Results of Archaeological Investigations at the La Bocana site, Baja California Norte

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Abstract

Test excavations at the La Bocana site revealed a long, stratified record detailing human use of changing Pacific marine resources. Multiple occupations were dated between 7170 ±80 and 4100 ±60 B.P.; nearby, additional undated occupations likely extend this record into the latest Holocene. Paleoenvironmental changes are reflected in the activation of dunes, paleosol development, and shift in frequency of invertebrate species in midden deposits after 7100 B.P. These records match the timing of dune growth in Baja California's interior. Sites like La Bocana contribute important information on the evolution of coastal landscapes, biotic populations, and context for human ecology along the Pacific rim.

Introduction

In the last few decades, attention has been placed on alternative models of human entry into the New World, with particular emphasis on a coastal route of migration across the Bering Land Bridge during the Pleistocene (Fladmark 1979; Gruhn 1988, 1993). Because of the geologic changes that occurred during the late Quaternary period, it has been difficult for archaeologists to find Pleistocene-age sites along the Pacific margin of the Americas. As sea level rose during the retreat of continental glaciers after 21,000 B.P., the Pacific coastline was reduced (Stanley 1995) destroying and submerging sites in the process. Due to its unique geologic character, however, the Baja California peninsula may retain relict portions of the Pleistocene shoreline. In areas along the northern coast of Baja California the continental shelf is very narrow, which would force early humans to stay close to the position of the modern shoreline. In regions affected by active faults, bedrock units are often uplifted through time, raising landscape components beyond the erosive action of the ocean and preserving any early archaeological sites they may contain. The challenge to research lies in finding coastal areas that correspond to these geologic and archaeological criteria. Based on this rationale, research efforts, which are reported here, sought to find and investigate sites that may hold Pleistocene-age cultural occupation.

Previous Investigations

In the spring of 1999, a survey team led by the author and other archaeologists from the University of Alberta located a site with stratified cultural horizons exposed in a large dune, just south of the mouth of the Santo Tomás River near the town of La Bocana at about 31.5° N latitude, 116.38° W longitude (Figure 1). This site, hereafter called the La Bocana site because of the proximity to the town of La Bocana, contains cultural materials in association with a series of

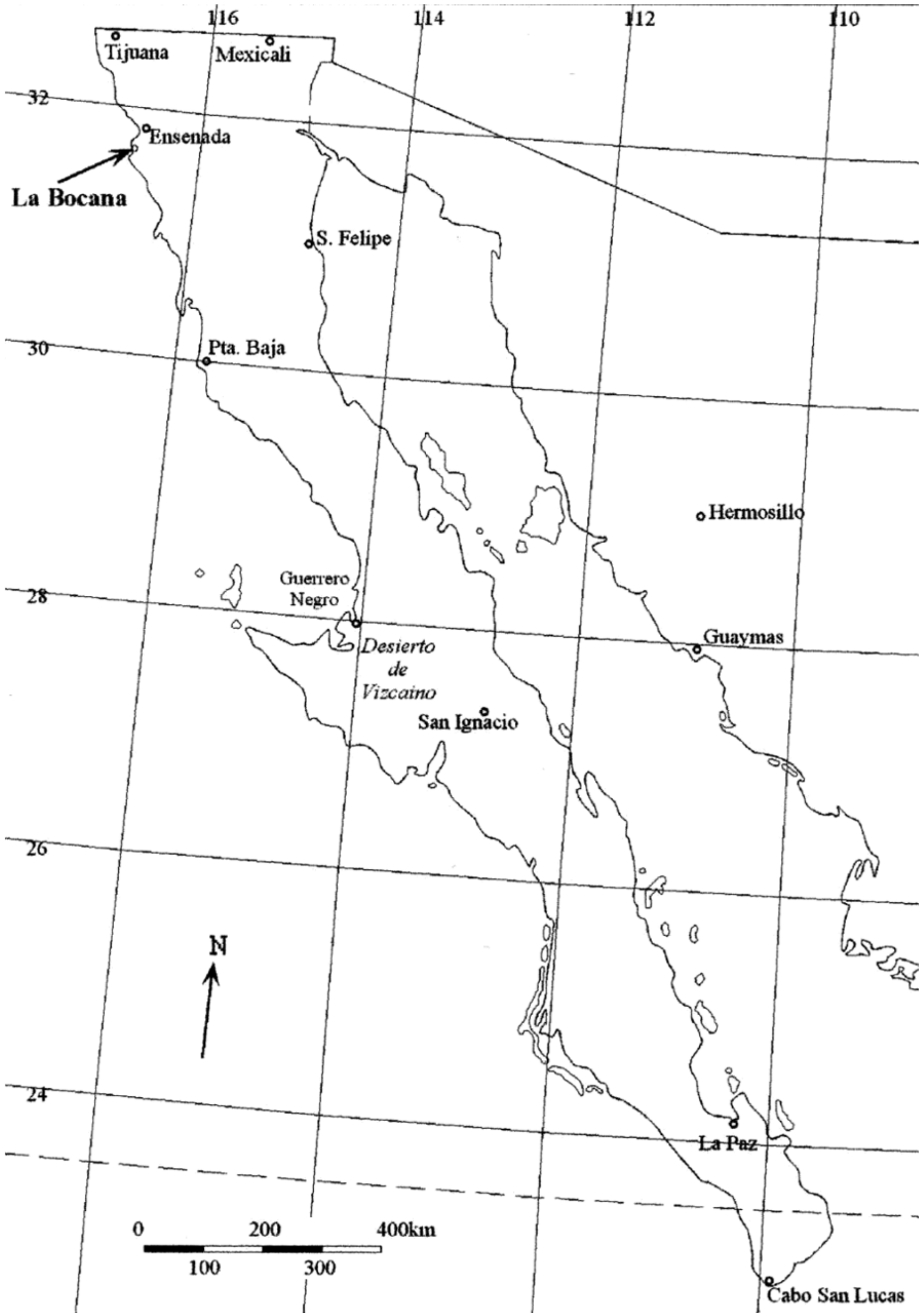

Figure 1. Map of the region, showing the location of the La Bocana site.

