Chronology, mound-building and environment at Huaca Prieta, coastal Peru, from 13 700 to 4000 years ago

Tom D. Dillehay[1,2], Duccio Bonavia[3], Steven Goodbred[4], Mario Pino[5], Victor Vasquez[6], Teresa Rosales Tham[6], William Conklin[7], Jeff Splitstoser[8], Dolores Piperno[9], José Iriarte[10], Alexander Grobman[11], Gerson Levi-Lazzaris[1], Daniel Moreira[12], Marilaura Lopéz[13], Tiffiny Tung[1], Anne Titelbaum[14], John Verano[14], James Adovasio[15], Linda Scott Cummings[16], Phillipe Bearéz[17], Elise Dufour [17], Olivier Tombret[17,18], Michael Ramirez[19], Rachel Beavins[4], Larisa DeSantis[4], Isabel Rey[20], Philip Mink[21], Greg Maggard[21] & Teresa Franco[1]

Renewed in-depth multi-disciplinary investigation of a large coastal mound settlement in Peru has extended the occupation back more than 7000 years to a first human exploitation ~13 720 BP. Research by the authors has chronicled the prehistoric sequence from the activities of the first maritime foragers to the construction of the black mound and the introduction of horticulture and monumentality. The community of Huaca Prieta emerges as innovative, complex and ritualised, as yet with no antecedents.

Keywords: Peru, Holocene, ritual mound, horticulture

[1] *Department of Anthropology, College of Arts and Science, Vanderbilt University, 124 Garland Hall, Nashville, TN 37235, USA*

[2] *Escuela de Antropología, Faculdad de Ciensias Sociales, Universidad Católica de Temuco, Manuel Montt 056, Temuco, Chile*

[3] *Academia Nacional de la Historia, Casa de Osambela, Jr. Conde de Superunda 298, Lima 1, Perú*

[4] *Department of Earth and Environmental Sciences, College of Arts and Science, Vanderbilt University, 5726 Stevenson Center, 7th floor, Nashville, TN 37240, USA*

Research

Introduction

The warming trend at the end of the Pleistocene led to new and generally richer terrestrial and coastal environments that were exploited by human foragers in several regions of the world (Straus *et al.* 1996). Post-Pleistocene complex hunters and gatherers who practised intensive maritime adaptations and established extensive often sedentary communities are best represented by the Jomon culture in Japan (Habu 2004), the Ertebølle culture in Scandinavia (Miller *et al.* 2010), the ring-mounds in the south-east of the United States (Thompson & Worth 2010) and the *sambaqui* mounds in Brazil (Fish *et al.* 2000). The settlements of these cultures are invariably characterised by mortuary rituals suggestive of social differentiation, and by extensive shell middens that have yielded a wide array of marine and terrestrial species. At different times between ~8000 and 4000 cal BP, some of these communities also practised various degrees of horticulture as evidenced by the appearance of food crops. Like these regions, the Pacific coast from southern Ecuador to northern Chile witnessed the early rise of complex societies, especially in Peru where sedentism and monumental non-domestic architecture appeared by at least 5200 cal BP (Moseley 1975, 1992; Richardson 1981; Bird *et al.* 1985; Haas & Creamer 2004). Some of these developments are due to the unique ecology of the region, with diverse and abundant maritime resources closely juxtaposed with a long fertile but arid coastal plain, through which rivers descend from the Andean mountains. Others are the result of emerging ideologies adopted by these communities, which built monuments prior to the use of pottery. Associated with these changes was a variety of food and industrial crops (Bird 1948; Pearsall

[5] *Instituto de Ciencias Geológicas, Facultad de Ciencias, Universidad Austral de Chile, Casilla 567, Valdivia, Chile*
[6] *Laboratorio de Bioarqueología, Universidad Nacional de Trujillo, Avda. Universitaria s/n, Trujillo, Perú*
[7] *Department of Anthropology, Field Museum, 1400 S. Lake Shore Drive, Chicago, IL 60605-2496, USA*
[8] *Boundary End Archaeology Research Center, One Walker Creek Road, Barnardsville, NC 28709-0592, USA*
[9] *Archaeobiology Program, Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington DC 20013-7012, USA & Smithsonian Tropical Research Institute, Balboa, Panama*
[10] *Department of Archaeology, University of Exeter, Laver Building, North Park Road, Exeter EX4 4QE, UK*
[11] *Universidad Nacional Agraria La Molina, Av. La Universidad s/n, Facultad de Ciencias, Lima 12, Perú*
[12] *Departamento de Arqueologia, Universidade Federal de Rondônia, Avenida Presidente Dutra 2965, Porto Velho 78900-500, Brasil*
[13] *Escuela de Arqueología, Universidad Nacional de Trujillo, Avenida Juan Pablo II s/n, Ciudad Universitaria, Trujillo, La Libertad, Perú*
[14] *Department of Anthropology, Tulane University, 101 Dinwiddie Hall, 6823 St Charles Avenue, New Orleans, LA 70118, USA*
[15] *Department of Anthropology, Mercyhurst Archaeological Institute, Mercyhurst College, 501 East 58th Street, Erie, PA 16546-0001, USA*
[16] *Paleo Research Institute, 2675 Youngfield St, Golden, CO 80401, USA*
[17] *Museum National d'Histoire Naturelle, Paris 75005, France*
[18] *Université de Picardie Jules Verne, Chemin de Thil, 80-025 Amiens, France*
[19] *Department of Geological Sciences, University of Texas at Austin, 6 East Mall EPS RM 1.130, Austin, TX 78705, USA*
[20] *Tissue and DNA Collections, Museo Nacional de Ciencias Naturales (CSIC), Jose Gutierrez Abascal 2, 28006 Madrid, Spain*
[21] *Kentucky Archaeological Survey, Department of Anthropology, University of Kentucky, Lexington, Kentucky 40506-9854, USA*

Figure 1. Location of Huaca Prieta on the remnant Sangamon terrace and outlying wetlands and Preceramic domestic sites in the Chicama Valley of the north coast of Peru.

2008). Particularly important was cotton for producing fishing nets, textiles and gourds for net floats. One of the early coastal monuments is Huaca Prieta, a large stone and earthen mound measuring 138 × 62 × 32m, built on the southern point of a remnant Pleistocene terrace overlooking the Pacific Ocean and estuarine wetlands and the delta plain of the Chicama River valley (Bird *et al.* 1985) (Figure 1).

Huaca Prieta was first excavated by Junius Bird in the 1940s and radiocarbon dated to between ~5302 and 1933 cal BP in the 1950s (Figure 2; Table 1). Based on the large size of the mound, on an abundance of marine resources, wood charcoal, ash and soot, thus the appearance of a black or *prieta* mound, and on the presence of small stone structures, Bird believed that the site was occupied by sedentary people living in pit-houses. In addition to a marine economy, he documented incipient gardening and social differentiation, as indicated by the remains of several food crops, the uninterrupted accumulation of cultural layers, the presence of room structures, the interment of human burials with grave offerings and a wide variety of material technologies including lithic, gourd, basketry, bone, wood and textile. The most developed technology at the site was cotton weaving and netting (Bird & Mahler 1952). The site's weavers devised sophisticated iconographic styles with various designs. Iconography was also exhibited through incised and engraved gourds, hematite

Figure 2. View looking north-west toward the mound at Huaca Prieta. Scale indicated by workers standing on the side. The Pacific Ocean is in the background. The wetland farm plot in the foreground is probably similar to those that existed near the site in Preceramic times.

painted pebbles and recently recovered coral sculptures. A crude lithic industry included grinding stones for processing plants and edge-trimmed pebble flake tools, hammerstones, cores and other implements used for various tasks (Bird *et al*. 1985: 77–91).

Until now, the broader importance of Bird's pioneering work at Huaca Prieta has been constrained by few radiocarbon dates and cursory study of the site's environment, stratigraphy and chronology, architecture and off-mound activity. In 2006 we began an interdisciplinary project at the site to re-examine the previous work and to better understand the relationship between coastal environments, economies and mound building within the site's changing social and natural landscapes. To date, we have excavated more than 2000m^3 in old and new areas of Huaca Prieta, located and explored other domestic sites on the remnant terrace, conducted a survey of Preceramic settlements along the coast of the Chicama River valley and reconstructed the local palaeoecology (Figure 3).

The new work has greatly extended the time span of occupation at the site and increased its significance for the understanding of the development of early societies in Peru. We have documented the site stratigraphy encountered by Bird and the primary refuse of charcoal, ash, burned rock, the remains of numerous marine organisms such as fish, urchins, shellfish, sea lion and porpoise, birds and other fauna, and cultivated plants. We have also obtained numerous radiocarbon dates from intact features and floors and defined several site phases (Table 1), ranging in chronometric age from 13 720–13 260 cal BP for the first human presence, from ~8979–7500 cal BP for a pre-mound occupational phase and from

Table 1. Radiocarbon dates from Huaca Prieta, nearby off-mound geological deposits and the Paredones site.

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
Unit 2						
AA76975	Unit 2 ext west, upper Stratum 3	−24.4	3535±35	3827–3696	3849–3639	Wood charcoal
Beta233650	Unit 2, lower Stratum 3	−22.2	3700±40	4073–3893	4088–3844	Charred material
AA76974	Unit 2 ext west, Stratum 5a	−24.2	3588±36	3873–3724	3956–3694	Wood charcoal
AA76973	Unit 2, Stratum 7a	−24.0	3748±40	4137–3933	4151–3898	Wood charcoal
AA81925	Unit 2, Stratum 7b	−19.1	3964±41	4418–4259	4511–4159	Wood charcoal
AA85506	First mound Layer: Unit 2, Stratum 7C-3	−25.4	6641±49	7555–7434	7571–7424	Wood charcoal
AA76972	Pre-mound occupation (?): Unit 2, Stratum 7C-7 base	−23.5	6797±48	7656–7572	7680–7508	Wood charcoal
Beta233651	Pre-mound occupation: Unit 2, Stratum 8, base		6920±30	7740–7660	7786–7618	Wood charcoal
Unit 3						
AA76977	Unit 3 ext south, Floor 2	−22.8	3530±36	3827–3693	3849–3636	Wood charcoal
AA76978	Unit 3 ext south, Floor 5a	−19.6	3567±40	3841–3717	3901–3643	Wood charcoal
AA76979	Unit 3 ext south, Floor 5b	−19.6	3758±40	4142–3978	4216–3901	Wood charcoal

Table 1. Continued

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
Beta247695	Unit 3, Stratum 8, below Floor 6	−20.8	4000±40	4510–4296	4520–4245	Organic sediment
Unit 7						
AA76970	Unit 7, Floor 1	−25.1	3649±36	3964–3841	4072–3727	Wood charcoal
Unit 8						
AA81916	Unit 8, Tomb 4	−17.2	3534±53	3833–3689	3892–3590	Bone
Unit 9						
AA81922	Unit 9, Stratum 7a, top	−22.0	3547±40	3829–3705	3876–3640	Wood charcoal
AA84168	Pre-mound occupation: Unit 9, Stratum 8, base	−22.8	7956±50	8931–8599	8979–8592	Wood charcoal
Unit 10						
AA81923	Unit 10, Base of Structure 2	−25.7	3556±44	3834–3705	3895–3640	Wood charcoal
AA81919	Unit 10, Floor 4	−26.4	3557±40	3834–3716	3891–3642	Wood charcoal
Unit 12						
AA81929	Unit 12, Ash Stratum 1	−25.2	3441±39	3688–3576	3817–3480	Wood charcoal
Unit 13						
AA81920	Unit 13, Floor 3	−19.7	3810±41	4224–3996	4283–3974	Wood charcoal
Unit 14						
AA81921	Unit 14, Floor 4	−25.1	3508±40	3825–3641	3838–3588	Wood charcoal

