by Betty Bell, pp. 57–67. Sociedad de Estudios Avanzados del Occidente de México, A. C., Ajijic, Jalisco.

Stow, Dorrik A. V.
2005 *Sedimentary Rocks in the Field: A Color Guide*. Manson Publishing, London.

Trigger, Bruce G.
1986 Introduction. In *Native Shell Mounds of North America*. Edited by Bruce G. Trigger, pp. xi–xxiv. Garland Publishing, New York.

Uhle, Max

1907 *The Emeryville Shellmound*. University of California Publications in American Archaeology and Ethnology, Vol. 7, No. 1. University of California, Berkeley.

Voorhies, Barbara

2004 *Coastal Collectors of the Holocene: The Chantuto People of Southwest Mexico*. University Press of Florida, Gainesville.

Voorhies, Barbara, Douglas J. Kennett, John G. Jones, and Thomas A. Wake

2002 A Middle Archaic Archaeological Site on the West Coast of Mexico. *Latin American Antiquity* 13:179–200.

Waselkov, Gregory

1987 Shellfish Gathering and Shell Midden Archaeology. In *Advances in Archaeological Method and Theory*, vol. 11, edited by Michael Schiffer, pp. 93–210. Academic Press, San Diego.

Webb, William S.

1950 *The Read Shell Midden: Site 10, Butler County, Kentucky*. University of Kentucky Reports in Anthropology, Vol. 7, No. 5. University of Kentucky, Lexington.

Wyman, Jeffries

1875 *Fresh-water Shell Mounds of the St. John's River*. Memoirs of the Peabody Academy of Science, Memoir 4. AMS Press, New York.

UCLA COTSEN INSTITUTE OF ARCHAEOLOGY PRESS

MONOGRAPHS

Contributions in Field Research and Current Issues in Archaeological Method and Theory

Monograph 80	*An Archaic Mexican Shellmound and Its Entombed Floors*, Barbara Voorhies (editor)
Monograph 79	*Archaeology of the Chinese Bronze Age: From Erlitou to Anyang*, Roderick B. Campbell
Monograph 78	*Visions of Tiwanaku*, Alexei Vranich and Charles Stanish (eds.)
Monograph 77	*Advances in Titicaca Basin Archaeology–2*, Alexei Vranich and Abigail R. Levine (eds.)
Monograph 76	*The Dead Tell Tales*, María Cecilia Lozada and Barra O'Donnabhain (eds.)
Monograph 75	*The Stones of Tiahuanaco*, Jean-Pierre Protzen and Stella Nair
Monograph 74	*Rock Art at Little Lake: An Ancient Crossroads in the California Desert*, Jo Anne Van Tilburg, Gordon E. Hull, and John C. Bretney
Monograph 73	*The History of the Peoples of the Eastern Desert*, Hans Barnard and Kim Duistermaat (eds.)
Monograph 71	*Crucible of Pueblos: The Early Pueblo Period in the Northern Southwest*, Richard H. Wilshusen, Gregson Schachner, and James R. Allison (eds.)
Monograph 70	*Chotuna and Chornancap: Excavating an Ancient Peruvian Legend*, Christopher B. Donnan
Monograph 69	*An Investigation into Early Desert Pastoralism: Excavations at the Camel Site, Negev*, Steven A. Rosen
Monograph 68	*The Chanka: Archaeological Research in Andahuaylas (Apurimac), Peru*, Brian S. Bauer, Lucas C. Kellett, and Miriam Aráoz Silva
Monograph 67	*Inca Rituals and Sacred Mountains: A Study of the World's Highest Archaeological Sites*, Johan Reinhard and Maria Costanza Ceruti
Monograph 66	*Gallinazo: An Early Cultural Tradition on the Peruvian North Coast*, Jean-François Millaire with Magali Morlion
Monograph 65	*Settlement and Subsistence in Early Formative Soconusco*, Richard G. Lesure (ed.)
Monograph 64	*The South American Camelids*, Duccio Bonavia
Monograph 63	*Andean Civilization: A Tribute to Michael E. Moseley*, Joyce Marcus and Patrick Ryan Williams (eds.)
Monograph 62	*Excavations at Cerro Azul, Peru: The Architecture and Pottery*, Joyce Marcus
Monograph 61	*Chavín: Art, Architecture, and Culture*, William J Conklin and Jeffrey Quilter (eds.)
Monograph 60	*Rethinking Mycenaean Palaces II: Revised and Expanded Second Edition*, Michael L. Galaty and William A. Parkinson (eds.)
Monograph 59	*Moche Tombs at Dos Cabezas*, Christopher B. Donnan
Monograph 58	*Moche Fineline Painting from San José de Moro*, Donna McClelland, Donald McClelland, and Christopher B. Donnan
Monograph 57	*Kasapata and the Archaic Period of the Cuzco Valley*, Brian S. Bauer (ed.)