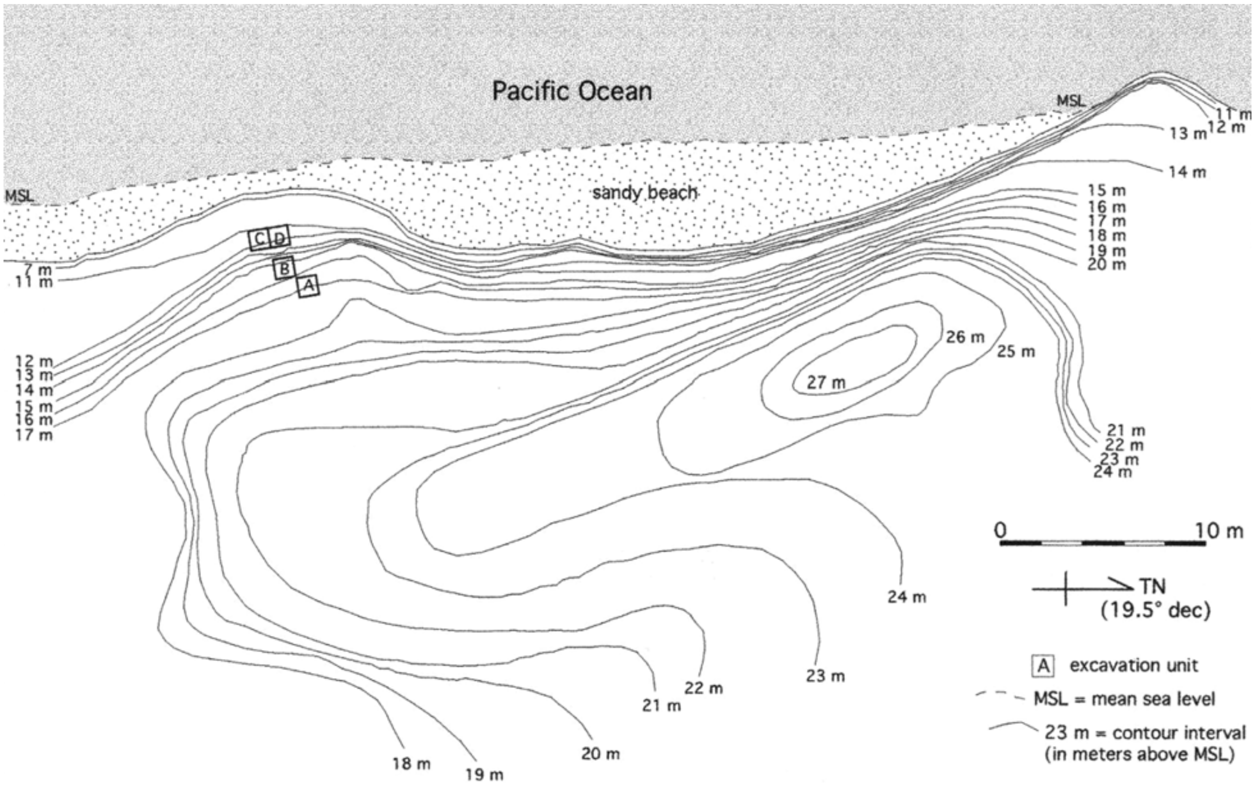

Figure 2. Topographic map of the La Bocana site, showing the position of excavation units.

Table 1. Radiocarbon dates from the La Bocana site. Provenience refers to depth of sample below referential datum (located at top of excavation Unit A). *Spisula hemphilli* and *Lottia gigantea* valve samples are carbonate accelerator mass spectrometry ages (AMS). Lab number includes the unique sample assay tracking code from IsoTrace Laboratory, at the University of Toronto. Uncalibrated ^{14}C ages are reported in years before present (B.P.), while calibrated ^{14}C ages are reported in calendar years (B.C.); calibration calculated by IsoTrace Laboratory using the INTCAL98 dataset (Stuiver et al. 1998:1041).

Provenience	**Description**	**Method**	**Lab Number**	**^{14}C Age (B.P.)**	**Calibrated Age**
150 cm BD	wood charcoal	AMS	TO-9218	4100 ±60	2825-2600 B.C.
340 cm BD	wood charcoal	AMS	TO-9219	4880 ±60	3650 B.C.
395 cm BD	*Spisula hemphilli* valve	AMS	TO-8193	6940 ±90	5835 B.C.
400 cm BD	*Lottia gigantea* valve	AMS	TO-8104	7170 ±80	6015 B.C.

buried paleosols (Figure 2). During the initial site visit, a large leaf-shaped biface and a core reduction flake were found in and at the base of a lowest paleosol. Other evidence of cultural occupation was noted in the two other paleosols positioned higher in the stratigraphic profile, including horizontal concentrations of lithic debitage, bone fragments, and mollusk shells. Shell fragments were collected from the lower paleosol and submitted for radiocarbon dating (Table 1). These samples returned dates of 7170 ±80 B.P. (TO-8194) and 6,940 ±90 B.P. (TO-8193). These dates suggested that early cultural occupations may be held in deeply-buried site deposits that would be worth investigating. On the basis of the field review, the results of radiocarbon dating, and the nature of the geologic context, as explained above, a permit was obtained from the Instituto Nacional de Antropologia e Historia (INAH). In the pages that follow, the results of investigations at the La Bocana site are presented and discussed in reference to issues relating to the chronology of cultural occupation and the changing context of human ecology.

Figure 3. Overview of the La Bocana site. The archaeologist points to an artifact exposed in lower red paleosol (S1). View is to north with the mouth of the Santo Tomás River in the background.

Site Setting

The La Bocana site is located in an area that is currently affected by large faults, which are moving portions of the local bedrock both horizontally and vertically (de Cserna et al. 1961; Gastil et al. 1971). The Santo Tomás River appears to have incised its course along the edge of a normal fault, which can be traced out along the southern edge of the Santo Tomás River canyon. This normal faulting uplifted the bedrock upon which the La Bocana site rests, relative to the mouth of the Santo Tomás River. Because the continental shelf narrows in the area of Punta Santo Tomás, the La Bocana site lies relatively close (ca. 4.5 km) to the projected 13,000 B.P. shoreline (cf. Inman 1983) -- much closer than in most other areas of the Pacific Coast. The proximity of the site to the Santo Tomás River likely offered a degree of ecological richness uncommon along the Baja California coast. Furthermore, the apparent accumulation of dune sand at the La Bocana site was expected to promote the preservation of relict land surfaces, archaeological components, and paleoenvironmental information.