Table 1. Continued

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
Unit 16						
AA86935	Off-mound domestic Unit 16, Stratum 13-7	−22.6	6310±33	7251–7162	7266–7021	Wood charcoal
Unit 20 (Paredones)						
AA86936	Unit 20, Stratum 5B	−23.8	4783±31	5578–5330	5583–5324	Wood charcoal
AA86937	Unit 20, Stratum 6B-18	−25.8	4849±31	5589–5479	5603–5333	Charred wood
Unit 21 (Unit 15)						
AA86941	Unit 21, Floor 2-3, 16	−10.6	3599±29	3889–3728	3956–3704	Corn cob
AA86931	Unit 21, Floor 3-2	−25.2	3638±29	3957–3838	3982–3728	Wood charcoal
AA86946	Unit 21, Floor 9	−11.9	3783±41	4148–3988	4235–3928	Corn cob
AA75322	Unit 15, Floor 26	−29.4	5018±86	5860–5599	5911–5488	Wood charcoal
AA85507	First mound layer: Unit 15	−25.6	6522±54	7429–7323	7474–7268	Wood charcoal
AA75327	Pre-mound occupation: Unit 15, below sunken plaza in mound	−29.5	7226±44	8019–7947	8156–7871	Wood charcoal
Beta290621	Buried surface of Sangamon Terrace	−25.6	11500±50	13403–13294**	13420–13260**	Charred wood
Beta299536	Buried surface of Sangamon Terrace	−28.3	11800±50	13757–13517**	13794–13459**	Wood

Table 1. Continued

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
Unit 22 (Paredones)						
AA86934	Unit 22, Floor 6	−13.4	4181±34	4809–4570	4821–4527	Charred cob
Beta263320	Unit 22, Floor 10, Capa 14	−24.5	4590±40	5308–5062	5435–5044	Wood charcoal
Beta263321	Unit 22, Floor 15	−25.6	4790±40	5580–5331	5585–5325	Charred material
AA86947	Unit 22, Floor 16, Fill 10	−24.0	4898±49	5644–5483	5711–5335	Wood charcoal
AA83260	Unit 22, Floor 24	−26.0	5750±60	6561–6405	6640–6319	Wood charcoal
Unit 23						
AA86930	Unit 23, Stratum 3-1	−10.0	1760±29	1690–1557	1697–1539	Wood charcoal
AA86949	Unit 23, Floor 3-3	−27.1	3467±39	3704–3584	3828–3560	Wood charcoal
AA86948	Unit 23, Floor 11	−23.5	5059±72	5887–5652	5902–5606	Wood charcoal
Bird's HP-2						
Beta233648	Basal mound layer: HP-2 west side of site	−23.8	5110±40	5891–5745	5919–5667	Organic sediment
Libby-598	Test Pit 2; Bottom	−22.2	4298±230	5260–4439	5462–4152	Charcoal
Bird's HP-3						
AA81926	HP-3, Stratum 5	−28.0	3394±40	3634–3485	3688–3464	Wood charcoal
AA86943	HP-3, Stratum 14	−24.6	3806±28	4213–3999	4233–3985	Wood charcoal
AA86940	HP-3, Stratum 19	−25.6	3875±30	4287–4107	4406–4090	Wood charcoal
AA81924	HP-3, Stratum 22	−23.5	3687±40	4063–3876	4084–3838	Wood charcoal
AA81927	HP-3, Stratum 23	−17.3	3728±40	4084–3927	4147–3875	Wood charcoal

Table 1. Continued

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
AA86948	HP-3, Stratum 35	−24.1	5020±35	5830–5598	5848–5585	Wood charcoal
AA82121	HP-3, Stratum 52 (39), upper part	–	5980±40	6789–6676	6882–6657	Cotton yarn
AA81907	First mound layer: HP-3, Stratum 52-53, lower part	−23.8	6170±45	7154–6899	7162–6808	Wood charcoal
Beta263318	Pre-mound occupation: Stratum 55	−24.9	7000±50	7830–7703	7927–7673	Charred material
Beta294021	Pre-mound occupation: Stratum 54	−23.3	7110±50	7946–7840	7979–7752	Wood charcoal
AA75321	Pre-mound occupation: base HP-3 Stratum 56, P-4	−28.9	7195±45	8009–7933	8040–7847	Wood charcoal
TP-3 (Ext. of HP-3)						
Beta278233	Test Pit 3, Stratum 2	−25.5	3660±40	3972–3854	4081–3730	Charred material
TP-6						
Beta247696	Test Pit 6, Base	−18.7	3350±40	3571–3464	3823–3483	Charred material
TP-9-13						
AA86944	Test Pit 9-13	−28.1	3334±38	3558–3455	3614–3398	Wood charcoal
TP-22						
AA86947	Test Pit 22, Stratum 10	−24.0	4898±49	5644–5483	5711–5335	Wood charcoal

Table 1. Continued

Sample no.	Provenience	δ^{13}C	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
Beta210862	Pre-mound Occupation, Stratum 20	−27.4	9530±50	[11000]–10501	[11000]–10579	Wood charcoal
Beta290620	Test Pit 22, Stratum 25	−28.3	11780±50	13732–13510**	13720–13440**	Wood
Bird's ^{14}C samples from HP-3*						
321	Test pit 3; Layer D		2966±340	3555–2621	3905–2160	Gourds, chewed fibre, squash stems, cotton, wood, barkcloth
Beta9286	HP 3, E		3730±300	4422–3634	4845–3272	Gourd (*Lagenaria siceraria*)
Beta9288	HP 3, F		3960±100	4510–4157	4784–3989	Gourd (*Lagenaria siceraria*)
Beta9287	HP 3, J		3270±100	3569–3343	3692–3169	Gourd (*Lagenaria siceraria*)
318b	Test pit 3; Layer J		3550±600	4569–3005	5446–2344	Twigs and treated huarango wood
362	Test pit 3; Layer K		4044±300	4845–3996	5298–3648	Carbonised cattail roots
315	Test pit 3; Layer M		3572±220	4088–3485	4423–3267	Shell
316	Test pit 3; Layer M		4380±270	5302–4539	5590–4158	Misc. woody plants
313	Test pit 3; Layer Q		4257±250	5263–4411	5462–3999	Misc. woody plants
Geological dates mentioned in text						
AA83255	Swash-laminated shoreface sands	−21.1	2767±90	2924–2746	3077–2505	Wood charcoal
Beta244172	Muddy back-dune swale	−19.1	2820±80	2950–2778	3078–2742	Organic-rich soil
AA83252	Sandy burned cultural horizon	−25.8	3521±49	3828–3645	3868–3610	Wood charcoal

Table 1. Continued

Sample no.	Provenience	$\delta^{13}C$	Conventional radiocarbon	1σ-calibrated age range (BP)	2σ-calibrated age range (BP)	Material
AA81933	Swash-laminated shoreface sands onlapping Huaca Prieta	−24.7	3598±40	3893–3725	3964–3696	Wood charcoal
AA83258	Carbonate lagoon sediments	−6.0	5739±51	6538–6404	6633–6321	Non-marine gastropod
OS-77302	Organic layer inter-bedded within Carbonate lagoon sediments	−25.6	6180±35	7155–6939	7158–6901	Plant matter
OS82737	Organic layer inter-bedded within Carbonate lagoon sediments	−29.9	6500±30	7421–7326	7428–7279	Plant matter
OS77304	Organic layer inter-bedded within Carbonate lagoon sediments	−24.1	6500±45	7422–7324	7432–7269	Plant matter
OS77303	Organic layer inter-bedded within Carbonate lagoon sediments	−27.7	6600±35	7483–7425	7518–7416	Plant matter

All dates calibrated using shcal04 (McCormac *et al.* 2004).
[ ]= calibrated range impinges on end of calibration data set.
* Bird's corresponding layers in HP-3 are based on study of his photographs, notes, and profile drawings.
** Calibration done on curve other than shcal04.

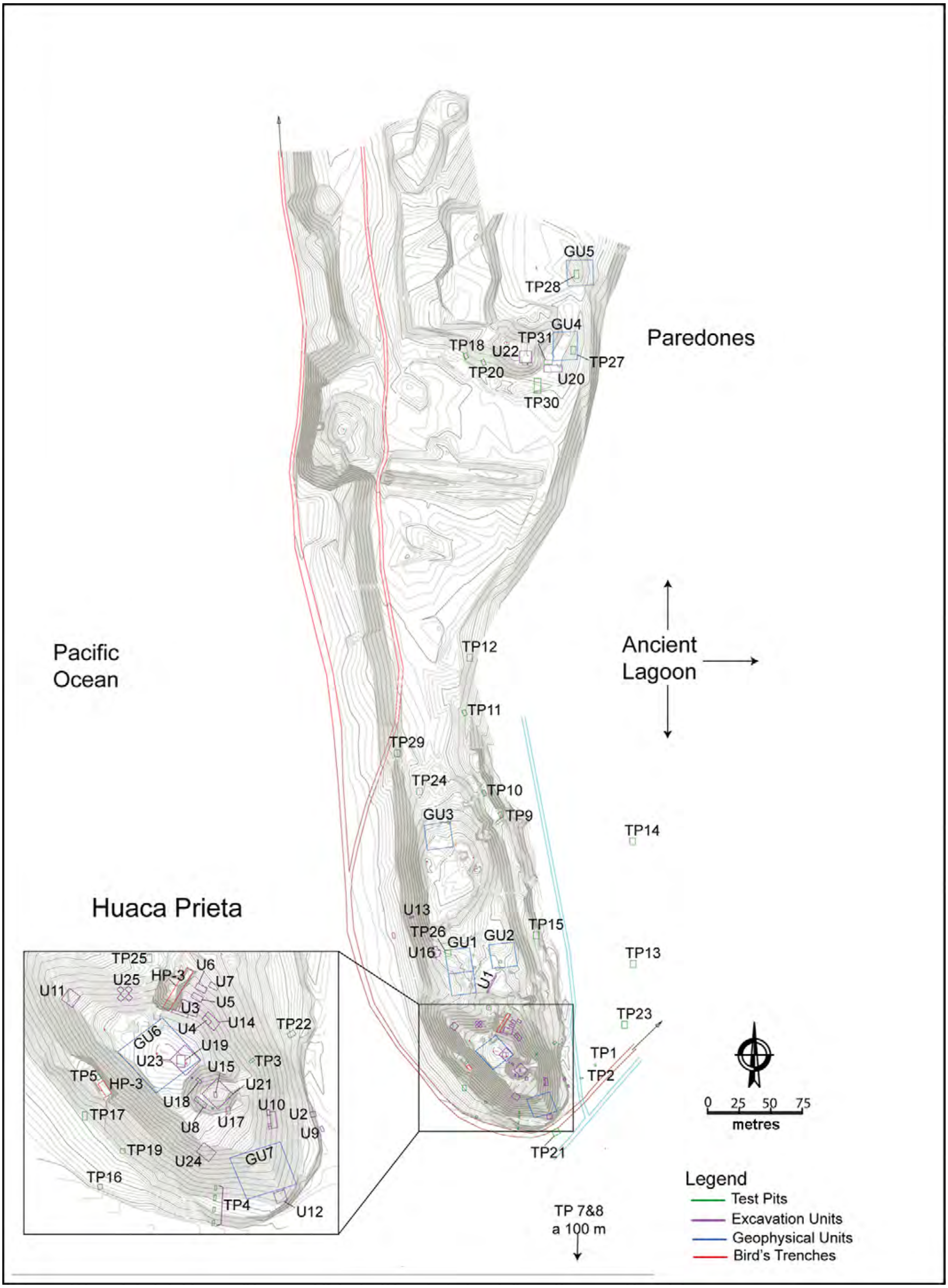

Figure 3. Map of the remnant terrace showing the location of investigations at Paradones and Huaca Prieta. HP: excavations by J.B. Bird; TP: test pit; GU: area of geophysical survey; U: excavations undertaken in the present campaign.