Monograph 56	*Berenike 1999/2000*, Steven E. Sidebotham and Willeke Wendrich (eds.)
Monograph 55	*Roman Footprints at Berenike: Archaeobotanical Evidence of Subsistence and Trade in the Eastern Desert of Egypt*, René T. J. Cappers
Monograph 54	*Advances in Titicaca Basin Archaeology 1*, Charles Stanish, Amanda B. Cohen, and Mark S. Aldenderfer
Monograph 53	*Us and Them: Archaeology and Ethnicity in the Andes*, Richard Martin Reycraft
Monograph 52	*Archaeological Research on the Islands of the Sun and Moon, Lake Titicaca, Bolivia: Final Results from the Proyecto Tiksi Kjarka*, Charles Stanish and Brian S. Bauer (eds.)
Monograph 51	*Maya Zooarchaeology: New Directions in Theory and Method*, Kitty F. Emery (ed.)
Monograph 50	*Settlement Archaeology and Political Economy at Tres Zapotes, Veracruz, Mexico*, Christopher A. Pool (ed.)
Monograph 49	*Perspectives on Ancient Maya Rural Complexity*, Gyles Iannone and Samuel V. Connell (eds.)
Monograph 48	*Yeki bud, yeki nabud: Essays on the Archaeology of Iran in Honor of William M. Sumner*, Naomi F. Miller and Kamyar Abdi (eds.)
Monograph 47	*Archaeology in the Borderlands: Investigation in Caucasia and Beyond*, Adam T. Smith and Karen S. Rubinson (eds.)
Monograph 46	*Domestic Ritual in Ancient Mesoamerica*, Patricia Plunket (ed.)
Monograph 45	*Pathways to Prismatic Blades*, Kenneth Hirth and Bradford Andrews (eds.)
Monograph 44	*Ceramic Production and Circulation in the Greater Southwes*t, Donna M. Glowacki and Hector Neff (eds.)
Monograph 43	*Pottery of Postclassic Cholula, Mexico*, Geoffrey McCafferty
Monograph 42	*Pompeian Households: An Analysis of the Material Culture*, Penelope M. Allison
Monograph 41	*Rethinking Mycenaean Palaces: New Interpretations of an Old Idea*, Michael L. Galaty and William A. Parkinson (eds.)
Monograph 40	*Prehistory of Agriculture: New Experimental and Ethnographic Approaches*, Patricia C. Anderson (ed.)
Monograph 39	*Recent Advances in the Archaeology of the Northern Andes: In Memory of Gerardo Reichel-Dolmatoff*, Augusto Oyuela-Caycedo and J. Scott Raymond (eds.)
Monograph 38	*Approaches to the Historical Archaeology of Mexico, Central and South America*, Janine Gasco, Greg Charles Smith, and Patricia Fournier-Garcia
Monograph 37	*Hawaiian Adze Production and Distribution: Implications for the Development of Chiefdoms*, Barbara Lass
Monograph 36	*New Light on Old Art: Recent Advances in Hunter-Gatherer Rock Art Research*, D. W. Whitley and L. L. Loendorf (eds.)
Monograph 35	*Pottery of Prehistoric Honduras: Regional Classification and Analysis*, J. S. Henderson and M. Beaudry-Corbett
Monograph 34	*Settlement Archaeology of Cerro de las Mesas, Veracruz, Mexico*, Barbara Stark (ed.)
Monograph 33	*Girikihaciyan: A Halafian Site in Southeastern Turkey*, P. J. Watson and S. LeBlanc
Monograph 32	*Western Pomo Prehistory: Excavations at Albion Head, Nightbirds' Retreat and Three Chop Village, Mendocino County, California*, Thomas N. Layton
Monograph 31	*Investigaciones Arqueológicos de la Costa Sur de Guatemala*, David S. Whitley and Marilyn P. Beaudry (eds.)
Monograph 30	*Archaeology of the Three Springs Valley, California: A Study in Functional Cultural History*, Brian D. Dillon and Matthew A. Boxt