Methods

To evaluate the significance of archaeological deposits at the site, four 2-x-2-m test pits (designated Units A through D) were excavated in an area where cultural materials were exposed (Figure 3). Excavation was conducted in arbitrary and stratigraphic levels using trowels and shovels, exercising care to recover features and occupation surfaces in place. The provenience of in situ finds was recorded in reference to north, east, and meters above sea level within each level, from datum pins at each excavation unit. Excavated sediments were passed through 1/8-in. wire mesh screen cloth to recover very small items.

Results

Site stratigraphy

Several geologic units were encountered during excavation (Figure 4), characteristics of which are summarized below in accordance to their lithostratigraphic, pedostratigraphic, chronostratigraphic, and allostratigraphic qualities (North American Commission on Stratigraphic Nomenclature 1983). Since excavations revealed only a portion of the extensive surficial deposits at the La Bocana site, future work will undoubtedly expand on the stratigraphic record presented here.

Lithostratigraphy. Lithostratigraphic units (LUs) are defined on the basis of the inclusive sedimentology, mineralogy, and geometry of geologic bodies (North American Commission on Stratigraphic Nomenclature 1983). Five LUs were observed during excavation of Units A-D.

- Lithostratigraphic Unit 1 (LU1): a cemented deposit of subrounded to rounded pebble- and cobble-sized igneous, metavolcanic, and metasedimentary gravels in a clast-supported matrix. Although directional measurements on clasts were not made, an imbricated fabric was not apparent.
- Lithostratigraphic Unit 2 (LU2): a reddish brown, cemented, medium to coarse sand with common pebble-sized ferric concretions and horizontal oxide sheets (likely produced by a groundwater or soil water phenomenon) that impart the appearance of repetitive bedding.
- Lithostratigraphic Unit 3 (LU3): a dark reddish brown, poorly-sorted deposit of silt, sand, and pebble-sized ferric concretions. A sharp, irregular boundary is seen between the base of LU3 and the top of LU2.
- Lithostratigraphic Unit 4 (LU4): a grayish, well-sorted quartzitic sand, which lacked well-defined bedding planes.
- Lithostratigraphic Unit 5 (LU5): a light yellowish brown, well-sorted, structureless quartzitic sand.

Pedostratigraphy.

- Soil 1 (S1): distinguished by its bright reddish-brown color, developed into the upper portion of LU3. This soil is characterized by moderate cementation, likely from the translocation of silica. Although fine to medium ferric concretions are common in the matrix of LU3, their presence here is likely due to erosion and redeposition of LU2 sediments, which form both the lithologic basis for LU3 and the parent material for S1. The S1 unit lacks a definable A horizon, and has a sharp, irregular upper boundary.
- Soil 2 (S2): lacking an A horizon, a grayish S2 paleosol developed into LU4 and including abundant medium to coarse calcium carbonate rhizoliths in its lower half and diffuse precipitation of calcuim carbonate throughout the entire matrix, which contributes to its friable consistency. The absence of an A horizon and the lack of erosional unconformities within LU4 reflects a cumulic soil context, wherein the deposition of parent material outpaced the accumulation of organic matter.
- Soil 3 (S3): characterized by its brown color and addition of silt, reflected in a loamy sand texture. Although the S2 and S3 paleosols share the same parent material (LU4), pedogenic development between the two soil horizons differs markedly. These