∼7555–4510 cal BP for subsequent mound-building phases. Our findings also indicate that the site was first occupied by maritime foragers. After ∼7500 cal BP, activity shifted about 50m north and the first mound layers, associated with burning and mortuary rituals, were built on the southern end of the terrace.

Method

During five recent field seasons, we recut, profiled and studied all of Bird's prior pits on the mound (Bird *et al.* 1985: 26), particularly his HP-2 and HP-3 units (Figure 4), taking more than 15 000 measurements of stratigraphic profiles in 60 different archaeological excavations, three with cultural deposits of 22–32m. We selected several new areas for extensive and deeper excavations, working with large teams of professional archaeologists and experienced local workers. Specialists such as botanists, geneticists, malacologists and geologists joined the research team for various periods of time to extract specific data sets.

In total, we excavated 31 block units ranging in size from 2 × 4m to 12 × 14m, 30 test pits ranging between 1 × 2m and 2 × 3m, more than 25 geological trenches and hundreds of sediment cores on and off the site. Many of the test pits and small block units were exploratory in nature, seeking to define the mound and off-mound stratigraphy, function and chronology (Figure 3). Given the depth and size of the mound, which covered or destroyed the early occupational deposits to a depth of 8–32m, we obtained only three terminal Pleistocene and six pre-mound Early Holocene radiocarbon dates (Units 2, 9, 15 [21], HP-2, HP-3 and TP-22). Additionally, five large 20 × 20m block units were subjected to geophysical mapping for purpose of testing deep subsurface features. Thus, the majority of our work was located in areas not probed by Bird, such as the lower and upper south side of the site and deposits buried underneath later Cupisnique and Moche mounds (∼3500–1500 cal years ago) located immediately north of Huaca Prieta.

We also carried out block excavations at Paredones, a smaller 30 × 70m mound located 1km north of Huaca Prieta (Figure 3). Paredones dates between ∼6700 and 4200 cal BP and presents a 6m-deep cultural sequence associated with domestic occupation. The stratigraphy at both Huaca Prieta and Paredones is intact, with almost impenetrable cement-like floors and floor fills. Minimal disturbance resulted from occasional architectural construction at Huaca Prieta.

In this paper we focus on the dating of the sequence. Summary reports on the floodplain deposits, mound stratigraphy, architectural phases, subsistence economy and off-mound domestic sites (including Paredones) will be found in the supplement online (SOL) at http://www.antiquity.ac.uk/projgall/dillehay331.

Holocene environmental history

Our recent palaeoecological studies indicate that the environs of Huaca Prieta are defined by the interface of several geo-climatic settings, which present diverse natural resources (Dillehay *et al.* 2010). Geological evidence reveals an intimate association with fertile deltaic wetland systems that were juxtaposed with diverse semi-arid lowlands and coastal estuarine and marine settings. Located at these ecological junctions, settings like that of Huaca Prieta were

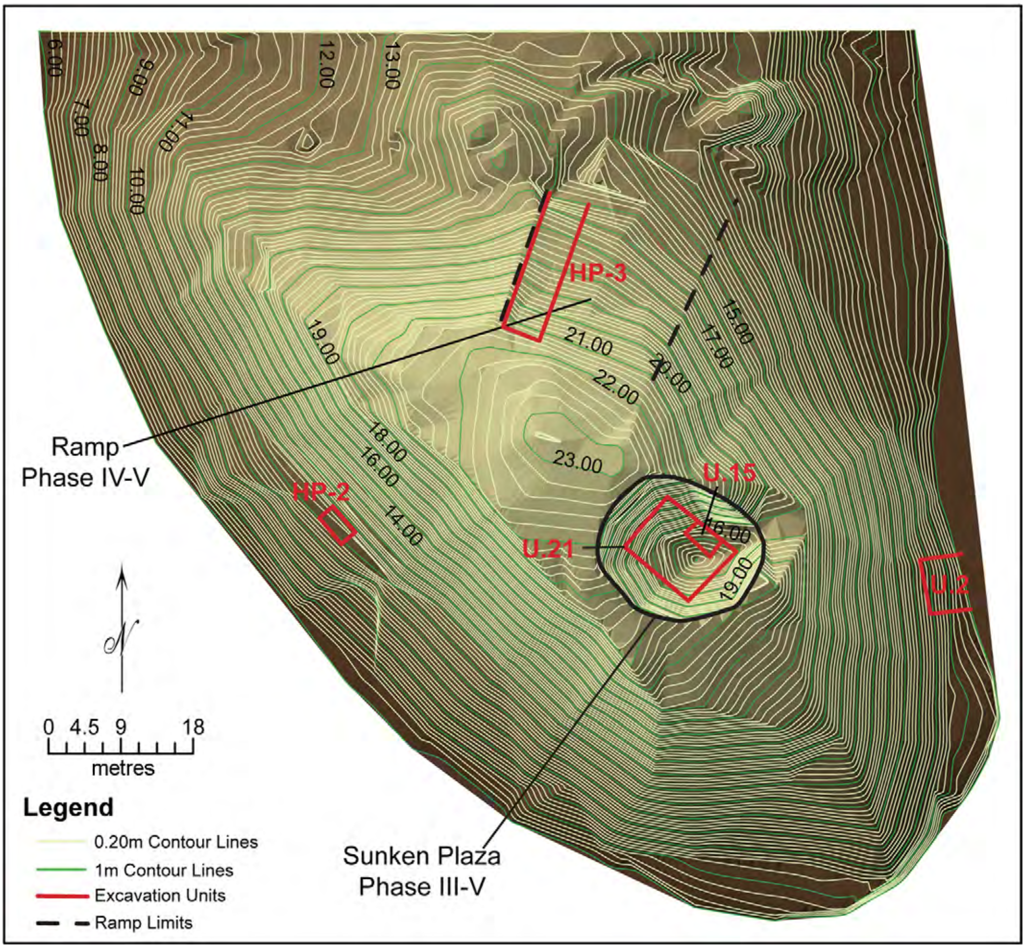

Figure 4. Topographic map of the mound at Huaca Prieta produced by digital contour mapping, GPR probing and pre-excavation drawings and photographs by J.B. Bird. Top of the mound shows a height of 23m above datum at present-day ground surface; however, the mound is 32m high from the top to the first mound layers buried below ground surface. Note the location of the ramp, the circular sunken plaza and excavation units mentioned in the text.

susceptible to environmental changes forced by various phenomena: local (e.g. river avulsion, earthquakes), regional (e.g. El Niño), global (e.g. sea-level change) or anthropogenic (e.g. land use) (Bird, R. 1983; Sandweiss *et al.* 1999, 2009; Wells 1999). The earliest coastal plain formation near the site is recorded by unique algal carbonate (*Charophyta*) and interbedded organic sediments that indicate the development of a widespread wetland-fringed, estuarine lagoon by 7457 cal BP (OS-77303, see Table 1). This setting persisted until 6470 cal BP (AS-83258, see Table 1), after which the onset of El Niño floods began to infill the lagoon with riverine silts. This major environmental transformation from open-water lagoon to a well-drained floodplain occurs over ~2000 years and is largely complete by 4500 cal BP. Floodplain deposition, largely through El Niño flood events, remains a continuous but episodic process up to the present (Sandweiss *et al.* 1999) (SOL 1).

A prominent feature across the relatively flat and narrow coastal plain of the Chicama River valley are several small drainages that cross-cut the plain as they descend from the Andean foothills to the ocean. These drainages change depending on the level of the water table and El Niño events, becoming larger when heavy rains in the highlands increase their load. When these drainages reach the ocean and mix with its salty tidal water, numerous estuary systems are formed between 2 and 20km north of Huaca Prieta. These estuaries are generally narrow and 2–7km long, running perpendicular to the seashore, although they may connect to lagoons that are elongated and parallel to the coast. Sand dunes created by the sediments dumped by rivers and shaped by the action of waves separate these wetland systems from the ocean. The wetlands provide a wide variety of edible plant and animal life, in addition to various species of reeds used to make mats, baskets and other utilitarian items. Today, people grow crops along the edges of the wetlands where the soils are rich and humid year round (Figure 2).

Phasing and dating at Huaca Prieta

In total, more than 150 radiocarbon dates were obtained from 60 mound and off-mound excavations and from various geological cuts and cores (Table 1). Not all floor and use episodes were radiocarbon dated, which would require more than 1000 chronometric measurements (see SOL). However, the deeper stratigraphic cuts were dated from the top to bottom, as shown in Figures 5–7 for Units 2, 15/21 and HP-3. All radiocarbon dates from Huaca Prieta and Paredones were taken on single chunks of wood charcoal, maize and cotton textiles recovered from features embedded in floors. Unfortunately, not all excavated strata contained single chunks embedded in floors or features. With the exception of fragments of maize and other organic debris, which will be detailed in later publications, all radiocarbon dates are on wood charcoal and cotton. No radiocarbon samples were taken from fills and middens or from marine shells. Given the different organic materials dated by four different laboratories over a period of six decades, nearly all dates agree and overlap chronologically and stratigraphically at the 1σ calibrated age range. There is also agreement and stratigraphic alignment between Bird's ^{14}C dates and his schematic profile of the north to south oriented HP-3 trench and our ^{14}C dates and stratigraphy in this same unit (Bird *et al*. 1985: 51–8) (Figure 5).

Our excavations at the site have defined limited terminal Pleistocene and Early Holocene occupational phases followed by four successive mound-building phases (Figures 8 & 9). The terminal Pleistocene materials are buried in the upper surface deposits of the ancient terrace upon which the mound sits at Huaca Prieta. Because these deposits are deeply buried beneath the mound, we have not yet fully studied the spatial extent and geological setting of this occupation. To date we have recovered simple edge-trimmed pebble flakes, several bone remains of fish and sea lion, and fractured shellfish valves from these deposits, which are dated between 13 720 and 13 260 cal BP (Table 1).

The mound sequence has been resolved in five phases. *Phase I* is dated ~9000–7500 cal BP and is associated with maritime foragers and incipient gardeners intermittently occupying around 80m of the lower east side of the Sangamon terrace near the banks of the brackish water, estuarine lagoon (see Table 1; Figures 3 & 4, Units 2, 9 & 15/21, HP-3 & TP 22).