Monograph 29	*Obsidian Dates IV: A Compendium of Obsidian Hydration Readings from the UCLA Obsidian Hydration Laboratory*, Clement W. Meighan and Janet L. Scalise (eds.)
Monograph 28	*Archaeological Field Research in the Upper Mantaro, Peru, 1982–1983: Investigations of Inka Expansion and Exchange*, Timothy Earle et al. (eds.)
Monograph 27	*Andean Archaeology: Papers in Memory of Clifford Evans*, Ramiro Matos M., Solveig Turpin, and Herbert Eling, Jr. (eds.)
Monograph 26	*Excavations at Mission San Antonio 1976–1978*, Robert L. Hoover and Julio J. Costello (eds.)
Monograph 25	*Prehistoric Production and Exchange in the Aegean and Eastern Mediterranean*, A. Bernard Knapp and Tamara Stech (eds.)
Monograph 24	*Pots and Potters: Current Approaches in Ceramic Archaeology*, Prudence Rice
Monograph 23	*Pictographs and Petroglyphs of the Oregon Country, Part 2*, J. Malcolm Loring and Louise Loring
Monograph 22	*The Archaeology of Two Northern California Sites*, Delmer E. Sanburg, F. K. Mulligan, Joseph Chartkoff, and Kerry Chartkoff
Monograph 21	*Pictographs and Petroglyphs of the Oregon Country, Part 1*, J. Malcolm Loring and Louise Loring
Monograph 20	*Messages from the Past: Studies in California Rock Art*, Clement W. Meighan (ed.)
Monograph 19	*Prehistoric Indian Rock Art: Issues and Concerns*, Jo Anne Van Tilburg and Clement W. Meighan (eds.)
Monograph 18	*Studies in Cypriote Archaeology*, Jane C. Biers and David Soren
Monograph 17	*Excavations in Northern Belize, Central America*, Raymond Sidrys
Monograph 16	*Obsidian Dates III: A Compendium of Obsidian Hydration Determinations Made at the UCLA Obsidian Hydration Laboratory*, Clement Meighan and Glenn Russell
Monograph 15	*Inland Chumash Archaeological Investigations*, David S. Whitley, E. L. McCann, and C. W. Clewlow, Jr. (eds.)
Monograph 14	*Papers in Cycladic Prehistory*, Jack L. Davis and John F. Cherry (eds.)
Monograph 13	*Archaeological Investigations at the Ring Brothers Site Complex, Thousand Oaks, California*,C. W. Clewlow, Jr., David S. Whitley, and Ellen L. McCann (eds.)
Monograph 12	*The Running Springs Ranch Site: Archaeological Investigations at VEN-65 and VEN-261*, Jack Prichett and Allen McIntyre
Monograph 11	*The Archaeology of Oak Park, Ventura County, California*, C. William Clewlow, Jr., and David S. Whitley (eds.)
Monograph 10	*Rock Art of East Mexico and Central America: An Annotated Bibliography*, Matthias Strecker
Monograph 9	*The Late Minoan I Destruction of Crete: Metal Groups and Stratigraphic Considerations*, Hara Georgiou
Monograph 8	*Papers on the Economy and Architecture of the Ancient Maya*, Raymond Sidrys (ed.)
Monograph 7	*History and Prehistory at Grass Valley, Nevada*, C. W. Clewlow, Jr., Helen F. Wells, and Richard Ambro (eds.)
Monograph 6	*Obsidian Dates II: A Compendium of Obsidian Hydration Determinations Made at the UCLA Obsidian Hydration Laboratory*, C. W. Meighan and P. I. Vanderhoeven (eds.)
Monograph 5	*The Archaeology of Oak Park, Ventura County, California*, C. W. Clewlow, Jr., Allen Pastron, and Helen F. Wells (eds.)

Index

Note: Page numbers in ***bold italics*** indicate illustrations or tables.