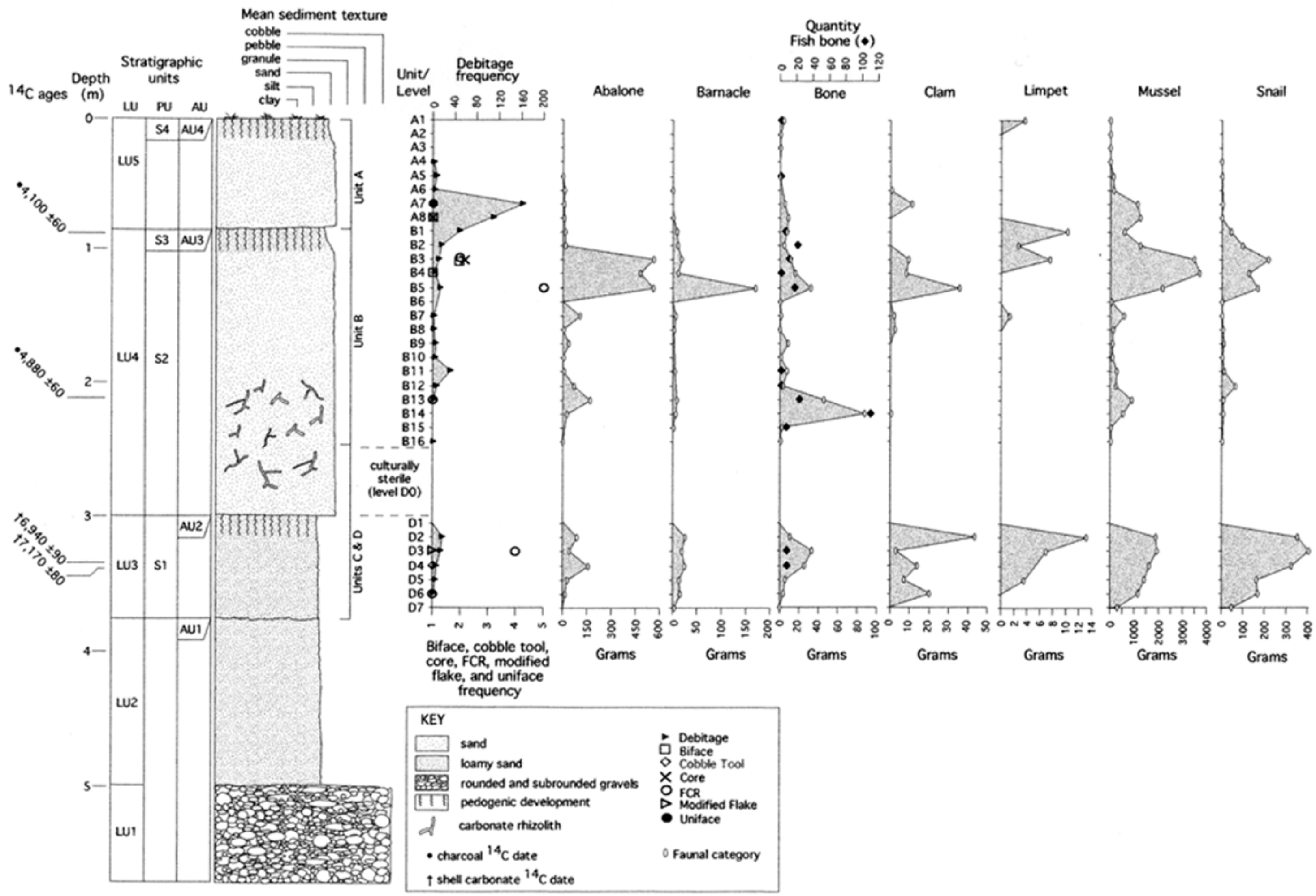

Figure 4. Composite stratigraphic profile of the La Bocana site compared with the distribution and frequency of artifacts and selected faunal categories, by unit and level. Column headings are as follows: ^{14}C ages are uncalibrated and reported in years before present; depth is shown in meters from top of Unit A, and is cumulative to bottom of Unit D; stratigraphic units include lithostratigraphic (LU), pedostratigraphic (PU), and allostratigraphic boundary (AU) units, as explained in text; the mean sediment texture scale follows clastic categories defined by Wentworth (1922) and corresponds to the length of geologic units drawn below (e.g., clay deposits would be shorter than cobble deposits); faunal data plots (e.g., abalone) are reported by weight (g) from corresponding unit/level, while all others (e.g., debitage frequency) are reported by quantity per unit/level.

differences are probably due to a hiatus in LU4 aeolian sand deposition, which provided a stable surface for extended organic input and development of an A horizon.

- Soil 4 (S4): Nearly identical to the S3 paleosol, retaining a brown, loamy sand A horizon. Also similar to the development of the S3soil, S4 pedogenesis likely occurred during a hiatus in aeolian sand deposition (LU5).

Chronostratigraphy. Four radiocarbon dates were submitted from La Bocana excavation units, ranging in age from 7170 ±80 and 4100 ±60 B.P. The vertical distribution of radiocarbon dates in the La Bocana profile suggests that multiple periods of human occupation occurred under changing environmental conditions during the early and middle Holocene.

Allostratigraphy. Allostratigraphic unit boundaries are defined on the basis of interruptions in the stratigraphic record, such as those caused by surficial stability (e.g., soil development), or erosional processes (North American Commission on Stratigraphic Nomenclature 1983; Waters 1992:68-73). Three periods of surficial stability (allostratigraphic units [AU] 2-4) are seen in the formation of the S1, S3, and S4 paleosols. Based on the radiocarbon dates, S2 soil formation occurred under rapidly accreting aeolian sand and did not act to stabilize the surface of the site for any significant period of time. The sharp, irregular boundary between LU3 and LU2 (AU1) appears to be an unconformable contact formed by erosion. This erosional unconformity suggests geologic deposits have been removed, probably erasing late Pleistocene-early Holocene archaeological evidence. While the timing of this unconformity is not directly dated, the pedogenic nature of S1 and the closeness of the radiocarbon dates from the upper portion of LU3 likely suggest that the deposition of LU3 was a relatively steady and rapid process. Therefore, the LU3-LU2 boundary probably dates within the early Holocene. Because radiocarbon dates from LU3 come from shells contemporaneously deposited with LU3 sediments, the terminal age for the formation of the S1 paleosol is not precisely known, but is expected to postdate 6940 B.P.

Site formation history

By considering the timing and nature of geologic deposition, interpreted from field observations and the results of laboratory analyses, a model addressing how the La Bocana site was formed is presented. To provide a historical perspective, three arbitrary periods of site formation are defined, with boundaries based on the presence of key geologic events.

Period 1 (prior to and just after 7000 B.P.): LU3 deposition and S1 formation. The presence of reworked ferric concretions suggests that LU3 probably originated from the erosion and redeposition of LU2 sediments. Because the S1 horizon lacks well-developed pedogenic features, it may have developed in a relatively short period of time. The absence of a well-defined A horizon at the upper portion of S1 may suggest that erosive action removed sediments prior to the deposition of LU4 aeolian sand; this interpretation is supported by site chronostratigraphy as well.

Period 2 (after ca. 7000 B.P. to 4100 B.P.): LU4 deposition and S2-S3 formation. Dune sand rapidly buried the eroded S1 surface sometime after ca. 7000 B.P. but before ca. 5000 B.P. Cumulic soil development occurred in a rapidly aggrading dune deposit under arid conditions, which encourage the extensive growth of carbonate rhizoliths. Dune deposition slowed greatly and/or stopped prior to 4100 B.P., allowing an A horizon to develop, defining the S2 paleosol.

Period 3 (after 4100 B.P.): LU4-LU5 deposition and S4 formation. After 4100 B.P., the

Table 2. Artifacts recovered from Unit A, by level.

Level	Description	Quantity	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Notes
surface	core	1	53.8	64.9	51.9	278.0	metavolcanic	multidirectional, exhausted, found on surface
surface	debitage	7	--	--	--	360.8	metavolcanic	found on surface
4	debitage	2	--	--	--	2.0	metavolcanic	--
5	debitage	7	--	--	--	4.6	metavolcanic	--
7	debitage	162	--	--	--	759.0	metavolcanic	--
7	uniface	1	82.9	79.0	21.7	200.5	metavolcanic	complete, exhibits primary reduction
8	biface	1	13.8	22.3	5.6	1.2	metasedimentary	broken crosswise, proximal fragment, basal and side notched projectile point
8	core	1	--	--	--	422.0	metavolcanic	multidirectional reduction on cobble

S2 paleosol was buried during a period of dune reactivation. However, the surface of the S2 soil is intact, suggesting that no erosion occurred prior to burial. Dune deposition continued for an undetermined amount of time, and eventually stopped or slowed greatly, allowing the development of the S4 soil. Although S4 is undated, its morphology is similar to S3, which suggests a relatively short developmental period, following a brief period of dune sedimentation. Therefore, S4 likely dates no younger than 3000 B.P.