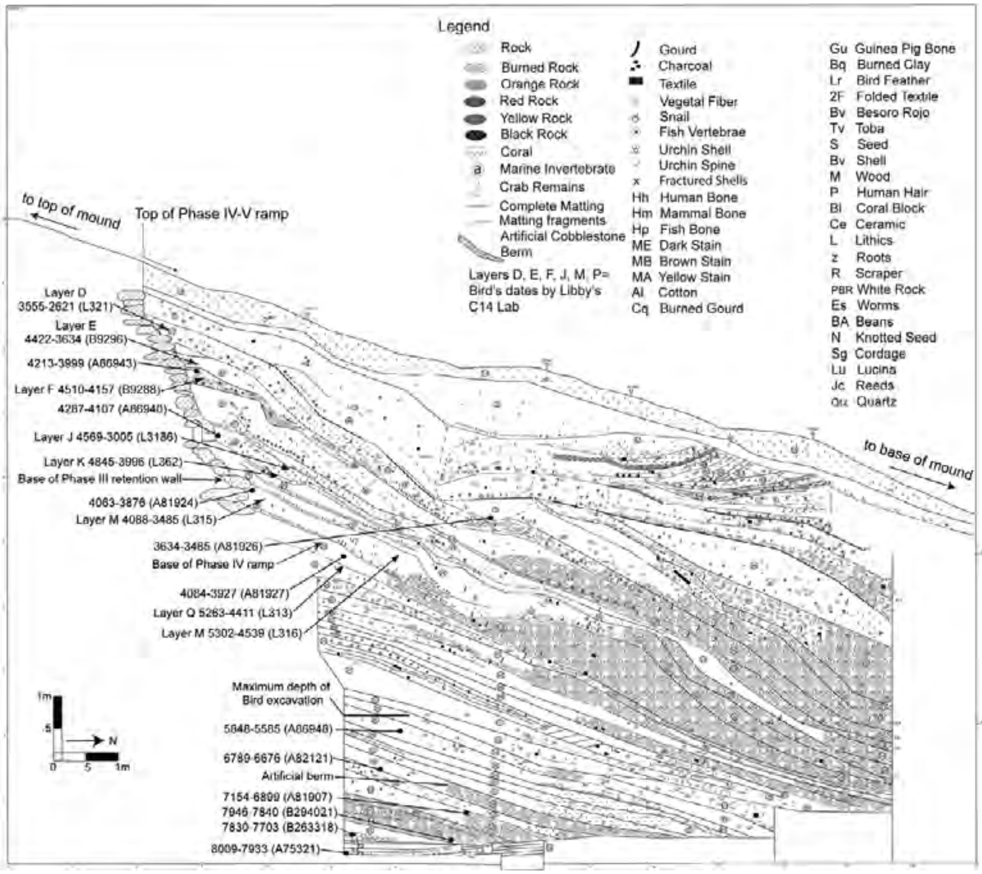

Figure 5. Profile view of a section of the west wall in the north-south trench (Bird's HP-3) showing the lower stratigraphic levels at the north end of Huaca Prieta, the stratigraphic location of the Phase IV–V ramp addition, and the combined radiocarbon date locations of Bird's and our excavations in the basal pre-mound and later mound layers in this sector of the site. The numeration of strata in this unit does not follow a progressive sequence. Those strata in the west wall that correspond with previously numbered strata in the east wall of the trench were given the same number, thus resulting in some strata with higher numbers, assigned by our work, overlying or underlying lower or higher numbers, respectively. Dates with prefix of 'Layer. . .' are radiocarbon dated strata from Bird's work at the site (Bird et al. *1985: figs 20 & 33). All dates are given at 1σ calibration years before present. Radiocarbon laboratory numbers beginning with A are from the University of Arizona, with B from Beta Analytic and with L are from Willard Libby's radiocarbon laboratory in the 1950s. The haystacking construction technique is best represented by strata 54, 53, 39, 48, 22 and 23.*

No architecture was detected for this phase. *Phase II* is dated between ~7572 and 6538 cal BP and represents the first mound construction stage. We estimate that the mound during this phase minimally measured ~5m high, ~25m wide and ~25–35m long and consisted of several cobblestone and soil layers. In Units 15/21 and HP-3, the first layers are dated between 7429 and 6899 cal BP, with younger and older dates stratigraphically bracketing these layers, respectively. In Unit 2, the first layer is represented by stratum 7C-2, which we have not dated due to the absence of datable charcoal (Figure 6). However, this layer overlies stratum 7C-3, which is AMS dated to between 7555 and 7434 cal years ago, suggesting the former probably dates to at least ~7000 cal years ago. The current evidence suggests that the earliest mound layers were placed on the south-east flank and crest of the ancient

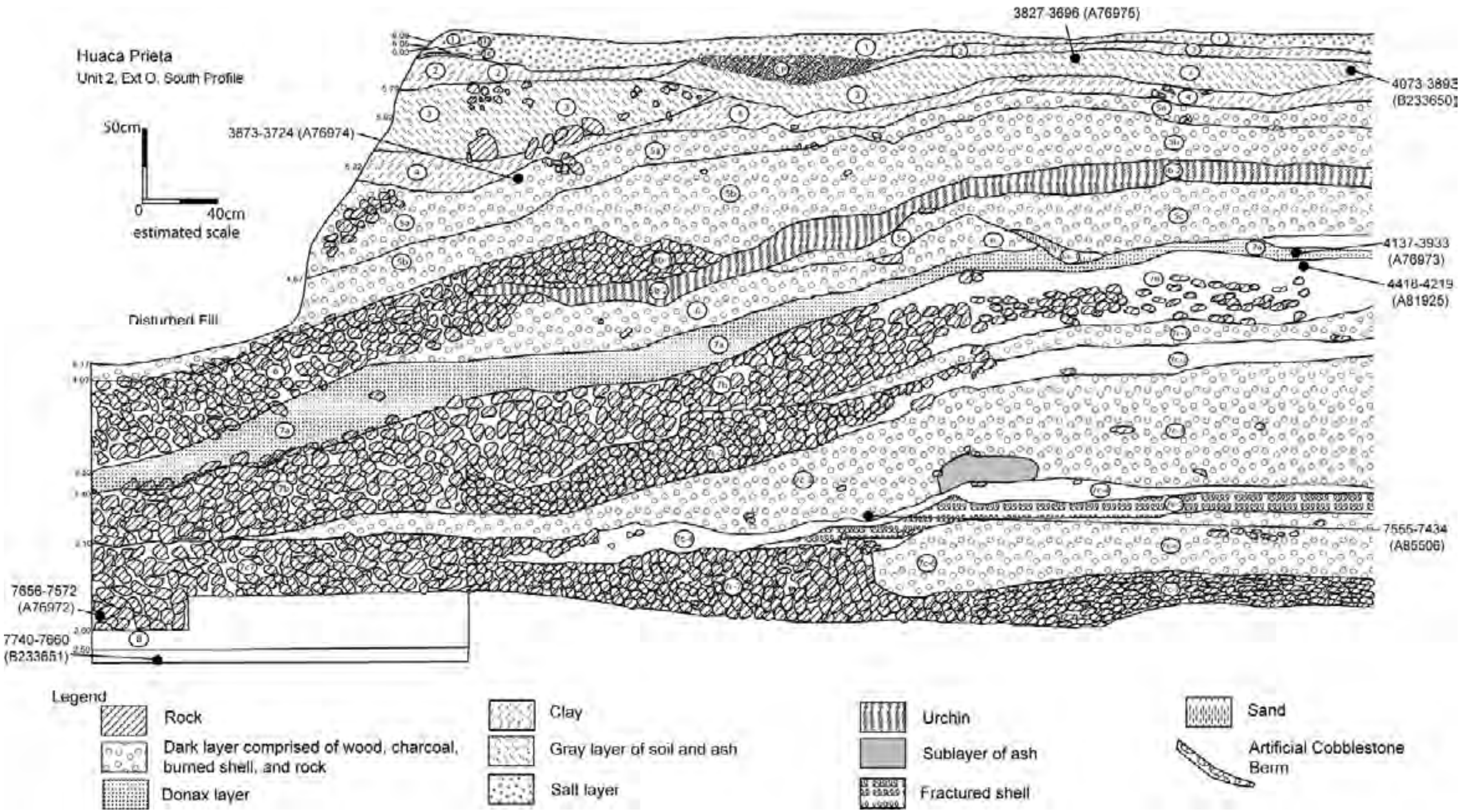

Figure 6. Profile view of Unit 2 showing the pre-mound occupational layers and the initial mound and later strata. All dates are given at 1σ calibration years before present. Radiocarbon laboratory numbers beginning with A are from the University of Arizona and with B from Beta Analytic. The haystacking construction technique is represented by layers 7b, 7b2, 6 and 5b-1.

terrace near the shoreline of the lagoon (Table 1, Units 2, 15/21 & HP-3; and see Figure 3 and SOL 2). From there, the mound appears to have gradually spread to the north and west along this flank, with later construction layers reaching to the western edge of the terrace in the vicinity of Bird's HP-2 pit. The use of space along the eastern flank and the crest of the terrace eventually became more restricted by the increasing steeper sloping sides of the mound. No stone room foundations were recovered for this phase, though a few postholes and cane poles were excavated suggesting the construction of perishable structures.

The mound building phases, beginning with Phase II, did not develop from a gradual accumulation of occupation midden but from deliberate and gradual, planned mounding over a period of ~3000 years. The beginning points of the individual mounding phases are represented in the form of *haystacking* strata whereby a basal ring or layer of shingled cobblestone berms are laid out and angled to define the outer limits of the structure and to provide an architectural footing for the space inside to be infilled by floors and floor fills (Figure 7).

During *Phase III* the focus of mound construction shifted more to the crest and the western edge of the terrace (Figure 3; Table 1, Units 2, 15/21, HP-2, HP-3). Phase III dates between ~6538 and 5308 cal BP and is characterised by the addition of more artificial layers, several small stone-faced, terraced rooms placed along the eastern and western slopes of the mound and, at the end of this phase, the lower floors of a circular sunken pit (Figures 7, 8 & 9: IIIa) on the south side, and the lower part of a stone retention wall on the north-east side (see Figure 4 and SOL 3). These structural features are spatially and architecturally conjoined, suggesting simultaneous planned construction and use across the entire upper surface of the mound at this time. These features began to give the mound a stepped platform-like form. During this phase, the mound expanded to ~8–10m in height in some places and ~80m in length.

Phase IV dates from ~5308–4107 cal years ago, when the mound spread over a more extended area of old and new ground and increased in height (Figures 8 & 9; Table 1, all units). Phases III and IV are separated by a yellowish clay cap ~25cm thick placed over most of the mound. Further additions during this phase were the first layers of a ramp built on the east side, the upper portion of the retention wall and the stepped structures in the sunken plaza (Figures 4, 8 & 9: IIIb) (see SOL 3). The ramp addition is ~40m long and ~35m wide and characterised by a series of thick cobble stone berm layers and by intervening floors built over and sealing the retention wall and the first construction phases of the mound. Later the foundations of the ramp rested directly upon the eastern edge of mound layers built during Phase III. The mound during Phase IV was roughly the size it is today, although a few new layers were added in Phase V.

During *Phase V* the steep sloping flanks of the mound to both the east and west were used less, with most activity now limited to the flat crest of the structure. It dates between ~4107 and 3455 cal BP when, during the early part of this phase, cobblestone burial chambers were built along the upper rim of the sunken pit and on the top of the mound. More layers were also added to the ramp, which eventually covered and sealed the retention wall. By ~4000–3800 cal BP the Preceramic use of the site terminated. People of later ceramic cultures, dating from the Cupisnique to Inca periods (~3500–600 cal years ago) carried out rituals and buried their dead on the top of the mound.

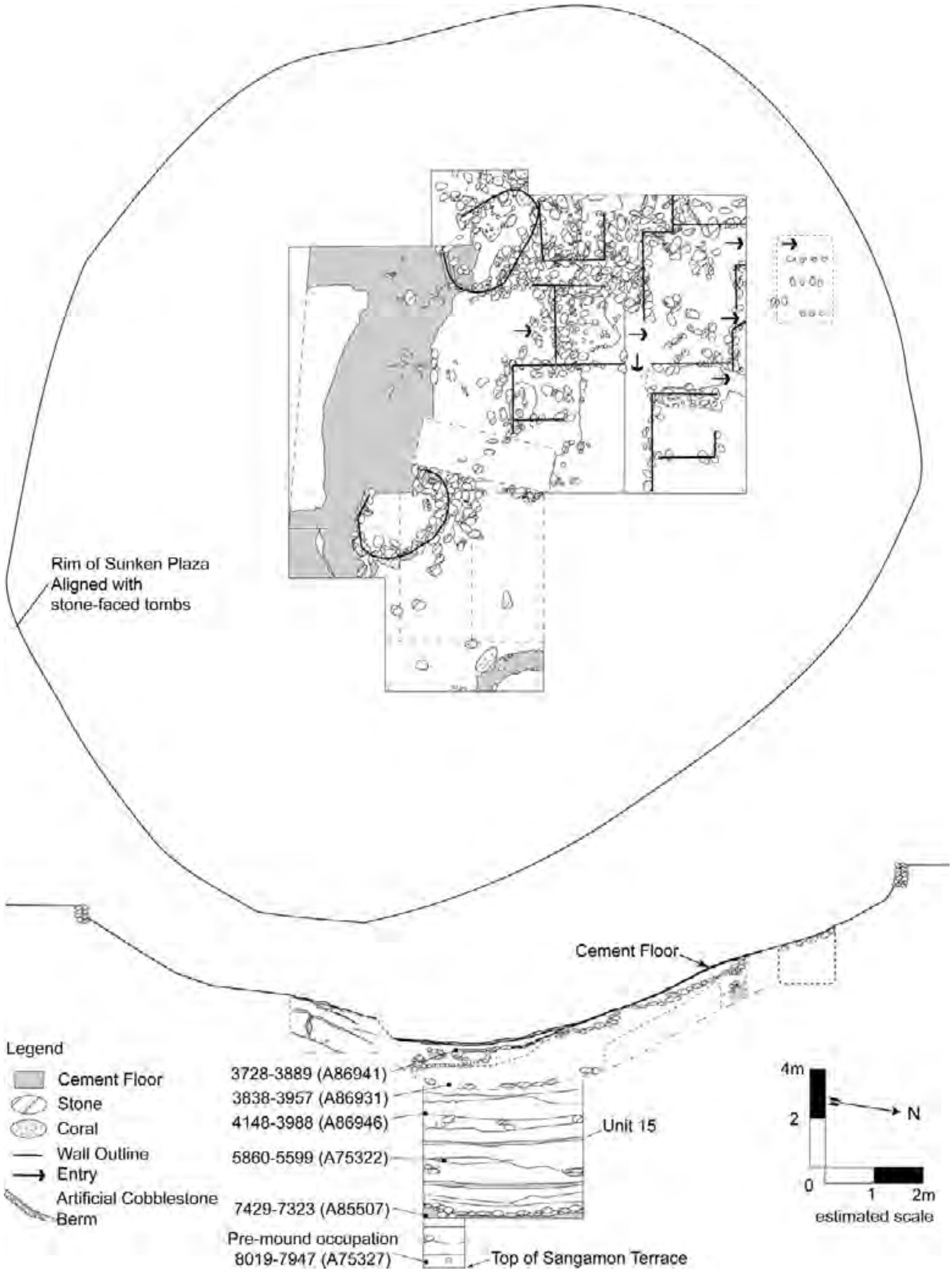

Figure 7. Plan and profile views of the circular sunken plaza showing stepped-rooms and platforms and radiocarbon dated stratigraphy in Units 15 and 21. All dates are given at 1σ calibration years before present. Radiocarbon laboratory numbers beginning with A are from the University of Arizona and with B from Beta Analytic.

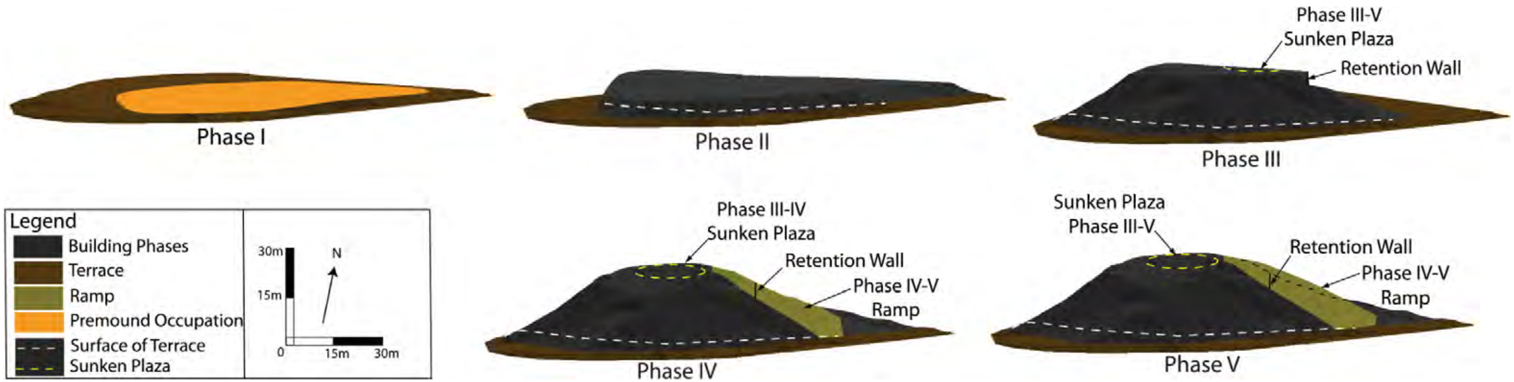

Figure 8. Mosaic of the pre-mound and mound building Phases I–V at Huaca Prieta. Phase I shows the pre-mound occupation area on the lower east side of the Sangamon terrace. Phases II–V reveal the sequential development of the mound from a small, low hummocked structure to a flat-top pyramid with a sunken plaza and ramp.

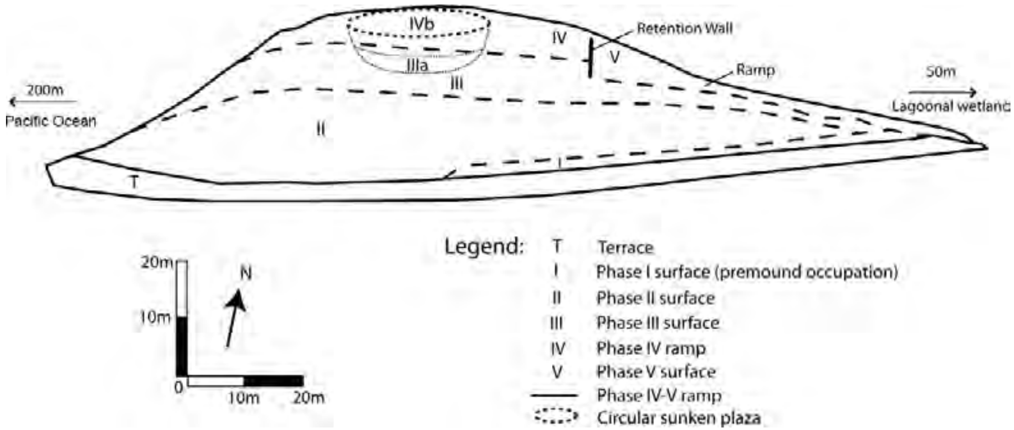

Figure 9. Schematic profile of the pre-mound occupational and mound building phases at Huaca Prieta.

Discussion

Huaca Prieta was a place where several important architectural, technological and artistic innovations took place. The rich coastal environment of the site continuously supported a mixed maritime, wetland and agriculture economy that gave rise to one of the earliest developments of cultural complexity in the Americas (see also SOL 4). Complexity is evidenced not only in the textile and gourd technology, iconography, burial chambers, mound architecture and mixed economy of Huaca Prieta, but in the growth and density of the Preceramic population in the diverse littoral environment north of Huaca Prieta of the Chicama Valley.

Huaca Prieta is an enigma in Andean archaeology because it currently has no known antecedents, either on the ancient terrace (see SOL 5) or further afield. Its complexity lies in its form, function and location. The haystacking construction technique, the circular sunken plaza and retention walls, and the multiple agglutinated rooms of the mound impart a sense of site planning as evidenced at other public monuments during the late Preceramic period (*c*. 5000–4500 cal BP), such as Alto Salaverry, Cerro Ventarrón, Sechín Bajo, Aspero, Bandurria and others along the north and central coast of Peru. However, the architecture, stratigraphy and mortuary remains evidenced for Phases II and III are different from the staircases, ramps and maze-like room construction of the late Preceramic platform monuments at sites such as Sechin Bajo, Caral, Caballete and Cerro Lampay located farther inland in coastal valleys farther south (Moseley 1975; Shady *et al*. 2001; Haas & Creamer 2004; Fuchs & Briceno 2006; Alva 2010), suggesting different activities. The inland sites do not exhibit large numbers of human burials, extensive soot layers and burning, isolated retention walls or the stone- and earth-layered mound, as seen at Huaca Prieta and Paredones. On the other hand, Phases II and III at Huaca Prieta are not associated with large platform structures, suggestive of more formalised, non-mortuary architecture and activity. Feasting associated with burned offerings and probably mortuary rituals appears to have been a primary activity at Huaca Prieta. It was not until Phases IV and V, when the agglutinated rooms and burial chambers on top of the mound and the ramp were added, that Huaca Prieta appeared more typical of other coastal monuments. None of these early coastal sites provide concrete evidence of permanent elites or authoritative figures.

The archaeological record and particularly the age and construction of the mound at Huaca Prieta contribute to a growing body of evidence indicating that the Early to Middle Holocene period in the Central Andes was a complex mosaic of different economies and social forms. For instance, in south-west coastal Ecuador (Piperno & Stothert 2003) and the western montane slopes of northern Peru (Piperno & Dillehay 2008; Dillehay *et al.* 2008; Dillehay 2011), mixed farming and foraging societies existed by at least 10 000–9000 cal BP. In the Andean highlands from Peru and Bolivia to northern Chile and Argentina, economies focused on camelid husbandry and high-altitude crops were developed by at least 6000 cal BP (Aldenderfer 1988; Bonavia 2008). Additional research will continue to reveal that the origins of Andean civilisation have several interrelated regional roots, each characterised by different social and economic conditions. In our perspective, a critical threshold was crossed when these societies moved beyond the domestic context to include planned sedentary communities and a formalised and structured public life. Not only did these societies establish social complexity and public monuments, but they also initiated important environmental changes such as extensive landscape modification and the domestication and spread of plants and animals that eventually led to the development of early states in the Andes.

Acknowledgements

We wish to thank the Instituto Nacional de Cultura (INC), Lima, Peru for granting us the permission to work at Huaca Prieta. We are grateful to Cesar Galvéz and Jesus Briceño (INC, Trujillo) for their support. Financial support for this project came from the National Science Foundation, National Geographic Society and Vanderbilt University. Additional support was provided by the Lupinski and O'Leary families. We also thank Marshall Summar and Jessica Blair of the Vanderbilt University Medical Center for genetic analysis. The first author is grateful to the Department of Anthropology at the American Museum of Natural History for granting permission to study Junius B. Bird's notes and photographs for Huaca Prieta, as well as the artefacts he recovered from the site.