Archaeological record

The archaeological record of the La Bocana site is dominated by faunal remains and a relatively small amount of artifactual evidence. Taken together, and interpreted with caution, this record may provide insights on early and middle Holocene subsistence patterns and settlement strategies.

A total of 514 pieces of lithic debitage, weighing 3335.9 g was recovered from Units A-D (Tables 2-5). Locally available metavolcanic material was first in frequency (n = 455, wt. = 3,268.7 g), while metasedimentary lithologies (n = 47, wt. = 40.3 g) and undifferentiated igneous rocks (n = 7, wt. = 24.5 g), followed at a distant second and third, respectively. Quartz (n = 3, wt. = 2.1 g) and obsidian debitage (n = 2, wt. = 0.3 g) were found in extremely small quantities. Although not identified to its eruptive source, obsidian is not available in this area and must have been transported to the La Bocana site. Proportionally, metavolcanic debitage overwhelms the archaeological record in both number and weight (n = 89% of total, wt. = 98% of total). This is not unexpected, given the abundant availability of metavolcanic cobbles in the conglomerate unit that underlies the site.

Lithic tools from several categories were found in all excavation units, including simple bifaces (n = 4), cobble tools (n = 1), cores (n = 4), modified flakes (n = 1), and unifaces (n = 1). Stratigraphically, lithic tools were encountered most frequently in the upper limits of Units B and

Table 3. Artifacts recovered from Unit B, by level.

Level	Description	Quantity	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Notes
1	debitage	25	--	--	--	--	metavolcanic	--
1	debitage	15	--	--	--	--	metavolcanic	--
1	debitage	7	--	--	--	24.5	igneous	--
1	debitage	2	--	--	--	7.0	metavolcanic	--
2	debitage	15	--	--	--	137.0	metavolcanic	--
2	debitage	1	--	--	--	0.1	quartz	--
3	biface	1	67.3	75.0	21.9	112.5	metavolcanic	complete, bifacial edging on cobble spall
3	biface	1	18.8	22.6	6.8	2.6	rhyolite	broken crosswise, distal fragment
3	core	1	--	--	--	468.0	metavolcanic	unidirectional reduction on cobble
3	core	1	98.2	98.6	46.2	499.0	metavolcanic	multidirectional reduction
3	debitage	10	--	--	--	37.0	metavolcanic	--
3	debitage	1	--	--	--	0.1	obsidian	--
3	FCR	2	--	--	--	15.7	metavolcanic	--
4	biface	1	12.7	18.3	5.6	1.5	quartz	broken crosswise and lengthwise, basal fragment
4	debitage	2	--	--	--	3.1	metavolcanic	--
4	debitage	1	--	--	--	0.5	metavolcanic	--
5	debitage	7	--	--	--	34.2	metavolcanic	--
5	debitage	7	--	--	--	89.7	metavolcanic	--
5	FCR	5	--	--	--	567.0	metavolcanic	--
7	debitage	2	--	--	--	0.5	metavolcanic	--
8	debitage	2	--	--	--	64.3	metavolcanic	--
9	debitage	4	--	--	--	9.2	metasedimentary	--
9	debitage	1	--	--	--	0.2	obsidian	--
10	debitage	4	--	--	--	1.5	metasedimentary	--
11	debitage	32	--	--	--	26.6	metasedimentary	--
12	debitage	7	--	--	--	3.0	metasedimentary	--
13	debitage	2	--	--	--	68.9	metavolcanic	--
13	FCR	1	--	--	--	41.3	granitic	--
16	debitage	1??	--	--	--	7.0	metavolcanic	--

D, associated with the S3 and S1 soils, respectively. A lanceolate biface (Figure 5) was found in 1999 at the base of an outcrop of LU2/LU3 sediments, in the area of excavation Unit D. Sediment adhering to one side of the biface matched that seen in LU3, suggesting that it had recently weathered out of the geologic exposure.

A spatulate bone tool with a beveled end and a cross-hatched pattern incised on one side (measuring 143.9 mm long, 37.4 mm wide, 7.6 mm thick; weighing 35.6 g) -- likely carved from whale rib bone -- was found protruding from a paleosol probably equivalent to S4 at the north end of the dune away from the excavations. The exact use of this tool is unknown, but it could have been wedged beneath certain shellfish such as abalone, limpets, or urchin to remove them from rocks.

Table 4. Artifacts recovered from Unit C, by level.

Level	Description	Quantity	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Notes
1	debitage	8	--	--	--	28.5	metavolcanic	--
1	FCR	12	--	--	--	440	metavolcanic	--
2	FCR	10	--	--	--	410	metavolcanic	--
3	biface	1	70.0	50.2	17.9	81.9	metavolcanic	broken crosswise
3	debitage	12	--	--	--	103.9	metavolcanic	--
3	FCR	5	--	--	--	69.7	metavolcanic	--
3	FCR	1	135.3	135.1	40.0	500	sedimentary	--
3	FCR	1	--	--	--	275	metavolcanic	--
3	FCR	1	--	--	--	600	metavolcanic	--
3	FCR	1	--	--	--	140	metavolcanic	--
3	FCR	1	--	--	--	210	metavolcanic	--
3	FCR	8	--	--	--	1600	metavolcanic	--
4	debitage	4	--	--	--	--	metavolcanic	--
4	FCR	1	--	--	--	126.7	metavolcanic	--
5	debitage	2	--	--	--	6.1	metavolcanic	--
5	FCR	1	--	--	--	500	metavolcanic	feature C1

Table 5. Artifacts recovered from Unit D, by level.

Level	Description	Quantity	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Notes
2	debitage	6	--	--	--	83.9	metavolcanic	--
2	debitage	12	--	--	--	147.2	metavolcanic	--
2	FCR	1	--	--	--	105.2	metavolcanic	--
3	debitage	1	--	--	--	1.0	quartz	--
3	debitage	14	--	--	--	95.4	metavolcanic	--
3	FCR	4	--	--	--	440	metavolcanic	--
3	MF	1	95.4	44.1	13.3	66.7	CCS	complete, bifacial edge wear
4	cobble tool	1	240	155.5	57.4	>500	sedimentary	broken crosswise and lengthwise, possible anvil stone
4	debitage	1	--	--	--	1.0	quartz	--
4	debitage	6	--	--	--	56.7	metavolcanic	--
5	debitage	5	--	--	--	51.3	metavolcanic	--
6	debitage	1	--	--	--	0.2	metavolcanic	--
6	FCR	1	--	--	--	17.6	metavolcanic	--

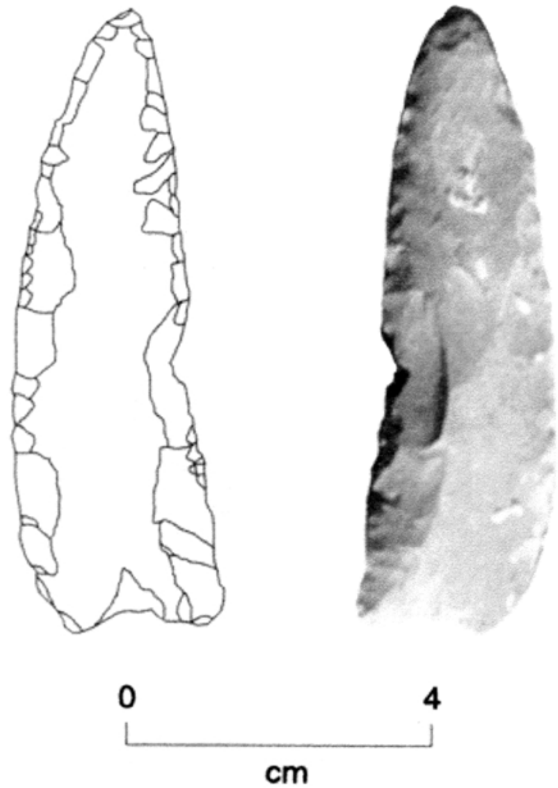

Figure 5. Image and illustration of a lanceolate biface recovered from the La Bocana site.

Fifty-six sedimentary and metavolcanic rocks exhibiting fracture and spalling patterns, consistent with the kind of extreme heat stress typical of campfires and hearths, were found in Units B-D. The greatest number of FCR were found in unit C, level 3 (n = 18), and a total of 42 pieces of FCR were found throughout Unit C.

Faunal remains dominated the material record recovered at the site, including the shells of abalone, barnacle, chiton, clam, crab, limpet, mussel, oyster, snail, and urchin, and mammal and fish bone of large and small varieties (Tables 6-9). Several observations may be made regarding the frequency of faunal remains recovered during test excavations. Figure 4 shows the distribution of selected faunal remains compared to the composite site stratigraphy and distribution of archaeological materials. Although mussel shell dominates the faunal record of the La Bocana site, some variations in the cumulative frequency of all faunal categories, shown in Figure 6, are worth mentioning. Snail shells show their highest cumulative frequency throughout Unit D but are much reduced in the lower reaches of Unit B. At the base of Unit B, in levels 12-13, and in levels 3-5, abalone shells were recovered in their highest amounts, representing more than 10% of the total. Weights of bone and the number of fish bones are highest in Unit B, level 14, but are much reduced in the remainder of the record.

The point behind these observations, and the utility of relative frequencies, is to highlight the presence of diversity in faunal assemblages. Unit B, level 5 shows a high degree of faunal diversity caused by increases in the relative proportion of abalone (17% of total), barnacles (5.2%), crab (1.1%), limpets (2.6%), snails (5.1%), and urchin (1.9%), compared to mussel shell (only 65.5% of total). Quantities of mussel shell are at their lowest in Unit B, level 12 as well -- comprising only 63.9% of the total; however the remaining total is largely accounted for by higher proprtions of abalone (18%) and snail shell (16.9%). Faunal diversity is very low

Table 6. Distribution and frequency (g) of faunal materials in Unit A, by level.

Level	Abalone	Barnacle	Mammal and fish bone	Chiton	Clam	Crab	Limpet	Mussel	Oyster	Marine snail	Unknown shell	Urchin shell/spinr
1	--	--	3.5	3.6	--	--	--	0.3	--	--	--	--
2	--	--	0.5	--	--	--	--	0.5	--	--	--	--
3	--	--	0.4	--	--	--	--	3.1	--	--	--	--
4	--	--	--	--	--	--	--	5.4	--	0.1	--	--
5	0.3	--	0.2	--	--	--	0.5	127.7	--	1.5	--	--
6	9.9	0.2	--	--	0.8	--	0.8	151.0	--	--	--	--
7	9.5	--	4.5	--	11.1	3.3	8.0	1120.0	--	3.7	12.7	--
8	8.8	0.8	8.1	--	--	8.4	11.3	1238.9	--	1.7	--	0.3

Table 7. Distribution and frequency (g) of faunal materials in Unit B, by level.

Level	Abalone	Barnacle	Mammal and fish bone	Chiton	Clam	Crab	Limpet	Mussel	Oyster	Marine snail	Unknown shell	Urchin shell/spinr
1	13.6	8.4	6.9	10.2	--	--	3.6	592.4	--	42.8	67.8	0.4
2	17.3	9.7	4.3	2.6	--	--	27.9	1,230.4	--	96.7	0.8	3.5
3	560.0	17.8	10.8	7.5	9.2	--	140.0	3,470.0	0.5	218.0	5.9	25.1
4	478.0	10.6	15.5	--	8.1	--	75.4	3,692.3	0.3	126.3	7.4	29.7
5	559.0	169.6	32.0	--	35.4	0.4	86.0	2,151.0	1.5	167.3	19.0	61.1
6	--	--	0.3	--	--	--	0.2	56.8	--	2.6	0.1	2.7
7	104.3	6.3	0.9	1.3	1.8	--	4.2	571.4	--	1.4	3.4	10.8
8	4.3	3.2	0.2	--	2.2	--	1.2	134.5	--	6.3	0.4	1.4
9	36.8	--	8.5	--	--	--	8.6	117.5	--	10.7	--	--
10	5.0	--	0.8	--	--	--	1.2	88.1	--	4.8	--	0.9
11	8.6	4.2	7.6	--	--	0.9	--	269.5	--	11.8	5.0	1.1
12	68.3	--	3.0	--	--	--	--	242.7	--	64.2	0.6	0.2
13	167.9	8.6	45.5	--	--	--	0.4	895.0	0.4	7.7	2.5	0.3
14	25.3	6.1	87.6	--	0.5	--	1.3	525.5	2.5	8.1	4.7	--
15	--	1.8	2.3	--	--	--	3.5	33.3	3.5	--	--	--
16	0.3	--	1.1	--	--	--	--	33.9	--	3.5	--	--

Table 8. Distribution and frequency (g) of faunal materials in Unit C, by level.