References

ALDENDERFER, M. 1988. Middle Archaic phase domestic architecture from southern Peru. *Science* 241: 1828–30.

ALVA MENESES, I. 2010. Los complejos de Cerro Ventarrón y Collud-Zarpan: del Precerámico al Formativo en el valle de Lambayeque. *Boletín de Arqueológia* PUCP 12: 97–118.

BIRD, J.B. 1948. America's oldest farmers. *Natural History* 17: 296–303.

BIRD, J.B. & J. MAHLER. 1952. America's oldest fabrics. *American Fabric* 20: 73–8.

BIRD, J.B., J. HYSLOP & M.D. SKINNER. 1985. *The Preceramic excavations at the Huaca Prieta, Chicama Valley, Peru* (Anthropological papers of the American Museum of Natural History 62: 1). New York: American Museum of Natural History.

BIRD, R. 1983. A tsunami, a head, maize and dates in the Peruvian early horizon. *American Antiquity* 45: 325–32.

BONAVIA, D. 2008. The *South American camelids* (Cotsen Institute of Archaeology monographs 64). Los Angeles (CA): Cotsen Institute of Archaeology at UCLA.

DILLEHAY, T.D. (ed.) 2011. *From foraging to farming in the Andes: new perspectives on food production and social organization.* Cambridge: Cambridge University Press.

DILLEHAY, T.D., J. ROSSEN, T.C. ANDRES & D.E. WILLIAMS. 2008. Preceramic adoption of peanut, squash and cotton in northern Peru. *Science* 316: 1890–93.

DILLEHAY, T.D., D. BONAVIA, S. GOODBRED & M. PINO. 2010. Un enfoque metodológico hacia un entendimiento de la interacción humana y medioambiente en el valle Bajo de Chicama. *Arqueobios* 4: 154–67.

FISH S., P. DE BLASIS, M.D. GASPAR & P. FISH. 2000. Eventos incrementais na construção de sambaquis, litoral sul do Estado de Santa Catarina. *Revista Museu Arqueo Etnologia* 10: 69–87.

FUCHS, P.R. & J. BRICENO. 2006. Investigaciones arqueológicas en el sitio de Sechín Bajo, Casma. *Boletin Arqueologico PUCP* 10: 111–36.

HAAS, J. & W. CREAMER. 2004. Cultural transformations in the Central Andean Late Archaic, in H. Silverman (ed.) *Andean archaeology*: 35–50. London: Blackwell.

HABU, J. 2004. *Ancient Jomon of Japan*. London: Cambridge University Press.

MCCORMAC, F.G., A.G. HOGG, P.G. BLACKWELL, C.E. BUCK, T.F.G. HIGHAM & P.J. REIMER. 2004. SHCal04 Southern Hemisphere Calibration 0–11.0 cal kyr BP. *Radiocarbon* 46: 1087–1092.

MILLER, F.P, A.F.VANDOME & J. MCBREWSTER. 2010. *Ertebølle culture*. Leiden: Alphascript.

MOSELEY, M.E. 1975. *The maritime foundations of Andean civilization*. Menlo Park (CA): Cummings.

– 1992. Maritime foundations and multilinear evolution: retrospect and prospect. *Andean Past* 3: 5–42.

PEARSALL, D.M. 2008. Plant domestication and the shift to agriculture in the Andes, in H. Silverman & W.H. Isbell (ed.) *Handbook of South American archaeology*: 105–120. New York: Springer.

PIPERNO, D. & T.D. DILLEHAY. 2008. Starch grains on human teeth reveal early broad crop diet in northern Peru. *Proceedings of the National Academy of Sciences USA* 105: 376–85.

PIPERNO, D. & K. STOTHERT. 2003. Phytolith evidence for Early Holocene *Cucurbita* domestication in south-west Ecuador. *Science* 299:1054–57.

RICHARDSON III, J.B. 1981. Modeling the development of sedentary maritime economies on the coast of Peru: a preliminary statement. *Annals of the Carnegie Museum* 50: 139–50.

SANDWEISS, D.H., K.A. MAASCH & D.G. ANDERSON. 1999. Transitions in the Mid-Holocene. *Science* 283: 499–500.

SANDWEISS, D.H., R. SHADY SOLÍS, M.E. MOSELEY, D.K. KEEFER & D.R. ORTLOFF. 2009. Environmental change and economic development in coastal Peru between 5800 and 3600 years ago. *Proceedings of the National Academy of Sciences USA* 106: 1359–63.

SHADY, R.S., J. HAAS & W. CREAMER. 2001. Dating Caral, a Preceramic site in the Supe Valley on the central coast of Peru. *Science* 292: 723–26.

STRAUS, L.G., B.V. ERIKSEN, J.M. ERLANDSON & D.R. YESNER (ed.). 1996. *Humans at the end of the Ice Age*: *the archaeology of the Pleistocene–Holocene transition*. New York: Plenum Press.

THOMPSON, V. & J.E. WORTH. 2010. Dwellers by the sea: Native American adaptations along the southern coasts of eastern North America. *Journal of Archaeological Research* 25: 23–45.

WELLS, L.E. 1999. The Santa beach ridge complex: sea-level and progradational history of an open gravel coast in central Peru. *Journal of Coastal Research* 12: 1–17.

Received: 19 April 2011; Accepted: 20 June 2011; Revised: 27 June 2011

Chronology, mound-building and environment at Huaca Prieta, coastal Peru, from 13 700 to 4000 years ago

Tom D. Dillehay[1,2], Duccio Bonavia[3], Steven Goodbred[4], Mario Pino[5], Victor Vasquez[6], Teresa Rosales Tham[6], William Conklin[7], Jeff Splitstoser[8], Dolores Piperno[9], José Iriarte[10], Alexander Grobman[11], Gerson Levi-Lazzaris[1], Daniel Moreira[12], Marilaura Lopéz[13], Tiffiny Tung[1], Anne Titelbaum[14], John Verano[14], James Adovasio[15], Linda Scott Cummings[16], Phillipe Bearéz[17], Elise Dufour [17], Olivier Tombret[17, 18], Michael Ramirez[19], Rachel Beavins[4], Larisa DeSantis[4], Isabel Rey[20], Philip Mink[21], Greg Maggard[21] &Teresa Franco[1]

[1] Department of Anthropology, College of Arts and Science, Vanderbilt University, 124 Garland Hall, Nashville, TN 37235, USA; [2] Escuela de Antropología, Faculdad de Ciensias Sociales, Universidad Católica de Temuco, Manuel Montt 056, Temuco, Chile [3] Academia Nacional de la Historia, Casa de Osambela, Jr. Conde de Superunda 298, Lima 1, Perú; [4] Department of Earth and Environmental Sciences, College of Arts and Science, Vanderbilt University, 5726 Stevenson Center, 7th floor, Nashville, TN 37240, USA; [5] Instituto de Ciencias Geológicas, Facultad de Ciencias, Universidad Austral de Chile, Casilla 567, Valdivia, Chile; [6] Laboratorio de Bioarquelogía, Universidad Nacional de Trujillo, Avda. Universitaria s/n, Trujillo, Perú; [7] Department of Anthropology, Field Museum, 1400 S. Lake Shore Drive, Chicago, IL 60605-2496, USA; [8] Boundary End Archaeology Research Center, One Walker Creek Road, Barnardsville, NC 28709-0592, USA; [9] Archaeobiology Program, Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington DC 20013-7012, USA & Smithsonian Tropical Research Institute, Balboa, Panama; [10] Department of Archaeology, University of Exeter, Laver Building, North Park Road, Exeter EX4 4QE, UK; [11] Universidad Nacional Agraria La Molina, Av. La Universidad s/n, Facultad de Ciencias, Lima 12, Perú; [12] Departamento de Arqueologia, Universidade Federal de Rondônia, Avenida Presidente Dutra 2965, Porto Velho 78900-500, Brasil; [13] Escuela de Arqueología, Universidad Nacional de Trujillo, Avenida Juan Pablo II s/n, Ciudad Universitaria, Trujillo, La Libertad, Perú; [14] Department of Anthropology, Tulane

Dillehay, T.D. *et al.* 2012. Chronology, mound-building and environment at Huaca Prieta, coastal Peru, from 13 700 to 4000 years ago. *Antiquity* 86: 48–70.

University, 101 Dinwiddie Hall, 6823 St Charles Avenue, New Orleans, LA 70118, USA; [15] *Department of Anthropology, Mercyhurst Archaeological Institute, Mercyhurst College, 501 East 58th Street, Erie, PA 16546-0001, USA;* [16] *Paleo Research Institute, 2675 Youngfield St, Golden, CO 80401, USA;* [17] *Museum National d'Histoire Naturelle, Paris 75005, France;* [18] *Université de Picardie Jules Verne, Chemin de Thil, 80-025 Amiens, France;* [19] *Department of Geological Sciences, University of Texas at Austin, 6 East Mall EPS RM 1.130, Austin, TX 78705, USA;* [20] *Tissue and DNA Collections, Museo Nacional de Ciencias Naturales (CSIC), Jose Gutierrez Abascal 2, 28006 Madrid, Spain;* [21] *Kentucky Archaeological Survey, Department of Anthropology, University of Kentucky, Lexington, Kentucky 40506-9854, USA*

This paper is published in full in *Antiquity* 86 (http://www.antiquity.ac.uk/ant/086/ant0860048.htm). Here we publish supplementary material.

The article by Dillehay et al. *in* Antiquity *86 summarised recent research at the mound of Huaca Prieta on the north coast of Peru where a first human presence was documented between ~13 700 and 13 300 cal BP, a combined maritime and incipient crop economy developed between ~9000 and 4000 cal BP and mound building began ~7500 cal BP. The findings contribute to knowledge of the origins of ancient monuments across the globe and to understanding the rise of early social complexity on the coast of Peru. The campaign also included exploratory work on the remnant Pleistocene terrace which has Huaca Prieta at its tip (Figure S1). The supplementary material provided here gives essential data on the floodplain, the stratification of the mound, structural features in the mound, the subsistence economy and domestic sites beyond the mound.*

Keywords: Peru, Holocene, ritual mound, horticulture

SOL 1. Floodplain deposits

The specific floodplain deposits of interest here comprise 1–8m of sand, mud and carbonate sediments that were deposited within various river, floodplain and coastal settings over the past 8000 years. The base of the Holocene sequence is readily identified by a sandy gravel and cobble surface that represents alluvial fan deposition during the late Pleistocene. The earliest Holocene sediments deposited over the lowstand gravels are silty, fine to medium sands typically found 6–8m below the modern surface. These sands are non-fossiliferous and lack any mud drapes or associated overbank muds, suggesting that they are channel and bar deposits of a largely clear-water, bedload-dominated stream channel, one presumably fed by meltwater from snow and glaciers in the Andean highlands. Such a fluvial system is probably not unlike the modern Chicama River during normal discharge regimes (i.e. a non-El Niño year). These fluvial sands are sharply overlain by a complex sequence of well-bedded lagoon deposits that extend <1km inland of the modern shoreline, reflecting the backwater influence of rising sea level. These Early Holocene lagoon sediments are 1–3m thick and characterised by thick, alternating layers (5–20cm) of algal carbonates (primarily *Charophyta*) and micro-fossiliferous blue muds (primarily *Ostracoda*). The ecology of both types of deposits is species depauperate (<6 total species) with intermittent wood, detrital organic layers and seagrass seeds (*Ruppia maritima*). Based on sediment lithology and ecological communities, these units reflect a predominantly oligotrophic and oligohaline lagoon, perhaps groundwater fed, with fringing wetland vegetation, a weak to intermittent connection to the sea and limited fluvial sediment input. Found at depths of 3–6m below the modern surface, three radiocarbon dates near the base of the lagoonal sequence bound its lower age to ~7500 cal BP (~6939–7483 cal BP, see Table 1), with one shallower date (6404–6538 cal BP) showing that this open-water lagoon persisted for at least 1000 years. These lagoon deposits correspond with the deepest pre-mound and early mound building layers at Huaca Prieta, located on the lower inland side of the terrace and dated to ~9000–7600 cal BP (Table 1). Preliminary data indicate that the lowstand gravels are overlain by dark to silty sands that roughly correspond to the ~9000–8000 cal BP phase of initial site occupation and probably represent an environment similar to the shallow, outwash wetland channels carved into the gravels and filled with vegetated sands and muds located 2–20km to the north of the site today. These data confirm that early settlement and mound building at Huaca Prieta was coincident with the long-term development of an expansive wetland-fringed, estuarine lagoon.