Level	Abalone	Barnacle	Mammal and fish bone	Chiton	Clam	Crab	Limpet	Mussel	Oyster	Marine snail	Unknown shell	Urchin shell/spinr
1	8.1	5.7	3.2	--	14.9	6.3	44.8	654.8	--	112.1	--	--
2	10.4	25.6	10.1	9.2	14.1	--	19.1	921.6	--	157.1	--	--
3	37.8	19.5	6.4	--	45.2	1.1	50.9	1,836.9	0.2	353.3	5.4	--
4	68.0	20.4	3.0	--	11.8	--	9.4	768.2	--	111.3	--	--
5	--	2.3	5.3	--	2.0	2.2	24.5	885.0	--	124.9	2.2	--
6	--	3.6	0.1	--	--	0.7	3.0	206.9	--	34.0	--	--

Table 9. Distribution and frequency (g) of faunal materials in Unit D, by level.

Level	Abalone	Barnacle	Mammal and fish bone	Chiton	Clam	Crab	Limpet	Mussel	Oyster	Marine snail	Unknown shell	Urchin shell/spinr
1	--	--	--	--	--	--	--	--	--	--	--	--
2	87.8	25.7	10.5	13.2	43.5	1.5	22.8	1,898.9	--	355.3	6.8	--
3	41.1	19.0	33.4	7.0	2.9	0.9	51.7	1,936.5	0.6	406.9	2.4	0.1
4	156.5	25.1	25.5	--	13.8	5.1	30.8	1,626.0	1.1	326.6	2.8	--
5	26.9	14.0	5.5	3.5	7.1	1.2	16.0	1,427.7	--	163.0	2.1	--
6	17.2	15.9	3.6	--	20.1	1.4	13.1	1,166.8	0.1	169.1	0.7	--
7	--	3.3	0.2	--	--	0.6	2.8	304.4	0.2	47.2	--	--

throughout Unit A, as mussel shell provides more than 90% of the total faunal remains. As well, mussel (84.7%) and snail shell (13.1%) represent nearly 98% of the total fauna recovered from the lower levels of Unit D. In all levels of Unit D, combined quantities of mussel and snail shell account for more than 90% of all faunal remains.

Discussion

Paleoecology and site occupation

The archaeological evidence suggests the La Bocana site was repeatedly occupied for short periods of time. Prehistoric hunter-gatherers likely used the site as a station for processing marine resources. Evidence for intensive resource processing is provided by the association of FCR and large quantities of marine shell and bone. On the basis of the evidence at hand, it is difficult to know whether these marine resources were consumed entirely at the site, or prepared to be eaten elsewhere.

The earliest evidence of human occupation encountered at the La Bocana site is associated with the S1 soil, predating 7170 B.P. The reddish color and slightly cemented nature

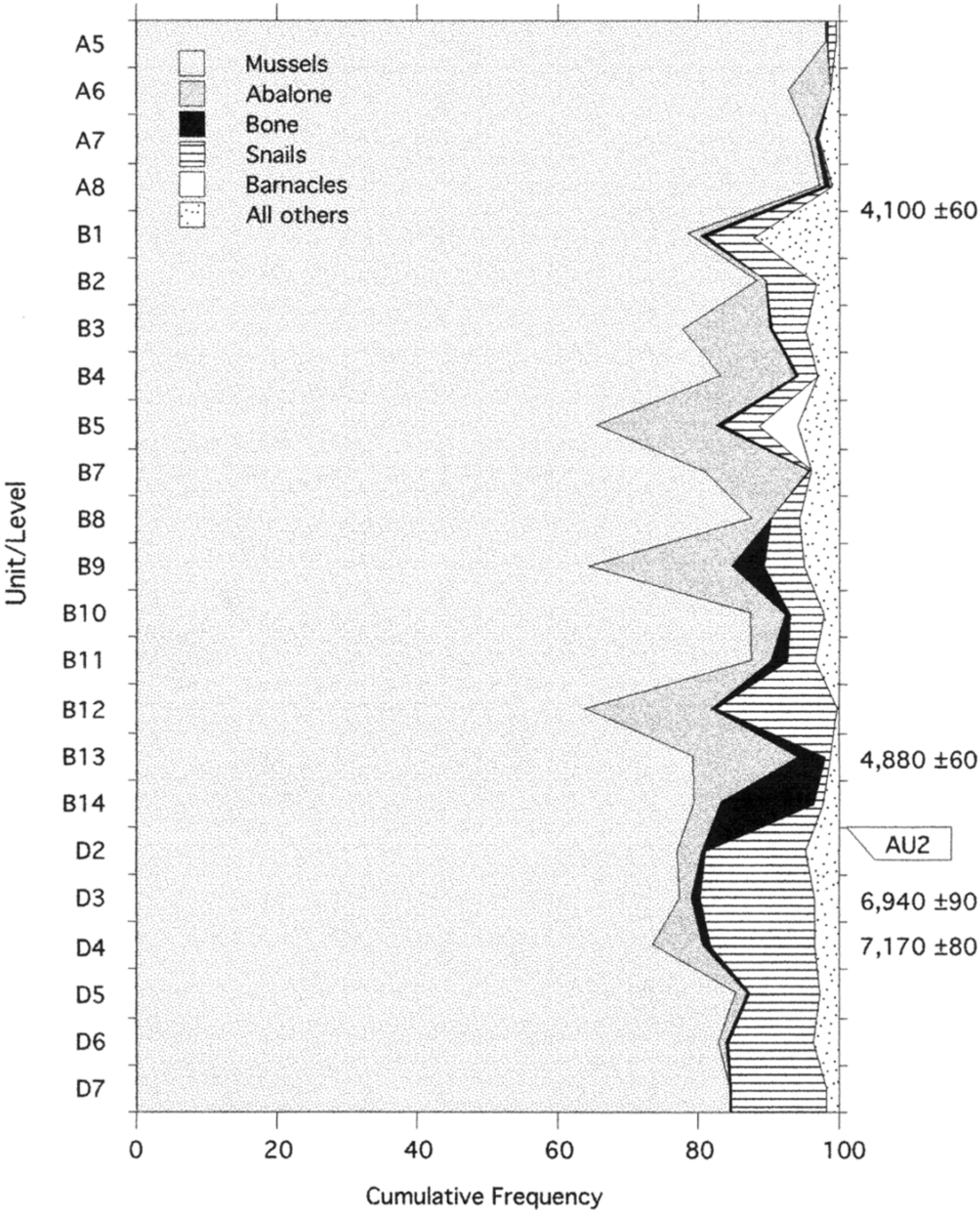

Figure 6. Cumulative frequency of faunal remains from excavation Units A, B, and D, by level. Radiocarbon dates on the right margin follow uncalibrated ^{14}C ages listed in Table 1.