After ~6500 cal BP, the carbonate and muddy lagoon sediments become increasingly rare in the stratigraphic record and are permanently replaced in the upper 3m by 10cm-thick, yellowish-brown silt layers. The silt deposits are massively bedded and characteristic of the modern floodplain, thus reflecting a major environmental transition from open-water lagoon to emergent riverine floodplain. This conversion began by at least 5000 cal BP and appears to have been largely complete by ~4500 cal BP as indicated by a complete lack of carbonate or fossiliferous mud layers after this time. Sediments between the lagoon deposits and floodplain silts contain regular organic-rich horizons that represent ephemeral wetlands that existed during the transition. The driving mechanism for this environmental change requires an increased flux of riverine sediment to the coast, which infilled the lagoon and developed an expansive subaerial floodplain, which provided additional cultivable land.

SOL 2. Mound stratigraphy

The stratigraphy of the mound is complex. Certain individual strata within the mound represent discrete cultural use components and others collectively constitute single components. Others cease toward one end or both horizontal ends of the mound in such a fashion that the underlying layers unite to clasp them and hold them within a uniform mass. Others join up laterally, like fingers extending from the palm of the hand, signalling contemporaneous strata (Figures 5–7). Thus, there is little current evidence to suggest that a single use or construction layer ever completely and evenly developed across the site, although such surfaces surely once existed. Furthermore, all stratigraphic components must have been subjected to different rates of deposition, as a result of short- or long-term use episodes, construction phases and, very infrequently, the deposition of thin water-borne and wind-borne deposits in the basal levels. It was thus necessary to clearly distinguish between these types of strata and those that represent physical boundaries between components. A case in point is a succession of strata that represent intermittent use episodes with time gaps between episodes. In such cases, the sediments at the point of juncture between any two components may be a floor, a fill layer or an architectural wall or room. To isolate discrete use episodes and component assemblages involved differentiating between fill and primary-deposition units, the latter best defined by floors and their *in situ* features and artefact offerings located on floors. Another important element in the stratigraphic analysis was the common practice of burying the dead in fills under floors in the mound. Graves served as reliable stratigraphic markers. Knowing the site was comprised of discrete depositional units, we devised an excavation strategy to examine and date as many horizontal and vertical components as possible by conducting deep trenching and horizontal stripping to examine strata, floors and features. We also carried out extensive off-mound trenching and block excavation to detect associated domestic areas (Figure S2). Given these stratigraphic characteristics, the excavation of the site involved a variety of techniques ranging from wall clearing, floor and use-surface stripping, trenching, block excavation or some other tactic designed to expose vertical profiles of a wide variety of cultural deposits both on and off the mound.

SOL 3. Observations on the architectural phases

Remnants of the pre-mound occupation and the subsequent early mound layers of Phases II and III were eventually deeply buried beneath later mound constructions, thus making it very difficult to expose them during excavation. Bird's (Bird *et al*. 1985: 35–43, 51–8) excavations were located on the ramp on the east side of the mound (HP-3), on its western edge (HP-2), and on top of it (HP-3), areas all dating to Phases IV and V. His excavations never reached the deeper, more interior layers of the mound, which are located ~3–4m directly below and behind the foundation stones of the Phase III retention wall. Thus, Bird's excavations in HP-3, the long north to south-trending trench on the eastern flank of the mound, exposed stratigraphy primarily associated with the ramp during Phases IV and V, which accounts for all of his radiocarbon dates between ~4500 cal BP and younger. His work in this area also exposed a stone-faced retention wall built during Phases III and IV, which was later covered by construction of the ramp during Phase V. Bird (Bird *et al*. 1985: 40–1) reports that he terminated excavation in HP-3 when he reached a culturally sterile conglomerate rock layer, but what he exposed was an artefact-free fill composed of rock and clean sediments, which corresponds to our stratum 35 in this unit (Figure 5). Our excavation below stratum 35 recovered nearly 3m more of cultural deposits.

Bird (Bird *et al*. 1985: 43–6) thought that the Phase III circular sunken pit on the south side of the mound was a looter's hole. However, our excavations have revealed that it is a sunken plaza defined by a series of stone-faced, stepped platforms and small rooms with stone walls constructed across a deep, roughly circular, concave-pit measuring ~25m in diameter. Shell, coca, bird feathers and other offerings, dating from at least ~4000 cal BP, were recovered from floors of the rooms and platforms of the plaza. The north end of the plaza ascends through a sinuous pathway to connect to burial chambers located on top of the mound that date to Phases III, IV and V.

After each use and building episode, the mound was completely capped by a hardened artificial cement layer composed of saltwater, sediment, ash, crushed shells and other organic debris. These layers not only sealed the prior floors and fills but also prevented erosion of the site. Scattered among the floors and rooms are artefacts, extensive burned areas and deposits of ash and charcoal, articulated and disarticulated human remains, and ritual offerings. No hearths, post-holes, storage pits, food containers and other indicators of domestic occupation were recovered from the mound. While Bird (Bird *et al*. 1985: 43–8) thought that the small, low-ceiling stone rooms (~1m high and 2–3m in diameter) on top of the mound were habitation structures, our excavations indicate they are burial chambers (cf. Rick 1990) containing articulated human skeletons and dated to Phases III–V. Human burials were recovered from all mound-building phases, suggesting the structure was closely associated with mortuary rituals. However, the most prevalent activity associated with the mound is thousands of individual burning episodes within and across all strata in the site, suggesting it was built by limited groups of people during numerous ritual and construction episodes over a period of ~3500 years. Also notable is the absence of domestic debris throughout the mound. Off-mound domestic areas appear ~7000 cal BP just north of the mound (Units 16 & 24), near Paredones and at domestic sites located several kilometres north in the coastal wetlands (Figure S1).

SOL 4. Subsistence economy

We recovered over 200 000 floral and faunal remains representing more than 360 individual species (Vasquez & Tham 2010), 65 of which correspond with Bird's findings in the 1940s (Bird *et al*. 1985: 229–44). A detailed quantitative report on the specific taxa far exceeds the space limits here, thus a brief listing of the major species is provided. Marine species dominate throughout all time periods, with fish and shellfish being the most abundant and diverse remains. There are 34 shellfish species: *Chiton, Fissurella, Collisella, Tegula, Polinices, Concholepas, Oliva, Cancellaria, Helisoma, Protothaca, Semele*; 5 crustacean species: *Cancer, Platyxanthus*; 2 echinoderm species: *Tetrapygus, Caenocentrotus*; 19 fish species: *Galeorhinus, Mustelus, Squatina, Rhinobatos, Myliobatis, Galeichthys, Engraulins, Ethmidium, Sardinops, Mugil, Trachurus, Sciaena, Anisotremus, Sarda*; 11 bird species: *Spheniscus, Diomedea, Charadrius, Larus, Egretta, Pelecanus thagus, Phalacrocorax, Sula, Zenaida, Podylimbus, Anas,* and 8 mammalian species: *Cavia, Canis, Lycalopex, Otaria, Balanidae, Delphinus, Odocoileus, Lama*. The frequency of these species changes throughout time, which probably reflects changes in the local environment.

Bird also recovered squash, chili pepper, lima bean, jack bean, gourd, cotton and other cultivars (Bird 1948; Bird *et al*. 1985: 229–40). Results of our macro-botanical study of floated feature fills and floor sediments, as well as starch grain, phytolith and pollen analyses, have added several additional species, including Preceramic maize (*Zea mays*), coca (*Erythroxylum coca*), peanut (*Arachis hypogaea*), chirimoya or guanábana (*Annona* sp.), pacae (*Inga feuillei*), sweet potato (*Ipomoea batatas*), yuca (*Manihot esculenta*), avocado (*Persea* sp.), quinoa (*Chenopodium* sp.), bean (*Phaseolus vulgaris* & *Phaseolus lunatus*), various tubers (*Solanum* sp.) and other crops. Not yet determined for some species is whether the morphological features are associated with domesticated forms. All of these crops are exotic to the littoral zone of the site.

Our combined ecological and dietary evidence indicates that the initial economy of Phase I (~9000–7500 cal years ago) depended primarily on fish, shellfish, birds, seaweeds and sea lions. Squash (*Cucurbita* sp.), lima bean, and avocado were minor food elements.

Between ~7000–6000 cal BP, chili pepper (*Capsicum* sp.) and gourds (*Lagenaria siceraria*) were added. Around 6800 cal BP (Table 1), when the deltaic floodplain began to form, there is evidence for cotton production. Corn and the other crops were incorporated in Phases II to V, after ~6500 cal BP. Although increases in plant species show a continuous greater reliance on cultigens, marine species dominated the diet throughout all phases.

SOL 5. Off-mound domestic sites

Our research also located 38 Preceramic domestic sites between the shoreline and backwater wetlands within 100m to 20km of Huaca Prieta (Figure S1). Preliminary results show that although these sites yield artefacts and food remains similar to those at Huaca Prieta, they differ significantly by containing domestic hearths, food preparation areas, middens and residential structures. However, they do not contain the black soot and ash found at Huaca Prieta. Geological dates and diagnostic artefacts place the majority of these sites between ~6000 and 4000 cal BP, which roughly corresponds with Phases III–V at Huaca Prieta and with an apparent population increase along this sector of the coast. The mound at Huaca Prieta was built and maintained probably by people living at these sites, especially Paredones, a large, deeply stratified domestic midden located ~1km to the north. The mound probably served these people for many generations as a communal ossuary and as a continuing focus for public events beyond the household and community levels.

The stretch of the coast north of Huaca Prieta is an area that shared characteristics of material culture dating between at least 6500 and 500 cal BP and evolved as an integrated region. Cursory observation of Preceramic sites (n=38) along this stretch shows that low house mounds consisting of small cobblestone structures, midden refuse and human burials characterize them. In some locations, the mounds form small hamlets or communities comprised of several households and an open plaza-like area. One exception to these sites is Pulpar, a smaller version of Huaca Prieta that is also built on a terrace remnant and has similar tomb construction and cultural debris, but probably dates to our Phases IV and V. These communities are located on both the coastal and inland sides of the estuarine wetlands, and were probably linked to Huaca Prieta and to late preceramic domestic sites situated farther inland, on the coastal plains and in the foothills of the Andes. The larger coastal sites are about 200m in length and defined by several mounded areas. Smaller sites have one to two house mounds and midden areas. As evidenced by study of the stratigraphy and artefact content in looter holes and natural drainages, many sites were continuously occupied from middle Preceramic to Chimu times (~5500–700 cal BP).