of this paleosol point to the presence of iron oxides, and suggest pedogenesis under relatively humid climate conditions (Birkeland 1984:72). Hyperarid conditions are interpreted following the burial of the lower paleosol (S1) sometime after 6940 B.P., on the basis of rapid aeolian deposition and calcic soil development. The onset of arid conditions matches well with dune growth and pluvial lake desiccation after 7000 B.P. in the Laguna Chapala Seca basin, located to the southeast in the middle of the Baja California peninsula. During the earliest period, corresponding with cultural occupation in Units C and D, sea level was ca. 10-12 m lower than today (Inman 1983), which would place the Pacific shoreline about 1 km west of its modern position.

Increased quantities of fish bone are seen in Unit B, level 14, dating just before 4880 B.P. By 5000 B.P., sea level rose within a few meters of its modern position (Inman 1983), and likely promoted the development of an estuarine ecosystem near the site, at the mouth of the Santo Tomás River (cf. Bickel 1978; Erlandson 1985, 1994; Rudolph 1985). Declining emphasis on shellfish and rising relative frequencies of bone may be related to rising early and middle Holocene temperatures and their influence on marine productivity and the potentially negative effects of rising sea level on littoral ecosystems (Rudolph 1985:131). By 4100 B.P., sea level rise slowed dramatically, likely providing a stable environment for the development of extensive littoral resources. This scenario is supported by increasing quantities of mussel shell in the upper levels of Unit B and the lower reaches of Unit A. Towards the end of LU5 deposition and the development of the S4 paleosol, cultural occupation decreased dramatically in the area investigated here. Extensive, dense midden deposits are seen at the northern end of the dune, suggesting that settlement and intensive use of local resources continued into the late Holocene.

Interpreting patterns of economic behavior

Clearly, work at the La Bocana site reveals an early record of marine resource use; however, interpretations of this record must be constructed with caution. While the discussion presented above emphasizes possible correlations between paleoenvironmental conditions and their effects on marine resources, which correlate well with archaeological and geologic records reported from southern California, these interpretations should be considered preliminary and must be tested with additional, more extensive research. Because many factors may shape the character of the archaeological record at the La Bocana site, several competing hypotheses concerning changing frequencies of marine fauna should be tested, including: (1) that variations in the abundance and relative proportion of different fauna may be directly related to changes in sea level, water temperature, and the physical character of the eastern Pacific littoral zone near the site; (2) that faunal frequencies could simply reflect cultural preferences toward food and diet, not the local abundances of species; (3) that changing quantities of different fauna record the effects of human predation on the recruitment and concentration of biotic resources near the site; (4) that taphonomic factors, including erosive actions and cultural behaviors (e.g., faunal processing and disposal practices) may have strongly biased the faunal database; and (5) that the sample size of the faunal record is insufficient to support statements regarding ecological, economic, or sociocultural conditions, and a larger database will reveal important differences from the record presented here.

Implications of the erosional unconformity

While the project's original goal to locate and recover a late Pleistocene-age cultural occupation at the La Bocana site was not realized, the discovery of an erosional unconformity at the base of the site raises some interesting questions that may help explain the absence of early cultural evidence. The AU1 erosional contact can be traced in stratigraphic exposures to the north and south of the La Bocana site, suggesting that a larger forcing mechanism, which affected entire landforms, might be at play. The implications of a regional unconformity are important to research seeking early cultural occupations. If erosion of Baja California coastal landforms was indeed widespread, early sites located in open settings (i.e., not in protected contexts, such as rock shelters) may have been destroyed or altered, making their discovery difficult and/or compromising their contextual integrity. The driving force behind this erosional episode was likely related to regional climate conditions during the late Pleistocene-early Holocene transition, which appear to have been wetter and cooler before 7000 B.P. Increased runoff in a more mesic climate regime may have promoted widespread erosion of coastal landforms. This scenario may explain the origin of the AU1 unconformity and the deposition of LU3 sediments. Earlier, this author suggested that LU3 sediments originated from the erosion and redeposition of older sediments -- sediments that may have held late Pleistocene-early Holocene cultural components. Thus, future efforts to locate early cultural occupations must account for the role of late Pleistocene-early Holocene environmental conditions on the preservation and visibility of sites.

Conclusions

Archaeological investigations at the La Bocana site revealed a long record of hunter-gatherer use of marine resources, beginning at ca. 7200 B.P. and extending into the late Holocene. Although changing patterns of marine fauna appear to correspond with changes in coastal paleogeography and their potential effects on littoral and estuarine ecosystems, additional research is needed to fully evaluate these hypotheses. Radiocarbon dating of deeply buried archaeological components revealed an early Holocene-age cultural occupation and expands our knowledge of Baja California prehistory. Archaeological sites near narrow, steeply sloping continental shelf zones, like the La Bocana site, are important, and should be the focus of future archaeological and geoarchaeological research. Because their modern-day coastline may closely approximate its full-glacial sea level state, these localities may retain evidence of early hunter-gatherer occupation along Baja California's coastline. The discovery of an erosional unconformity at the base of the La Bocana site, coupled with an absence of late Pleistocene-age cultural components, however, points to the dynamic role of geologic processes on the preservation and distribution of early sites along the Baja California coast. Thus, future archaeological and geoarchaeological research at the La Bocana site and others like it will hopefully address the questions raised here regarding the nature of prehistoric cultural occupation and adaptation, and its preservation through time.

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