Particularly significant is the discovery of raised agricultural platforms buried ~1.5m below the present-day ground surface in ancient wetlands immediately east of Huaca Prieta and the domestic sites. The fields are radiocarbon dated to ~4800 cal BP, contain phytoliths of beans, squash and chili pepper, and are probably where crops were grown by occupants of Paredones and other nearby domestic sites.

References

BIRD, J.B. 1948. America's oldest farmers. *Natural History* 17: 296–303.

BIRD, J.B., J. HYSLOP & M.D. SKINNER. 1985. *The Preceramic excavations at the Huaca Prieta, Chicama Valley, Peru* (Anthropological papers of the American Museum of Natural History 62: 1). New York: American Museum of Natural History.

MCCORMAC, F.G., A.G. HOGG, P.G. BLACKWELL, C.E. BUCK, T.F.G. HIGHAM & P.J. REIMER. 2004. SHCal04 Southern Hemisphere Calibration 0–11.0 cal kyr BP. *Radiocarbon* 46: 1087–1092.

RICK, J. 1990. Review of The Preceramic excavations at Huaca Prieta, Chicama Valley, Peru, Anthropological Papers of the American Museum of Natural History, New York, by J.B. Bird *et al*. 1985. *American Anthropologist* 92: 543–44.

VASQUEZ, V. F. & T.E. THAM. 2010. Resumen Final 2010: Restos de fauna y vegetales de Huaca Prieta y Paredones, Valle de Chicama. Manuscript housed at Vanderbilt University, Nashville.

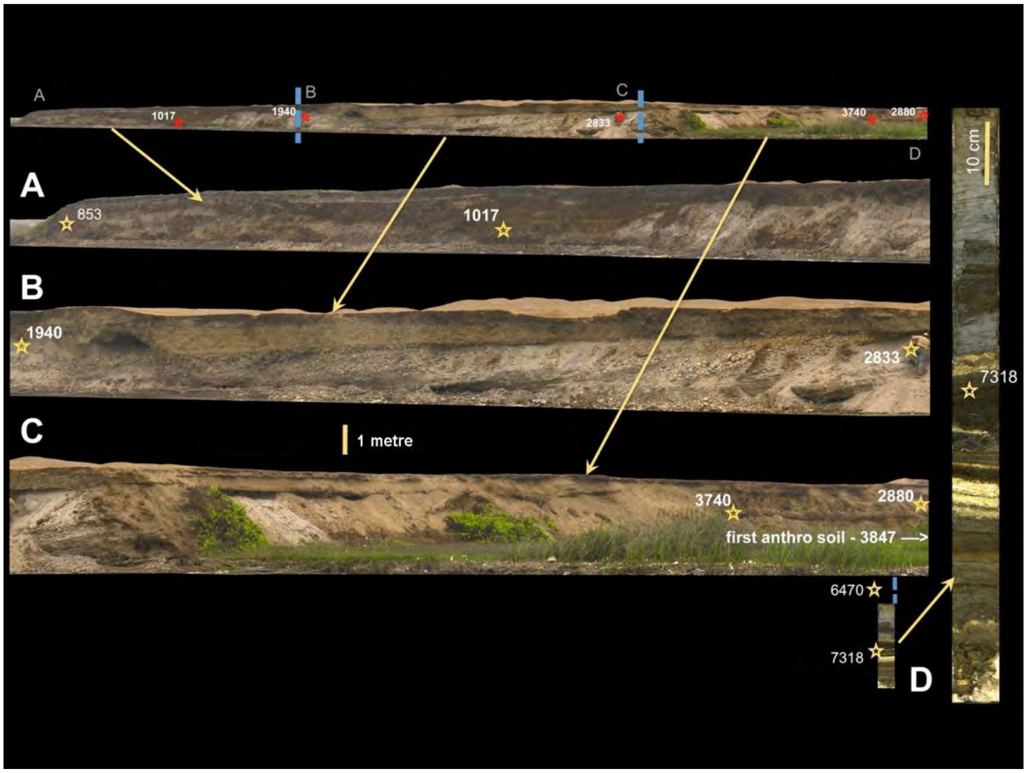

Figure S1. Photomosaic of cutbank exposures (A–C) at the Chicama River mouth (shoreline is 50m left of A), plus a core section from the underlying stratigraphy (D). Each panel (A–C) is contiguous and shown together in the top panel. The stars mark the location of radiocarbon ages, reported in calendar years BP. Overall, the stratigraphy here records a late Holocene prograding cobble-and-sand shoreface sequence (lower B) capped by younger muddy El Niño flood deposits (upper B) that prograde seaward (A). In panel B the cobble shoreface deposits are truncated by a curvilinear surface that extends over 100 landward (panel C) before transitioning into a thin-sand layer reaching another 100m onto the floodplain, representing a tsunami that impacted the coast just before the 1940 cal BP radiocarbon age from the overlying sandy shoreface. The remnant of an earlier tsunami truncation surface is preserved on the right side of panel B, just up and left of the 2833 cal BP radiocarbon age. Another age of an organic-rich swale deposit that is capped by the cobbles dates to 2880 cal BP (panel C), confirming the occurrence of this first, earlier tsunami. The point of maximum shoreline transgression is recorded where shoreface cobbles onlap backdune sediments dated to 3740 cal BP (panel C), roughly the same age as a 3847 cal BP-dated human occupational horizon around 25m away. Underlying the exposed shoreface and floodplain sequence are a series of carbonate-rich coastal lagoon deposits dating from ~6500–7500 cal BP (panel D). These well-bedded sediments include alternating layers of carbonate, organic-rich sediments, and blue mud that each represents changing fluvial sediment inputs and water levels during time of deposition. The carbonates suggest deeper clear water, with the organic deposits indicating shoaling water with emergent vegetation, and the blue muds reflecting river sediment discharge into the lagoon.

Dillehay, T.D. *et al.* 2012. Chronology, mound-building and environment at Huaca Prieta, coastal Peru, from 13 700 to 4000 years ago. *Antiquity* 86: 48–70.

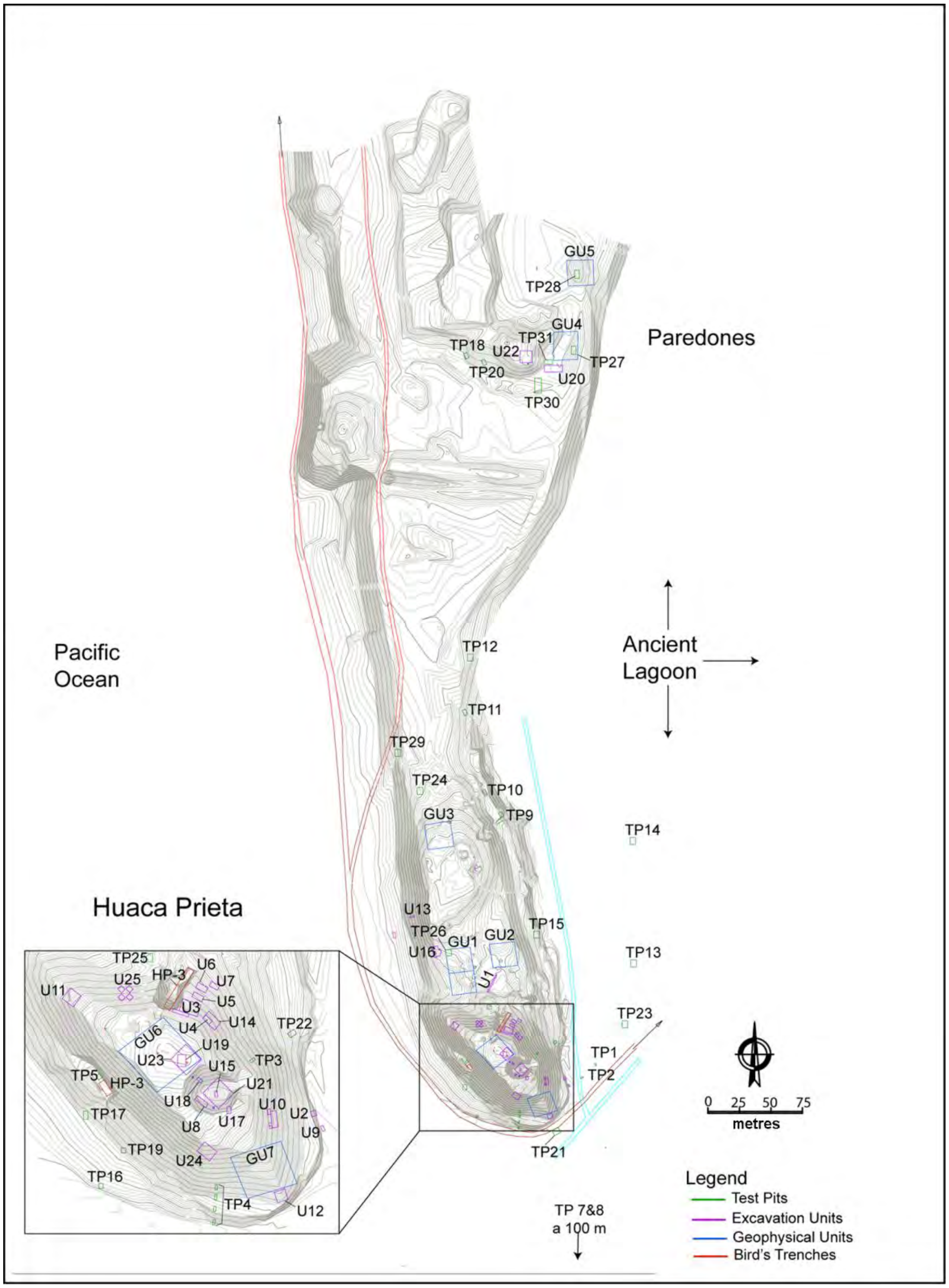

Figure S2. Topographic contour map of Huaca Prieta and Paredones, showing all excavation and geophysical units and the position of the Pacific Ocean and the ancient lagoon to the sites. This stretch of the coast north of Huaca Prieta is an area that shared characteristics of material culture dating between at least 6500 and 500 cal BP and evolved as an integrated region. Cursory observation of Preceramic sites (n=38) along this stretch shows that sites are characterized by low house mounds consisting of small cobblestone structures, midden refuse and human burials. In some locations, the mounds form small *hamlets or communities comprised of several households and an open plaza-like area. One exception to these sites is Pulpar, a smaller version of Huaca Prieta that is also built on a terrace remnant and has similar tomb construction and cultural debris, but probably dates to our Phases IV and V. These communities are located on both the coastal and inland sides of the estuarine wetlands, and were probably linked to Huaca Prieta and to domestic sites situated farther inland on the coast plains and in the foothills of the Andes. The larger coastal sites are about 200 m in length and defined by several mounded areas. Smaller sites have one to two house mounds and midden areas. As evidenced by study of the stratigraphy and artefact content in looter holes and natural drainages, many sites were continuously occupied from middle Preceramic to Chimu times (~5500–700 cal BP).*

Dillehay, T.D. *et al.* 2012. Chronology, mound-building and environment at Huaca Prieta, coastal Peru, from 13 700 to 4000 years ago. *Antiquity* 86: 48–70.